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Agrobiodiversity, Cultural Factors and their Impact on Food and Nutrition Security:

A case-study in the south-east region of the Peruvian Andes

Dissertation submitted to the Faculty of Agricultural, Nutritional Sciences and Environmental Management, Justus-Liebig-University Giessen, Germany for the degree of Dr. oec. troph.

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Dipl. oec. troph. Ursula Chávez Zander

Born in Lima, Peru

Gießen, July 2013

Table of contents

List of tables

List of figures

List of abbreviations

AGP	α-1-acid glycoprotein
ASF	Animal source foods
ANOVA	Analysis of variance
BMI	Body Mass Index
CIC	Conjunctival Impression Cytology
CRP	C-reactive Protein
DBS assay	Dried Blood Spot assay
DD	Dietary diversity
DDS	Dietary diversity score
Farm-S	Farming or sowing season
FVS	Food variety score
GLM	General linear model
HH	Household
Hb	Hemoglobin
ID	Iron Deficiency
IDA	Iron Deficiency Anemia
IDDS	Individual dietary diversity score
IQR	Interquartile range
MUAC	Mid-Upper Arm Circumference
Post-S	Post-harvest season
Rain-S	Rainy season
RBP	Retinol Binding Protein
SES	Socio-economic status
sTfR	soluble Transferrin Receptor
VA	Vitamin A
VAD	Vitamin A deficiency
WDDS	Women dietary diversity score

Glossary

Altiplano: Spanish for “high plain” in west-central South America. It is the most extensive area of high plateau on Earth outside of Tibet and has an average altitude of 3,750 m. The Altiplano occupies parts of northern Chile and Argentina, western Bolivia, and south Peru.

Aymara: Native ethnic group in the Andes and Altiplano regions of South America. Aymara is also one of the two dominant language families of the central Andes, along with Quechua.

Camelids: Group of even-toed ungulate mammals from the family *Camelidae*. The llama, alpaca (s. Box 1, p 103), guanaco, and vicuña are originally from South America and among the six living species of camelids, along with the dromedary and the Bactrian camel.

Chacra: Small parcel of agricultural land.

Charki, charqui: jerked meat, sun- and/or air-dried and with salt preserved strips of meat e.g. llama, alpaca or sheep.

Choqa, chocca: *Fulica Americana*, a bird of the family *Rallidae* that is commonly found at the Lake Titicaca but also widely spread in North and South America

Chuño: from Quechua ch’uñu meaning frozen potato. It is a freeze-dried potato product traditionally made by Quechua and Aymara communities from Peru and Bolivian, but also known in Argentina and Chile. Foremost the bitter potatoes are selected for this food processing in order to remove the high content of glycolalkaloids (anti-nutrient substances). The food preservation technique includes freezing nights, exposure to the sun, trampling by foot to eliminate water and remove the skin, and subsequent freezing. Once dried, these freeze-dried tubers can easily be stored for years prepared by just boiling them.

Guinea pig: *Cavia porcellus*, is a species of rodent in the family *Caviidae* and the genus *Cavia*. It plays a role in the folk culture of many indigenous South American groups as a food source, in folk medicine, and in religious ceremonies.

Isaño, mashua: *Tropaeolum tuberosum*, a species of flowering plant in the family *Tropaeolaceae* which is native to Colombia, Ecuador, Peru, and Bolivia. Its edible tuber is eaten as a root vegetable. Isaño is also cultivated as an ornamental for its brightly colored tubular flowers.

Kañihua, Cañihua, Canihua: *Chenopodium pallidicaule*, a species of goosefoot and a grain-like Andean crop closely related to quinoa. It is usually consumed as “kañi-huako” (toasted and milled grains). Kañihua and quinoa can be used in weaning food mixtures. More information is available in Box 1 p 103.

Muña: *Minthostachys mollis* is a medicinal plant endemic to the South American Andes from Venezuela to Bolivia.

Oca, occa, oka, uqa: *Oxalis tuberosa*, edible tuber endemic to and domesticated in the Andes. It is a perennial herbaceous plant. Its stem tubers are consumed as a root vegetable and they can be traditionally processed in a similar form than bitter potato for chuño to be used as a storage product called khaya. This crop has also become very popular in New Zealand where it is called yam.

Olluco, ullucu, papaliza: *Ullucus tuberosus*, also a popular native Andean tuber (*Basellaceae*) which is consumed as a root vegetable.

Quinoa: *Chenopodium quinoa*, a species of goosefoot and one of the most important staple in the Andean cultures. This grain-like crop is considered as pseudo-cereal because it is not member of the grass family. Its balanced composition of essential aminoacids is similar to the composition of the milk protein, casein. More information is available in Box 1 p 103.

Tarwi: *Lupinus mutabilis*, traditionally cultivated leguminous species grown above 1,500 m, from Venezuela to Chile and Argentina. The high oil and protein content are the most important property of this crop that is almost comparable to soy bean. Prior to their consumption, however, seeds need to be treated in order to remove anti-nutritional substances.

Watia, huatia: A traditional earthen oven which dates back to the period of the Incan Empire. The common way is to construct a dome or pyramid from clay pieces with an opening to place the food to be cooked. A fire is built inside until the oven becomes sufficiently heated to bury the food. The heat inside remains for a long time, and the food, mostly fresh, harvested tubers and meat in addition to herbs, is then left to cook for many hours.

1 Introduction

Eradicating extreme hunger and poverty is the primary Millennium Development Goal. Halving hunger[1] by 2015 is part of this goal and still a great challenge due to the worldwide economic crisis, climate change, rising costs of food and energy, and the effects of natural disasters. However, hunger resulting from insufficient food intake is no longer the only topic to be addressed. A poor diet quality and general lack of access to wide food diversity increase the risk of micronutrient deficiencies, impairing a healthy life and high labor productivity. Micronutrient deficiency, also called the "hidden hunger", affects more than 40% of the world's population (Bokeloh *et al.* 2009), most of them in low and middle income countries (Muller 2005) and particularly women and children. Although approaches such as supplementation, fortification, and food-based approaches are developed to solve this problem in the short, mid, and long term, respectively, micronutrient deficiencies are still a global public health issue.

Whereas the protective effects of consuming a wide variety of vegetables and fruit is well known, dietary diversification is another low-cost but useful long term strategy to improve the diet quality in rural or isolated settings. In terms of sustainability, agricultural biodiversity is regarded as essential not only for coping with the present climate change but also for enhancing food security and therefore improving household nutrition security (Frison *et al.* 2011).

In recent years many studies have shown evidence of association between dietary diversity and nutritional status in developing countries of Africa and Asia using quantitative methods such as the *dietary diversity score* (DDS) and *food variety score* (FVS) (Torheim *et al.* 2004; Savy *et al.* 2005; Savy *et al.* 2006). Moreover, dietary diversity assessed by these food scores seems to be associated with the socio-economic status (SES) at the household level (Hoddinott *et al.* 2002; Hatløy *et al.* 2000). Therefore, the DDS and FVS may have potential as predictors of food security. However, further investigation is needed, taking into account cultural and geographical conditions. For example, less is known about these associations in the Latin American context, specifically among Andean people living in the study region.

[1] In this context the definition of "hunger" is the one used for the Sixth World Food Survey, "The number of people who do not get enough food energy, averaged over one year, to both maintain productive activity and maintain body weight" (FAO 1990, 1996b in (FAO 2002)).

1.1 Rationale of the study and objectives

In Latin America, Peru has experienced noticeable improvements in its economy and health sector during the last decade (The World Bank 2009; World Health Organization 2011). In terms of overall population statistics there has been general improvement in the nutritional situation from the early nineties until now, but severe problems for marginalized population groups, for instance indigenous people, still persist.

As with Bolivia, Ecuador, Mexico, and Guatemala, Peru is another country in Latin America with a large indigenous population. Including all households in which the head of household or the partner have parents or grandparents who spoke an indigenous language, 48% of the Peruvian population can be considered indigenous. Regarding households in which the mother tongue of the head of household or his/her partner is an indigenous language, the percentage decreases to 25% (IWGIA 2006). As is common in many Latin American countries, the indigenous belong to the lowest socio-economic and political strata, and there are great differences in poverty, health, and education between indigenous and non-indigenous people (Minorities at Risk Project 2003). Moreover, due to historical as well as legal and political factors, indigenous people such as the Aymara still face discrimination and social exclusion.

On the one hand, the whole Andean region of Latin America is considered one of the greatest centers of world species domestication (Hernández Bermejo *et al.* 1994), and utilizing traditional plants could enormously help improve human nutrition. On the other hand, malnutrition, food insecurity, illiteracy, limited access to basic needs (potable water, sanitation, etc.) and to supportive facilities (hospitals and/or health centers with adequate equipment and medical support) are common characteristics, for instance, in the central and south regions of the Peruvian highlands. Thus, these limitations impair many of the benefits from ecological diversity.

The term “agrobiodiversity” or agricultural biodiversity is used in this work according to the FAO definition: “the variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. […]” (FAO 1999). In the study region, special attention was given to crop farming, gathering, and home gardening. The diversity of Andean crops and their invaluable nutritional properties have already been investigated by several researchers (Hernández Bermejo *et al.* 1994; Maxted *et al.* 1997; Jacobsen *et al.* 2003). However, due to acculturation, integration into markets, increasing consumption of processed food and urban dietary patterns, many Andean crops and indigenous foods have become marginalized, neglected, or regarded as “food of the poor". In contrast, promoting their re-valuation, nutritional knowledge, usage, and consumption improvement on the food supply, nutrition quality and thus a better nutritional status could be achieved.

Several development programs and studies have been carried out aiming to improve the nutritional status of children and pregnant women in Latin America, but somewhat less is reported about non-pregnant women of childbearing age. National health programs in Peru pay special attention to children up to three years old through monitoring and vaccination and to pregnant women through supplementation and prenatal examinations, but medical preventive checks in other population groups such as seniors, men, and non-pregnant women are not culturally wide-spread. Considering that women's health before pregnancy plays a key role not only in avoiding health risks for both mothers and developing fetuses, but also because women play an important role as caregivers in the households, more attention should be paid to this group.

Recent results of the Peruvian National Demographic and Health Survey ENDES highlight the prevalence of anemia in women aged 15-49 and children. Thereafter, about three out of ten women in this age suffer from anemia (29%), and the prevalence increases if they live in rural areas. Moreover, further results from this survey showed that children are more likely to be anemic if the mother has any level of anemia at all (INEI *et al.* 2007).

Available data about the prevalence of vitamin A deficiency (VAD) at the national level are based on a few intervention studies carried out in certain regions of the country. An international database on VAD in Peru is based on those results (WHO 2006) as well, but they do not represent all existing population groups of the country. However, the results suggest that VAD is a national public health problem affecting children and in a lower magnitude women of childbearing age.

Finally, linking all mentioned environmental, socio-economic, cultural, and nutritional aspects, this present work relies on the following hypothesis:

"Rural populations living in an environment with high agrobiodiversity are likely to have a more diversified and balanced diet and therefore a good nutritional status."

Nevertheless, indigenous and rural population groups are currently exposed to socio economic changes and urbanization processes, and these conditions have to be considered as well: for instance, the influence of market access and consumption of processed food.
Because the use of qualitative food scores in other cultural settings is still needed in order to compare information on food patterns across countries, one broad aim of the present study was to fill this gap. However, compared to other studies focused on associations between food scores and nutrient adequacy, the main objectives of this study were to investigate the links between agrobiodiversity, dietary diversity[2], and nutritional status, and to examine influencing factors on dietary diversity using food scores in the south-east region of the Peruvian Andes.

The different areas of the study were allocated within the model of nutrition security (Krawinkel 2009) shown in Figure 1.1.

Based on the hypothesis stated above, the following key questions were examined:

- Is agrobiodiversity potentially available as a resource for a diversified diet?
- How diverse is the current diet of the population measured with the food scores? Does seasonality influence the dietary diversity (DD)?
- Which socio-economic and household-related factors influence individual DD?
- Is there a relationship between the food scores and nutritional outcomes?

[2] In this work, dietary diversity means diversity of food groups and food items.

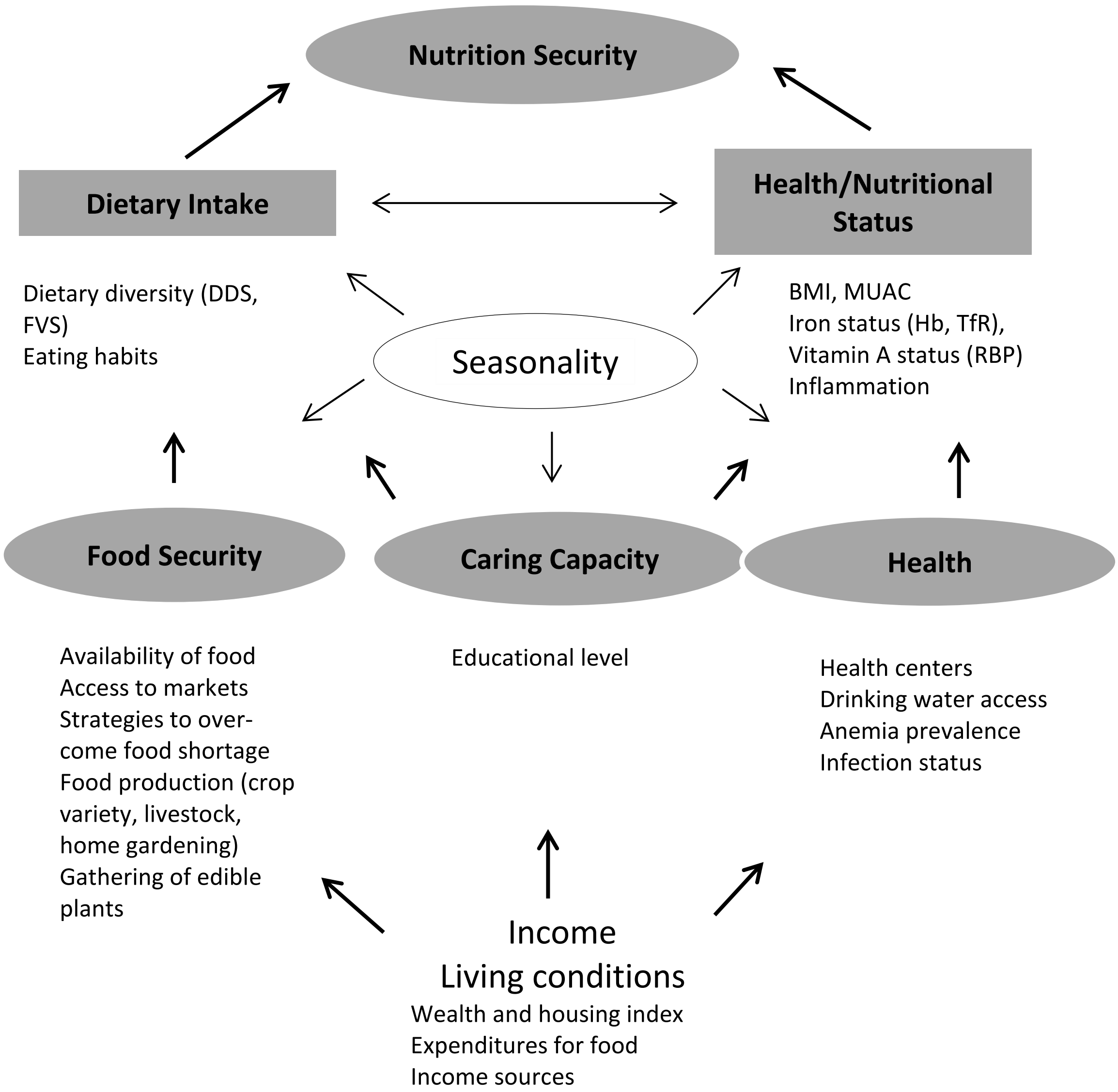

Figure 1.1 : Model of nutrition security with indicators from the present study (modified according to Krawinkel 2009)

A big concern of this research work was to apply “field-friendly” methods that are not time-consuming or expensive but instead reliable and easy to conduct for personnel under field conditions such as those in the selected study region.

By considering the complexity of this topic and using data from three seasons throughout the year, this research also attempted to create a model of DD determinants. Due to this complexity, results from this study cannot be representative for the whole Andean region, but they give a general picture of patterns that are observed in many regions of the South American highlands and emphazise how important the integration of agricultural, nutritional, health and socio-economic components is.

The research project “Andean Diversity and Nutrition” (ANDINU) was implemented in collaboration with “Universidad Nacional del Altiplano” in Puno, Peru, and the local NGOs “Qolla Aymara” and “Paqalqu” (Asociación para la promoción rural). Thus, the nutritional aspects of the project could serve as a complement to the mostly agricultural focal point of the on-going activities carried out by these institutions.

2 Materials and methods

2.1 Study area and subjects

2.1.1 Research location

Within the five poverty strata defined by the Peruvian government, Puno belongs to the second poorest stratum (Foncodes 2006). Harsh geography as well as poor health and nutritional conditions are characteristic in rural areas of this region. A serial cross-sectional study was conducted in four small, rural villages of the *Departamento* of Puno in the south-east Peruvian highlands situated in the south of the department between 3,850 and 4,100 m above sea level (MASL) and near Lake Titicaca (Figure 2.1). For logistical reasons and due to the skeptical attitude of villagers towards foreigners, villages were selected according to existent local staff that were accurately trained and could conduct the surveys with each woman in the Aymara language during the study period. The population in each village had to be estimated, because size information from the national demographic survey (INEI 1999) prior to the one assessed in 2007 grouped these small villages into greater districts. After direct observation, approximately 300 households were estimated in each village.

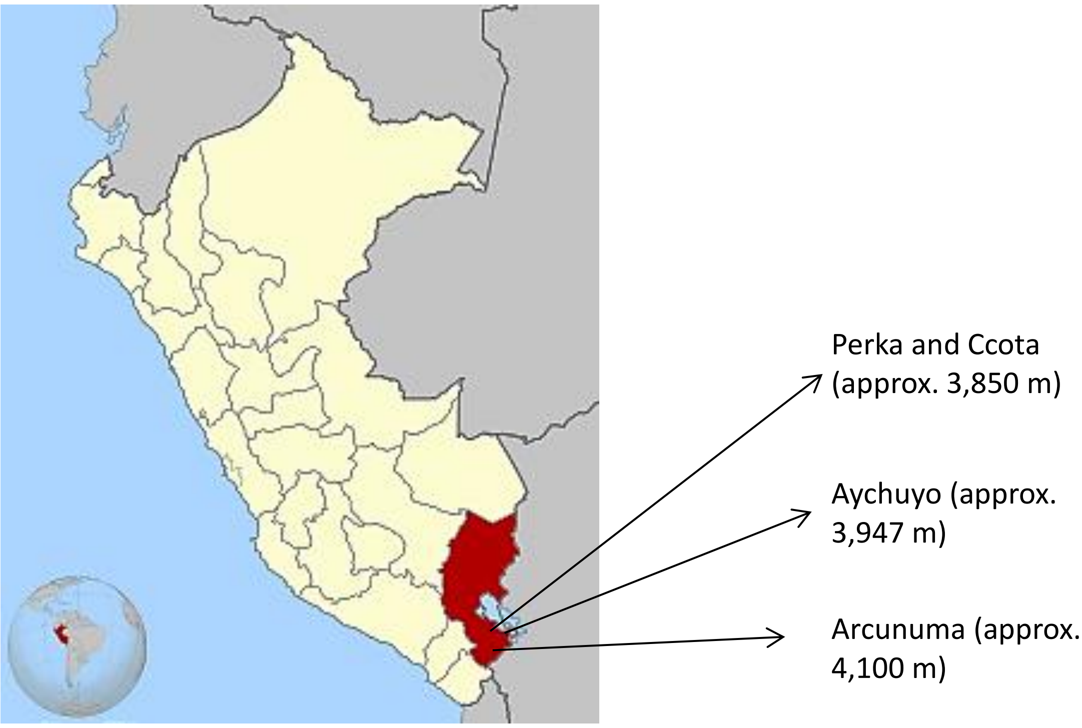

Figure 2.1 Geographical location and altitude of the study villages

The selected population was rural, and characterized by homogenous ethnicity (Aymara) and subsistence agriculture. Information was collected in order to select study places based on a previous visit to the region in 2006, meetings with local NGOs, and interviews with research experts of the Universidad del Altiplano (Puno, Peru). Thus, women belonging to the following villages were chosen: Ccota and Perka (approx. altitude: 3,850 m), Aychuyo (3,947 m) and Arcunuma (4,100 m). Due to the common ethnic background, eating habits are similar, and agriculture is based mostly on the cultivation of native potato species, quinoa (*Chenopodium quinoa* spp), broad beans, and barley. They also own domestic animals such as sheep, llama (*Lama glama*), and alpaca (*Vicugna pacos*). Livestock farming is present in many households but mainly in the highest situated village (Arcunuma). The main purpose of animal husbandry is the production of sheep wool or alpaca fleece. Additional food items, for instance fresh vegetables and fruits, are purchased in local markets and/or, on a smaller scale, obtained through traditional bartering. Transportation from each village to the next large town is usually done on foot or by bike. Bus connections are less frequent or non-existent. Home gardening for vegetables and fruits is not widespread. In the rainy period (from October until April), fresh herbs and wild edible plants are usually gathered. In the beginning of 2007, the usual rainfalls in the region started later than expected. In March, precipitation had an average of 236.7 mm and was higher than in prior years (Instituto Nacional de Estadística e Informática 2009). After the harvest (from April to early June), households usually consume their own freshly produced crops as long as they last. Food availability is thus reported as highest between June and August and limited in the months before the harvest (Leonard 1989). In order to preserve agricultural products, traditional food storage techniques have been used up until present times. After the harvest, some native potato varieties are processed into *chuño* (freeze-dried potatoes), and meat into *charqui* (dried llama, alpaca, or lamb meat). The months before the harvest and during the sowing season (approx. November) are often regarded as the “food shortage period” in terms of depletion of stored staples, mainly tubers and cereals. This period appears to be overcome through a stronger dependence on the local markets.

2.1.2 Subjects

Inclusion criteria were females of childbearing age (between 15 and 49 years), one per household. Prior to the study, authorities and families were informed in detail about the purpose of the research. Thereafter, 196 women could be recruited. They gave their free oral informed consent to participate in the complete study.

A major challenge of the study was to gather enough information from as many women as possible and to obtain complete data in the three assessed seasons rather than setting a large sample number that could not be achieved under the time and budget frame. Though a formal randomization procedure was not used, subject recruitment attempted to consider one woman per household, distributed throughout the community.

The term “participants” is another word to refer to the females involved in this study. Because household information was also collected, the term “household” is used when results about living conditions, food security situation, and agricultural activities are reported.

The surveys were performed by trained personnel, two people per village. They visited the women in their own houses or, if necessary, in their fields or while leading animals to pasture. After the visits, anthropometric data and blood samples were collected by a trained nurse and the researcher at a meeting point in each village, which was the health center of the villages in Ccota, Perka, and Aychuyo, while in Arcunuma a small classroom[3] was made available to the research team.

Following the study design, three time periods were assessed during 2007: the rainy season (***Rain-S***, February-March), post-harvest season (***Post-S***, June-July), and farming season (***Farm-S***, October-November).

A few women said they were pregnant as the first phase finished. In the second (June-July) and third survey (October-November) periods, it was not possible to find all the women again. Some reasons for drop-outs were moving to other places for temporary jobs, travelling, forgetting the appointments with the interviewers, leading cattle or sheep to pasture, or in the case of the nutritional status assessment, refusal to give a capillary blood sample. The third season was also identified as the beginning of the food shortage period in terms of stored staple foods.

2.2 Data collection

The data collection consisted of two major components:

1. Individual standardized questionnaires with socioeconomic, health, and nutrition-related questions.

[3] This classroom was a seldom used kindergarten.

2. Anthropometric measures including blood samples to assess iron status through hemoglobin (Hb), soluble transferrin receptor (sTfR), and retinol status through retinol-binding protein (RBP).

Originally questionnaires were in English and Spanish. Before interviews were conducted, the contents were discussed with the staff members in order to adapt the questions to the cultural context when required and translate them into the Aymara language.

Within the nutritional status assessment, a short health questionnaire was used to collect information about the intake of medicines or supplements, illness signs, pregnancy, etc.

The study was carried out following the approval of the Ethics Committee of the Faculty of Medicine of the Justus Liebig University of Giessen, Germany (file reference number 150/06), and after approval by local authorities of Puno in collaboration with the National University of the Altiplano (UNA).

2.2.1 Questionnaires

Some socio-economic variables were assessed only once during the baseline (Rain-S), while other variables were assessed thrice (Table 2.1).

Because of large income fluctuations over the seasons, and migration for work reasons, information on income sources and expenditures for food, instead of income per se, was collected. These variables were assessed in each survey phase.

As part of the individual surveys, a qualitative 24h recall was conducted as well.

A wealth and housing variable was built in order to classify households. Each household could reach a minimum of 4 and a maximum of 41 points for lower or higher wealth, respectively. When possible, answers about wealth assets and housing were verified by the interviewers through direct observation. The following information was included: material of house and roof, cooking material and type, water and electricity supply, livestock, and household assets (radio, TV, bicycle, mobile phone, motorcycle or other transport vehicles, other assets). All included variables and the ranking system for them are summarized in Table 2.2.

Savings via asset accumulation is a means of delaying the consumption of what one might need in the future (Byron 2003). Since livestock is a form of asset accumulation and often sold in times of income scarcity, the type and number of existing animals were assessed as well. Each animal was ranked by present monetary value and multiplied with the actual inventory of the household. Subdivision into five groups according to quintiles allowed a point system from 1 to 5 (0 if no livestock is present), resulted in an index, which was considered in the final wealth and housing variable.

Table 2.1 Selected socio-economic information of the three surveys: rainy season (Rain-S), post-harvest season (Post-S), and farming season (Farm-S)

Socio-economic and food security questions	Rain-S	Post-S	Farm-S
General questions			
• Age, marital status, head of household (sex and education degree), household size, schooling degree, literacy	x		
• Main occupation, income sources	x	x	x
Living conditions			
• House and roof material, cooking material, current supply, drinking water sources, water shortage period	x		
Food situation			
• Home gardening, gathering of wild plants, food shortage period, strategies to overcome food shortage	x	x	x
• Food aid	x	x	x
Agricultural activities			
• Land tenure	x		
• Cultivated crops, animal husbandry, fishing	x	x	x
Purchase			
• Source of additional food, responsible person for food purchasing, frequency of purchase	x		
• Expenditures for food	x	x	x

The size of cropland was not considered even when asked, because most participants couldn’t answer this question, and in most cases the land parcels were very small or spread throughout the district, making it difficult to measure. After calculating the wealth and housing score, women could be classified into terciles, i.e. SES levels: low, medium, and high. Subsequently, correlations with the DDS and the FVS were examined.

Table 2.2 Variables included in the "wealth and housing" index

Variables	Score (min.-max.)
Material of house	1-3
Material of roof	1-3
Cooking material	1-3
Drinking water sources	1-3
Electricity supply	0-1
Household assets:	
Radio	0-1
TV	0-2
Bicycle	0-2
Mobile phone	0-3
Motorcycle	0-4
Tricycle*	0-3
Moto taxi	0-3
Other assets**	0-5
Livestock	0-5
Count of minimal/maximal total points:	**4-41**

*In the study region tricycles are used for public transportation as a kind of taxi.
**Car for own use or used as taxi.

As in several culture groups in developing countries, meals are often consumed from a common plate in the Aymara population. Additionally, the generally low education level among the rural population makes the use of some types of questionnaires and estimation of portion sizes difficult (Savy *et al.* 2005). In recent years many scientists have been concerned with the development and use of qualitative methods in rural populations of developing countries. Most of these studies have been conducted in the African or Asian context for measuring the overall dietary quality, at the household or individual level (Ogle *et al.* 2001; Torheim *et al.* 2004), but less is reported in the Latin American context. Thus, the present work used the Dietary Diversity Score proposed by FAO/FANTA (Kennedy *et al.* 2011) that considers food groups/food items. The Dietary Diversity Score aims to measure changes in dietary quality at the household and individual level. Based on the individual DDS with 14 food groups, a women's DDS (WDDS) with nine food groups has been proposed in the present guidelines mentioned above. However, in order to specifically characterize the diet in the study region, the original DDS with 14 food groups was considered.

Based on the qualitative dietary recall over the previous 24h in each season, an individual DDS with 14 food groups and a FVS with 61 food items were set up. The DDS and FVS were calculated by adding up the number of food groups/food items consumed by each woman during the dietary recall. Food items that were available in the region and mentioned by the participants at least once during the complete study period were included. Purchased fresh or processed products consumed in the region were taken into account as well. Except for red palm products, which are not consumed in the region, the food groups considered are specified in Table 2.3.

Instead of the names "vitamin A-rich vegetables" and "vitamin A-rich fruits", the corresponding food groups were labeled with "pro-vitamin A-rich vegetables" and "pro-vitamin A-rich fruits."

Because of the great variety of potatoes in the studied region and difficulty in classifying the consumed varieties of native potatoes during the 24h recall, we only considered pro-vitamin A-rich vegetables as one group and all tubers as another food group. Nuts and seeds belonging to the group "legumes" according to FANTA classification are not traditionally consumed in the region. Therefore, only legumes were considered for this food group. Frequently consumed herbs and wild plants were also taken into account in the food scores, since many local dishes are prepared with them, and herbs are daily consumed with meals, mostly for breakfast and for dinner as tea. The database i.e. "Tablas peruanas de composición de alimentos" (Peruvian Food Composition Database) with detailed micronutrient compositions of several edible plants in this region is often incomplete or the nutrient composition of several indigenous plants is not yet extensively explored. The indigenous cereal-like goosefoot plants of the genus *Chenopodium*, namely quinoa and kañihua, were also included into the grain cereals.

Table 2.3 Food items* within food groups used for DDS and FVS

Food group	Food items within the food group
Cereals	Wheat (whole grain, bread, and noodles), barley, quinoa (*Chenopodium quinoa*), kañi-hua (*Chenopodium pallidicaule*), rice, oat, maize
Tubers and roots	Potato (*Solanum tuberosum* spp.), oca (*Oxalis tuberosa*), isaño (*Tropaeolum tuberosum*), olluco (*Ullucus tuberosus*)
Pro-vitamin A-rich vegetables	Carrot, pumpkin, chili pepper (*Capsicum* spp)
Dark green leafy vegetables	Spinach, chard, sage, culinary plants, other local plants, quinoa leaves
Other vegetables	Onion, garlic, tomato, lettuce, celery, leek, brassica varieties
Pro vitamin A-rich fruits	Papaya, mango
Other fruits	Banana, apple, orange, grape, pear, peach, pineapple, watermelon, mandarin, pepino (*Solanum muricatum*), lemon
Organ meat	Lamb liver
Meat	sheep, llama (*Lama glama*), alpaca (*Vicugna pacos*), beef, pork, guinea pig (*Cavia porcellus*), chicken, choqa (*Fulica americana*)
Eggs	Chicken eggs
Milk and dairy products	Fresh cow milk, evaporated milk, cheese
Fish	Sea fish (fresh and canned), local lake fish
Pulses	Broad bean (*Vicia faba*), lentils, peas (*Pisum sativum*), tarwi (*Lupinus mutabilis*)
Oil and fats	Vegetable oil (sunflower, cottonseed, soy-bean), lamb fat

**Local or traditional foods are listed with their scientific names.*

2.2.2 Nutritional Status

Anthropometric measurements

The Body Mass Index (BMI) is the most commonly used indicator for under- and over-nutrition in adults and was therefore selected for the study. Another useful tool for measuring adult nutritional status (Ferro-Luzzi *et al.* 1996) is the Mid-Upper Arm Circumference (MUAC).

Weight and MUAC were measured by trained personnel according to standard procedures (Cogill 2003) in each season. Height was measured in the baseline survey to the nearest mm with a measuring board equipped with a height gauge (SECA 206 Bodymeter, Hamburg,Germany). The women's weight was measured while they wore light clothing without shoes by using a spring scale accurately calibrated to 0.1

kg. The arm circumference was measured to the nearest mm with a non-stretch measuring tape. BMI was calculated for the assessment of under- and overweight status, and indices were classified according to standard international references (World Health Organization 1995).

Iron status

Iron Deficiency Anemia (IDA) is one of the most common nutritional deficiencies in Puno. The prevalence of anemia in the region is 50.9% among non-pregnant women aged 15-49 y (World Health Organization 2006). Although anemia is multifaceted, it is the most significant negative consequence of iron deficiency (ID) (Clark 2008). Since Hb measurement is a low-cost and field-friendly tool, it is frequently used for screening populations at risk of iron deficiency. Moreover, sTfR is another indicator that can also be used to differentiate IDA from other types of anemia such as the one caused by folate or vitamin B12 deficiency. According to the literature, this indicator is a useful tool in the diagnosis of iron depletion and is elevated in IDA (Punnonen *et al.* 1997; de Azevedo Paiva *et al.* 2003; Skikne 2008). Although the measure of ferritin combined with Hb and sTfR is a more accurate way to identify ID, high costs are involved with it. For this study, Hb and sTfR were the selected parameters for iron status.

Sterile, disposable microlancets were used to obtain capillary blood samples, and hemoglobin concentrations were determined in the field with the portable HemoCue Hb 201™ -analyzer (HemoCue Co., Grossostheim, Germany) following operating guidelines. The analyzer was calibrated every time with appropriate control solutions before starting measurements.

Anemia was defined as hemoglobin concentration below 120 g/L (WHO *et al.* 2001). sTfR is known to be elevated as a result of ID, and it is not influenced by inflammation (Wander *et al.* 2009; Shell-Duncan *et al.* 2004) . This parameter was measured using the Dried Blood Spot (**DBS**) assay developed by Erhardt and co-workers (Erhardt *et al.* 2004). There are some suggested cut-off points for sTfR but no widely accepted standard value. As measured protein concentrations were calibrated using the Ramco assay (Erhardt *et al.* 2004), ID was defined using the cut-off value of > 8.3 mg/L, whereby values equal or above are classified as iron-deficient.

Vitamin A status

As mentioned in 1.1, the sub-clinical deficiency of vitamin A (VA) is a public health issue in Peru. Nevertheless, because measuring serum retinol is highly expensive, studies on VAD in the country are rather scarce. A further difficulty is the sceptical attitude toward blood withdrawal. Hence, it was also of interest to identify this problem in the study population and investigate a possible association with dietary diversity measured by the qualitative DDS method. Originally, the study design included Conjunctival Impression Cytology (CIC) (Munene *et al.* 2004) for the assessment of VA status. However, due to a lack of acceptance during the first survey in the rainy season, it was decided to measure VA status by using RBP concentration instead of CIC in both subsequent surveys.

Since stages of inflammation can alter retinol concentration and therefore RBP, resulting in false lower values, the markers of infection, α-1-acid glycoprotein (AGP) and C-reactive protein (CRP), were included in blood analysis (Engle-Stone *et al.* 2011).

Besides sTfR and RBP, CRP and AGP were assessed as indicators of inflammation in the post-harvest and farming seasons using the DBS assay mentioned above. This method was applied for the first time in the study area.

For this purpose, free-flowing capillary blood was collected from one finger prick onto filter paper (Whatman 903® Schleicher & Schuell). In order to be as minimally invasive as possible the finger prick performed for measuring Hb values was used to obtain samples for DBS. After drying, samples were first saved in plastic bags with desiccant and stored under refrigeration at -20 °C. After the third study survey ended, samples were analyzed in Germany using an ELISA protocol developed for whole blood spots (Erhardt *et al.* 2002; World Health Organization 2006).

Because of the equimolarity between RBP and retinol in circulation, which has already been reported in other studies, VAD was defined by RBP < 0.7 µmol/L and marginal or low VA status by RBP <1.05 µmol/L (Stephensen *et al.* 2000; Baeten *et al.* 2004). Infection was defined by CRP ≥ 10 mg/L, AGP >1 g/L, or both above cut-off.

Within the questionnaire for health status, the women were asked for intake of any kind of supplements and medicines. Since the participants stated no intake of supplement or medicines at the time of the surveys, all available blood samples could be considered for the measurements and further statistical evaluation.

2.3 Data analysis

Data entry and statistical evaluation was done using SPSS version 19.0 and 20.0. Three cross-sectional surveys over one year allowed assessment of socio-economic, nutritional, and health-related data. Regarding the cohort of women in all three surveys, an additional longitudinal design allowed comparisons between the seasons.

Figure 2.2 shows the sample size according to seasons and indicators assessed as well as the cohort selected for all three seasons, i.e. data sets from women who were present in all three surveys. Thus, complete socio-economic, agrobiodiversity, dietary, and nutritional data sets were considered. Anthropometric and hemoglobin data sets were somewhat smaller, for instance due to pregnancy, inflammation, or drop out in the course of the year. Drop-out from the study was not systematic and its reasons have already been explained (s.section 2.1.2). Furthermore, there were no differences in educational level, DDS, FVS, SES, or agricultural diversity between those women for whom anthropometric and biochemical data was available and those who were lost to follow-up.

If not otherwise specified, the sample size used for the statistical tests is the same indicated in the graphic. For all statistical tests, an alpha level of 0.05 was used.

All variables were tested for normal distribution, and criteria applied were K-S (Kolmogorov-Smirnov) being below 0.1 and S-W (Shapiro-Wilk) above 0.95 (Hollenhorst 2006). If deviations from normal distribution were not severe according to the used criteria, the mean (standard deviation) value is indicated; otherwise the median (interquartile range) is specified. For differences between two or more groups, t-test and analysis of variance (ANOVA) were used, respectively. If the tested variables or residuals from ANOVA were not normally distributed, the Kruskal-Wallis test for independent or the Friedman test for dependent samples were then selected as non-parametric alternatives. These tests do not rely on an assumption of normality. The Friedman test can therefore be used instead of ANOVA for repeated measures. In order to examine trends among groups the Jonckheere-Terpstra test was used. This non-parametric test works with the hypothesis that $\mu_1 \leq \mu_2 \leq \mu_3$ (or the opposite $\mu_1 \geq \mu_2 \geq \mu_3$), i.e. tests differences between the medians of the groups when a meaningful order of medians is expected (Field 2009).

In the first step it was of interest to examine each season related to seasonal characteristics, crop and dietary diversity, and nutritional status defined in this study through anthropometric indicators and biochemical parameters.

In the second step, and in order to generate a holistic view of the year and therefore a valid statement for the longitudinal design, data also were analyzed under consideration of the three seasons.
Considering the fact that each village grouped certain characteristics, for instance, altitude and access to markets, the effect of the place was examined as well. This is indicated whenever it was statistically significant.

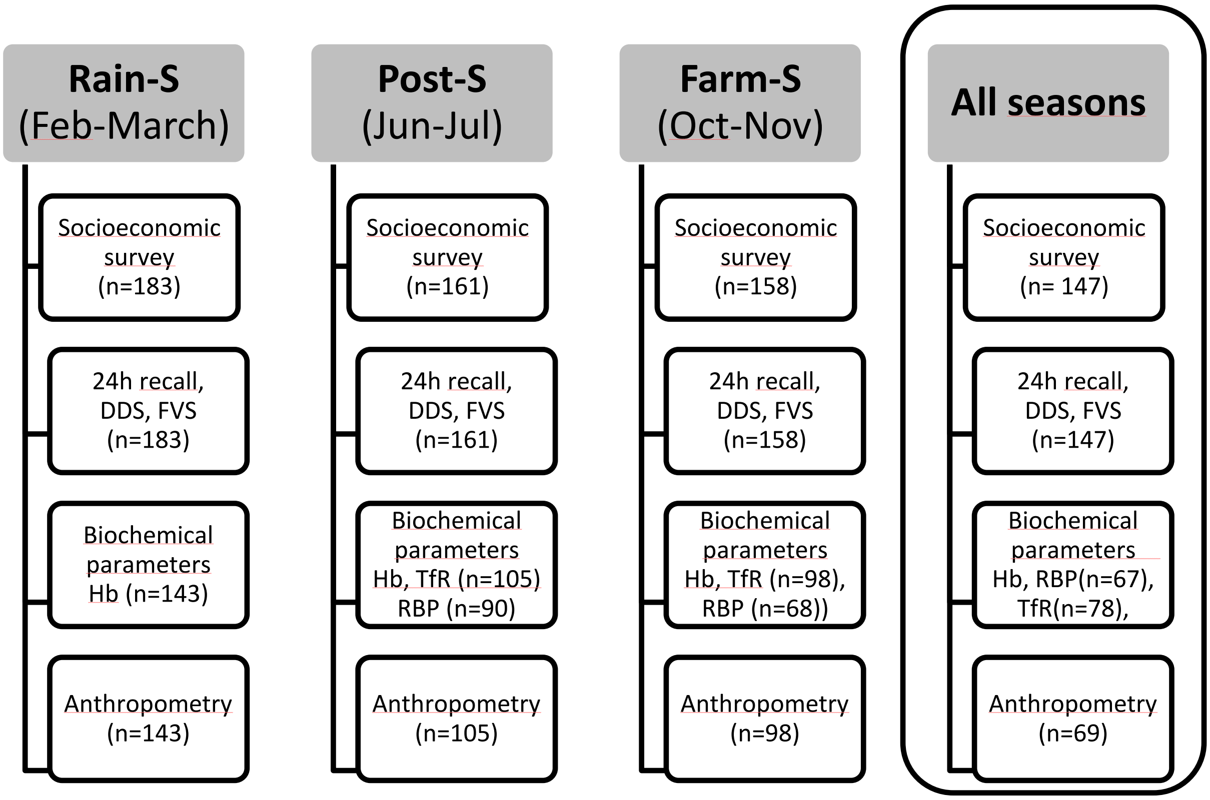

Figure 2.2 Available data of the study population in each survey season and in the cohort

Agrobiodiversity components included cultivated crops, gathering of edible plants, and home gardening for vegetables and/or fruit. Animal husbandry was included in the wealth and housing index and thus considered within this variable.
Because the impact of education and its associations with the other variables were other important points within the further examinations of Chapter 4, a binomial variable with “low” (< 3 years of schooling) and “high” (at least 3y and higher education) based on the categorical one (s. section 3.1.1) was compiled.

Data cleansing

For data cleansing, pregnant women were excluded from biochemical and anthropometric available data. However, socio-economic and dietary diversity data from these participants were taken into consideration when focusing on the relationships between DDS/FVS and socioeconomic factors. Moreover, even if dietary intake may be increased during pregnancy, dietary scores used in this study do not regard portion sizes but rather consumed food groups/food items.

In relation to RBP, samples with any inflammation evidence were excluded whenever VA-related parameters were the dependent variables in the analyses. Separately, infection cases were taken into account for comparison purposes.

Food scores

In order to evaluate the nutritional quality of the population, DDS and FVS were not only analyzed as continuous but also as categorical variables. For this purpose, terciles based on the first survey period for low, medium, and high DDS or FVS were applied for all seasons but also for the average DDS and FVS from the three values (s. section 3.2).

There were no significant differences between non-pregnant, lactating, and pregnant women. If all other required information was available, data of the corresponding woman were included in the analysis related to DDS, FVS and socio-economic factors.

Relationships between food scores, socio-economic factors, and agrobiodiversity

Existing relationships between food scores and other variables were investigated using Pearson's correlation coefficient *r* for continuous, normally distributed variables and Spearman's rank correlation coefficient rho for ordinal or non-normally distributed continuous variables. Relationships and associations between the DDS/FVS levels (low, medium, high food group diversity or food variety, respectively) and nominal variables were examined using crosstabs and taking into account the Pearson's chi square under the condition that not more than 20% of the cells have a count less than 5. Otherwise, accuracy of the test is not given. Relationships were then identified for each season. Additionally, correlations between average values of the women's DDS and FVS (*mean DDS* and *mean FVS*) and several demographic and socio-economic and agrobiodiversity related factors were tested as well. Thereby, it was assumed that the mean DDS and mean FVS could reflect the usual consumption of food groups/food items across the year and be correlated to certain variables assessed in the study.

Assessing consumption of indigenous food and seasonality

In order to explore how the consumption of certain food groups or food items varies across the year, data from the same women were further analyzed. Because of the binomial character of the variables, Cochran's Q test for dependent *k* variables was selected to identify differences across the seasons. This nonparametric test is a binomial data version of the repeated-measure ANOVA or Friedman tests. For pairwise post-hoc comparisons the McNemar-test was used.

Assessing interaction of the season with socio-economic factors

Considering the three survey seasons across the year as a longitudinal study design, the linear mixed models (SPSS procedure MIXED) were applied to analyze both the effect of seasonality and the interaction of the seasonal effect with selected factors on the DDS and FVS using all available data from each survey round.

Generally, it should be ethically desirable to use all data collected under field conditions. Thereafter, the choice of statistical methods should consider this fact. One of the advantages of using mixed models is the allowance made for missing data. Regarding the complexity of repeated measures in the study design, mixed models also provide results that take the covariance structure or interdependence of the data into account (Brown *et al.* 1999).

Assessing determinants on dietary diversity and food variety in each season

Given the cross-sectional design of the study, in section 4.3 of the discussion chapter the influence of socio-economic and agrobiodiversity related factors on the women's DDS and FVS was explored in each season. In general, the use of MANOVA is more appropriate than ANOVA when the dependent variables correlate with each other (Pospeschill 2010). However, since the DDS focuses on the diversity of food groups and the FVS on the variety of food items, they should be examined separately. For this purpose, models with each food score as a dependent variable were fitted using univariate analysis of variance (ANOVA) included in the General Linear Model (GLM) of SPSS. One condition supporting the validity of the models is the normal distribution of the unstandardized residuals (Horton 1978).

In an initial approach, certain environmental, socio-demographic and household economic characteristics of the women were selected based on the bivariate correlations from section 3.2.6 and then models were run for each survey period. Because each food score can be explained by different factors (Torheim *et al.* 2004), univariate tests were run using the GLM with DDS and FVS as dependent variables respectively. Due to missing values in some used explanatory factors, sample sizes may vary. Since interactions between several factors resulted in small size of cases, attention was given to the main effects adjusted for all other selected factors.

The continuous variables age, household size, number of months with perceived food shortage, and SES measured with the wealth and housing index were used as covariates, and they were added into the models in three steps:

Step 1: Agricultural biodiversity with crop variety levels (low, medium, high) and gather practice (yes/no).

Step 2: Demography and cash with the place of residence (all four villages) and source of income from the last month (seasonal and/or unskilled labor, agricultural labor, agricultural and additional activity, regular monthly salary/wage).

Step 3: Caring capacity with education of the household's head (<3y primary school, complete primary school, complete secondary school, higher degree).

It has to be noted that the women's wealth and housing index includes information about the building material of their houses, household assets, water and electricity supply, and livestock farming.

The place of residence was considered instead of the access to markets, since this variable included information about the altitude in terms of agro-ecological zones as well as access to markets (the distance and time spent to reach the nearest market).

In order to reflect the effect after controlling for other variables in the model, the values of the partial eta squared (η^2) are given in all corresponding tables shown in chapter 4.3.

Anthropometric measures

After calculating the BMI, women were then classified into under-, over-, or normal weight groups. Correlations between BMI and MUAC were tested in order to analyze the relationship between both tools. Cases of pregnancy were excluded for all analysis.

As described with the food scores, changes in weight, BMI and MUAC across the year were also analyzed using linear mixed models. In a second step, the effects of DDS/FVS and relevant socio-economic characteristics were then identified. Additionally, relationships between anthropometric indicators and several assessed variables were investigated.

Iron status

Since WHO hemoglobin cut-offs for anemia refer to sea-level values, measured Hb concentrations were adjusted to the altitude using the equation (CDC 1995) below to evaluate the prevalence of anemia in the study region:

$$Hb_{adj\ value} = -0.32*(altitude\ in\ meters*0.0033) + 0.22*(altitude\ in\ meters*0.0033)^2$$

The calculated correction values (g/L) for the relevant altitudes were then subtracted from the measured hemoglobin concentrations. After adjustment, the prevalence of anemia and its levels according to WHO classification (WHO 2011) were identified for each season. Data from pregnant women were excluded from all analysis on Hb.

As with anthropometric indicators, changes in Hb concentration across the three seasons were examined using mixed models.

For the evaluation of sTfR, available data from the second survey period (Post-S, n = 105) and the third one (Farm-S, n = 98) were used. As far as could be determined after a literature search, no adjustment of sTfR values according to altitude was done.

If sTfR was above 8.3 mg/L, women had a poor iron status or ID. The relationships with hemoglobin and with the prevalence of anemia were also tested with either Pearson's or Spearman's correlation coefficients.

Changes in sTfR between the post-harvest and farming season were analyzed using the Wilcoxon test, i.e. the non-parametric alternative to the t-test, because the calculated variable of differences between each set of pairs was non-normally distributed (Bortz 1993). Correlations between sTfR and the other nutritional indicators were investigated with either Pearson's *r* or Spearman's rho. In addition, linear regression models were used to explain the Hb concentrations with selected food groups and further variables.

Vitamin A status

Exclusion of participants with acute phase response to infection resulted in a subsample of 90 women in the post-harvest season and 68 women in the farming season. The women who were present in both surveys accounted for 67. Data on pregnant women were excluded from all analysis on RBP.

Using the cut-off points mentioned in section 2.2.2, women with either low or marginal VA status were identified, and differences between the assessed seasons were examined using the t-test for related samples.

In order to investigate whether the VA status was influenced by seasonal change, the t-test for paired samples was used.

As with the other biochemical indicators, associations with the nutritional and socio-economic characteristics were examined using Pearson's *r* or Spearman's rho, and linear regressions were tested to identify the influence of food groups and other characteristics.

2.4 Local features and limitations

Regarding distances, cultural attitudes, and willingness of the population to take part in time-consuming surveys or invasive assays, methods to be applied in the field should be concise, easy to conduct, but at the same time reliable. This was an important concern of the study after previous information about the Aymara population was obtained. The execution of the research faced several constraints and challenges such as cultural taboos related to blood sample collection, carrying out the surveys, limited budget, and unwillingness of the population to be part of the surveys throughout the entire research period, i.e. the rainy, post-harvest, and farming seasons during 2007.

Due to festivities during December (Christmas) and local celebrations during the first half of February, the study began at the end of February and lasted until March. Although this period is normally seen as the rainy season (end of November until March) the expected frequency of rainfalls did not take place until March. This resulted in increased work in the fields at a later time than usual and influenced the availability of the potential participants to take part in the study.

After carrying out a pre-test with questionnaires and 24h dietary recalls, the time spent with each participant could be estimated. It was difficult asking the women for portion sizes and amounts of meal components, and even more difficult for them to estimate this at lunch time ("fiambre"). Farmers are used to eating together from a blanket i.e. from a common plate where mostly the women put some food as meal components on it. Moreover, compliance of the women decreased when interviews took longer than 15 minutes. Because participation of the same women across the three seasons was required, "field-friendly" methods had to be taken into consideration. Thus, a qualitative 24h dietary recall was carried out.

Another important limitation was the collection of capillary blood samples. Although women and men[4] of each selected village were previously informed about the purpose of the study, and the women gave their oral consent, they had several taboos about blood. This was one of the most common reasons why the number of participants was reduced during the following phases.

[4] In many households husbands or partners had to agree with women's consent of taking part in the study, otherwise they were not allowed to participate.

3 Results

3.1 Demographic and socio-economic characteristics

3.1.1 General information

The study population described below includes all women interviewed in the first survey season with available data sets from 24h recall and socio-economic questionnaires (n=183).

Ages ranged from 15 to 49 years with a median (interquartile range) of 34 (26 to 40) y. The number of household members ranged from 2 to 11 and had a median (interquartile range) of 5 (3 to 6).

In general, the education level of the women was different than that of their partners. For instance, 40% of the women had had three years of primary school or had finished it, while about 20% of the men had the same amount of education; however, more than 50% of the men had a secondary school degree compared to 40% only for the women (Figure 3.1). In both groups about 78% had completed primary and / or secondary school education.

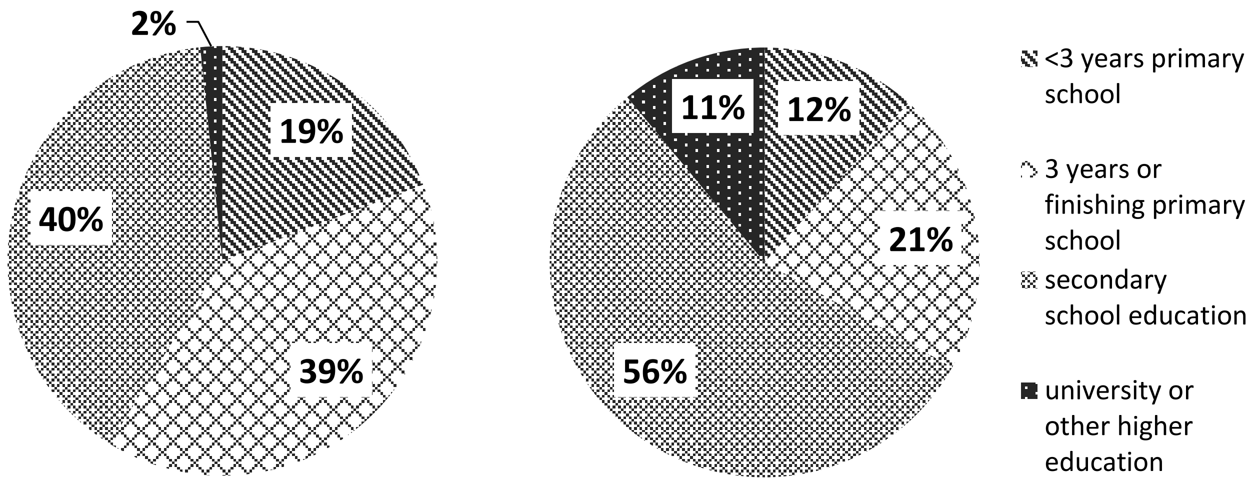

Figure 3.1 Education degree of the participating women (n = 183, left pie chart) and the women's partners (n = 154, right pie chart)

With respect to the educational level of the head of the household, 11.4% had less than three years primary school, 24.6% had at least three years or finished primary school, 53.9% had secondary school, and 10.2% had a university degree or other higher education. Women who indicated other relatives as head of the household could not specify their educational level. Most women were married or lived with their partner. The husbands or partners of the women were the head in about 50% of the households. The assessed information is summarized in Table 3.1.

Table 3.1 General information of the participating women assessed through nominal and ordinal variables (n = 183)

Variable	**Percentage (%)**	**n**
Age groups		
15-19 y	11.0	20
20-29 y	24.0	44
30-39 y	36.0	66
40-49 y	29.0	53
Marital status		
Single	11.5	21
Married	58.0	106
Living with a partner	26.2	48
Widowed	1.6	3
Separated	2.7	5
Head of the household		
Participant	23.0	42
Participant's partner	49.7	91
Both of them	18.6	34
Other	8.7	16
Religion		
Catholic	75.4	138
Evangelical	8.7	16
Adventist	10.9	20
Other	2.8	5
No religion	2.2	4
Spoken language(s)		
Aymara	24.6	45
Aymara and Spanish	75.4	138
Spoken language(s) of the partner		154
Aymara	5.8	9
Aymara and Spanish	93.5	144
Aymara, Quechua, Spanish	0.6	1
Literacy		
Reading and writing	45.9	84
Reading, difficulty in writing	47.5	87
Neither	6.6	12
Literacy of the partner		154
Reading and writing	70.1	108
Reading, difficulty in writing	29.9	46
Neither	0.0	0

The main occupation of the participants was crop and livestock farming (61.9%), agricultural activities and additional activities (35.9%), and informal, unskilled activities or artisan work[5] (2.2%).

The main occupation of the head of the household was crop and/or livestock farming (40.4%), informal or unskilled activities (3.8%), skilled employee (3.8%), agricultural and additional activities (41%), or other (2.2%). A share of 8.7% remained unanswered or unknown.

3.1.2 Livelihoods, wealth and housing index

As previously described the wealth and housing index collected information about household assets, water and electricity supply, cooking, house and roof materials, and livestock (type and number). Thus, the mentioned variable had a median (interquartile range) of 14 (12 to 15) and ranged from 7 to 24 points (of the total 41 points that could be reached per household). Subdividing the subjects into terciles allowed further classification into low (0-12), middle (13-15), and high (>15) wealth and housing groups.

Most of the households had electricity. Even though asking about sanitation was not included in the questionnaire, interviewers merely observed public or private latrines while visiting the participants in their houses.

Drinking water sources during the dry season and other assessed variables describing the living conditions and included in the wealth and housing index are listed in Table 3.2. During the rainy season, it is usual to combine existing water sources with rain or river water.

The existence of critical months with water shortages was a problem indicated by 65.6% of the women, while 33.3% said that they did not have any water shortage during the year. Two participants (1.1%) did not give any answer to this question. The most commonly indicated months when water is scarce during the year were October and November (Figure 3.2).

[5] When indicating artisan or handicraft work, women referred to knitwear made of alpaca hair that they produced and then sold in the markets, or that they are paid for labor by wholesalers.

Table 3.2 Certain characteristics of living conditions

Variable	% of total population (n = 183)
*SES**	
Low	32.2
Middle	43.7
High	24.1
Electricity	
Yes	76.5
No	23.5
Cooking material	
Firewood, shrubs, and animal manure	89.7
Gas stove or kerosene in addition to fire-wood and animal manure	8.7
Gas stove	1.6
Drinking water sources	
Own public water supply	39.3
Own water well	10.9
Public water well	40.4
Other sources (spring, river)	9.4

* SES according to the wealth and housing terciles

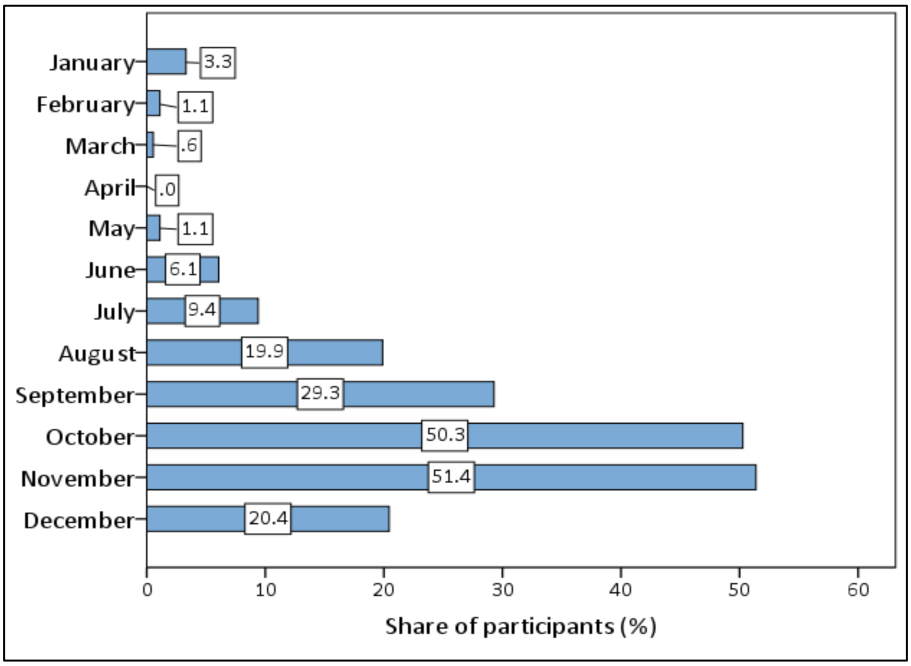

Figure 3.2 Perceived water shortage over the year (n = 183)

Women were asked about the source of household income in the month prior to each survey (Table 3.3). Thereafter, the identified income sources were agricultural labor, agricultural labor and an additional activity, seasonal and/or unskilled labor, or regular monthly salary/wages.

Table 3.3 Income source of the households in each survey period, n (%)

Source of income in the last month	Rain-S (n = 183)	Post-S (n = 161)	Farm-S (n =158)
Agricultural labor	59 (32.2)	45 (28.0)	37 (23.4)
Agricultural labor and an additional activity	37 (20.2)	31 (19.3)	41 (25.9)
Seasonal and/or unskilled labor	69 (37.7)	69 (42.2)	64 (40.5)
Regular monthly salary/wages	17 (9.3)	15 (9.3)	14 (8.9)
Unknown	1 (0.5)	1 (0.6)	2 (1.3)

3.1.3 Food situation and care

If further food items are needed, 80.2% of the participants purchase them in the markets; 18.7% combine purchasing and bartering, exchanging for instance wool, their own crop products, and dried meat; while 1.1% merely exchange their own produced food items (crops, milk, etc.) for other food stuffs (mostly at the market). A large share of them visit the next market and purchase food once a week (72.1%), a minority do so 2-3 times a month (26.2%), or even once a month (1.6%).

Expenditures for food were assessed during each survey round. In the course of the year the share of households with the highest expenditures tended to increased (Figure 3.3). Further analysis and tests using this information are explained in detail in chapter 4.

Access to markets was assessed, taking into account distance, availability of public transportation, and time spent to reach the next greater market. Thus, Aychuyo (n= 53) and Ccota (n=35) had a close proximity to markets with frequent availability of public transportation, while Perka (n=42) had a medium distance with public transportation once a day, and Arcunuma (n=53) had difficult access without public transportation, which was why inhabitants had to walk about two hours or go by bike in order to reach the next market.

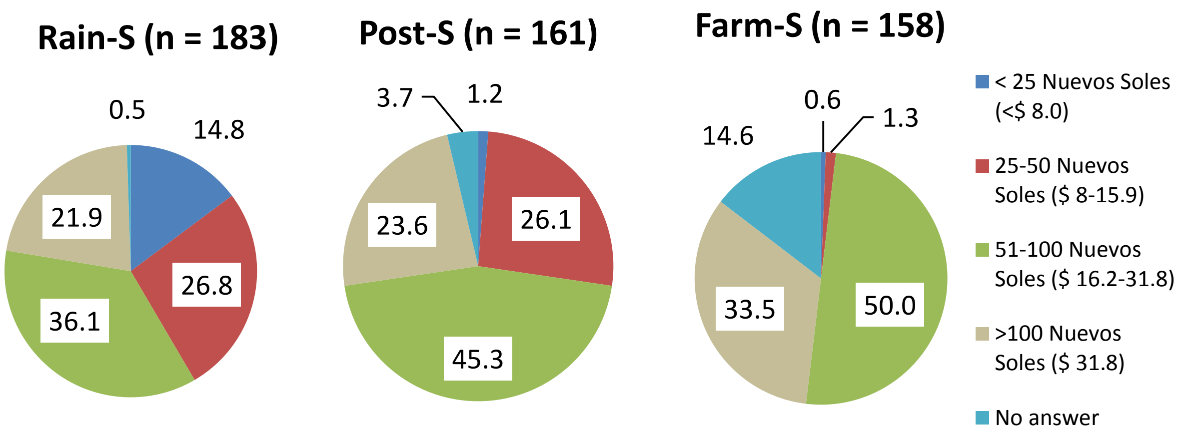

Figure 3.3 Household expenditures for food (%) in each survey period (national currency and equivalent amount in US dollar per month)

Beside food sources from subsistence agriculture and the others mentioned above, 23% of the women said they have a home garden for cultivating vegetables and/or fruit. Otherwise, home gardening was not wide-spread in the region, and horticultures were not grown over the whole year (Table 3.4).

Table 3.4 Cultivated species in the home gardens (percentage of women according to the respective sample size, %)

Cultivated plant	Aychuyo (n = 53)	Arcunuma (n =53)	Ccota (n = 35)	Perka (n = 42)	Total sample (n = 183)	Cohort (n = 147)
Beetroot	1.9	0.0	0.0	2.4	1.1	1.4
Carrot	1.9	0.0	0.0	2.4	1.1	1.4
Lettuce	9.4	0.0	14.3	11.9	8.2	8.8
Onion	37.7	11.3	11.4	11.9	19.1	21.1
Other horticultures	3.8	0.0	0.0	2.4	1.6	2.0
Medicinal and/or culinary Herbs	9.4	1.9	0.0	4.8	4.4	5.4

Additional gathering of herbs and edible plants for their own consumption was practiced by 82.5% of the women, mostly in the rainy season. Many of the gathered plants are used not only for infusions frequently consumed for breakfast and dinner but also for preparation of soups and stews. The list of plants mentioned by the participants is presented in appendix Table 9.1.

Food processing is also an important household task in the Aymara context. For instance after or during the harvest, farmers classify potatoes for consumption, for the next farming season, and for processing into *chuño*. Not only potatoes but also other crops are selected and processed in a similar way. Thus, food processed in this way can be stored for months or even years.

In general, results from Table 3.5 clearly indicate that many of the household tasks – specifically tasks related to food security – are largely assumed by the women.

Table 3.5 Distribution of tasks among household members

Household tasks	Share of the total sample (%)
Responsible person for the home garden*	
Participant	46.5
Participant's partner	11.6
Both of them	25.6
All family members	7.0
other	9.3
Responsible person for processing food**	
Participant	35.5
Participant's partner	4.9
Both of them	47.0
All family members	8.7
other	3.8
Responsible person for gathering (wild edible plants and herbs)	
Participant	63.3
Participant's partner	4.7
Both of them	14.7
All family members	2.7
Own children	11.3
other	3.4
Responsible person for raising the children	
Participant	56.8
Participant's partner	2.2
Both of them	27.9
No children/adult children	13.1
other	0.0
Responsible person for food purchase	
Participant	78.7
Participant's partner	3.3
Both of them	10.4
Participant joining another person	2.7
Other	4.9

* Home garden for cultivation of vegetables and/or fruit
** Processing potatoes into *chuño;* cleaning quinoa grains; drying barley, herbs, etc.

Periods of food shortage, mainly in terms of depletion of stored food staples are perceived by 90.7% (166), while 8.8% (16) of the participants said that they do not experience any food shortage periods at all. One woman (0.5%) did not answer the question. January and December were the months when most women perceived food scarcity (Figure 3.4).

Within the group with perceived food scarcity over the year, strategies for overcoming food shortage were as follows: consuming available food from the previous harvest and purchasing (56.1%), purchasing food only (31.3%), consuming the remaining crops from the previous harvest only (6.6%), or both the preceding strategies together with bartering (6%). When speaking about food from the previous harvest, villagers mainly mean the freeze-dried potato (*chuño*) but also pulses, maize, or quinoa. Nevertheless, the amount of food stored from the harvest period is often not enough to satisfy household food needs.

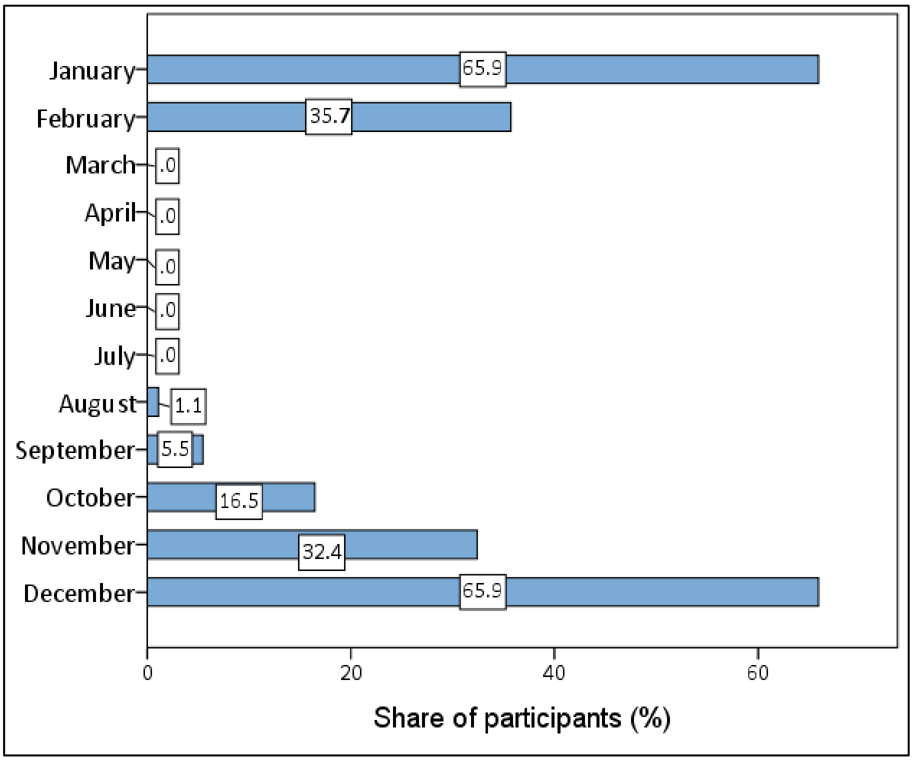

Figure 3.4 Perceived food shortage over the year (n = 183)

Food aid in the region addresses families with children up to three years old and is part of the national food assistance program PRONAA (Programa Nacional de Asistencia Alimentaria). Thus, 14.3% of the households were enrolled in this program. The following food items were included: rice, vegetable oil, sugar, lentils or similar pulses, canned fish, evaporated milk, and an instant cereal for infants. Nevertheless, the food sets distributed do not contain the same combination in each village. Moreover, they are distributed in the nearest health center of the villages in order to be picked up by the targeted households.

3.1.4 Agricultural activities

Land property is often family property. Parents usually distribute agricultural crop land among their own children. This results in parcels that become smaller for the next generations. As a cropping strategy against the usual climatic conditions in the region, farmers cultivate crops in differently located parcels. Thus, the risk of crop losses or damage due to freeze, rainfalls, or hail is diminished depending upon their location on a slope or in a valley.

Constraints in assessing the exact size of cropland were already mentioned in the previous chapter (s. section 2.2.1).

Out of all households, 78.7% owned the land, 9.3% indicated that the land still belonged to the parents (but they worked the land), 6.6% had both their own and leased land, 1.6% had leased land only, and 3.7% gave no answer to this question.

The number of cultivated crops ranged from 1 to 11, with a median (interquartile range) of 6 (5 to 7) crops. The total number of identified cultivated crops was 13. Moreover, crop variety was classified into “indigenous” and “exotic” crops. Indigenous ones were those that have been cultivated for centuries, even before colonization (about 1550), while exotic crops meant those cultivated after influence from Western civilizations, i.e. mostly Spanish colonists, began. The variety of indigenous crops ranged from 1 to 7 out of eight possible types and had a median (interquartile range) of 3 (2 to 5), whereas the variety of “exotic crops” ranged from 0 to 5 out of five possible types and had a median (interquartile range) of 3 (2 to 4). The variety and frequency of cultivated crops according to “indigenous” and “exotic” cultivated crops are highlighted in Figures 3.5 and 3.6. The potato is the most important cultivated staple food in the region and was cultivated in all households.

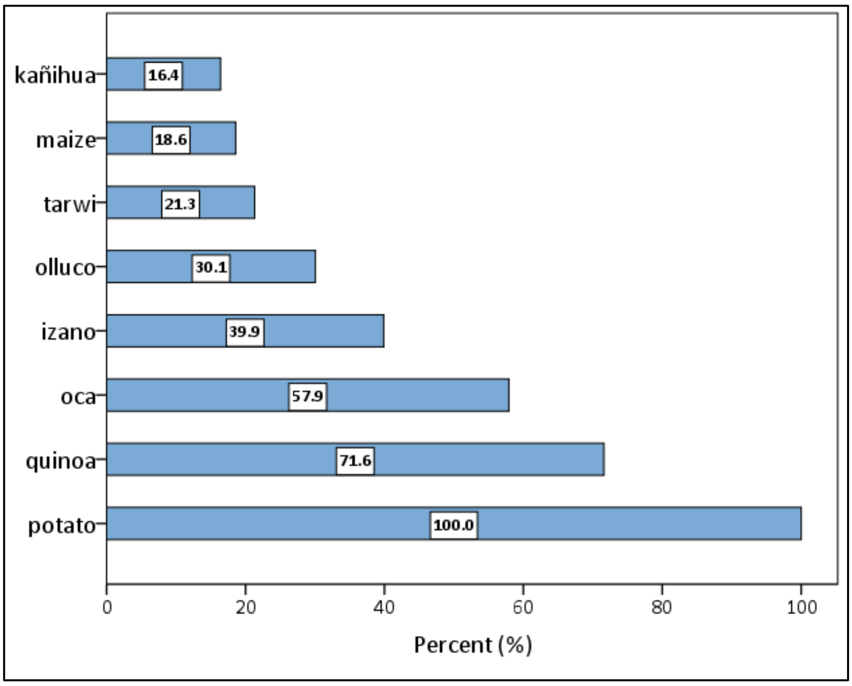

Figure 3.5 Cultivated indigenous crops in the study households (n = 183)

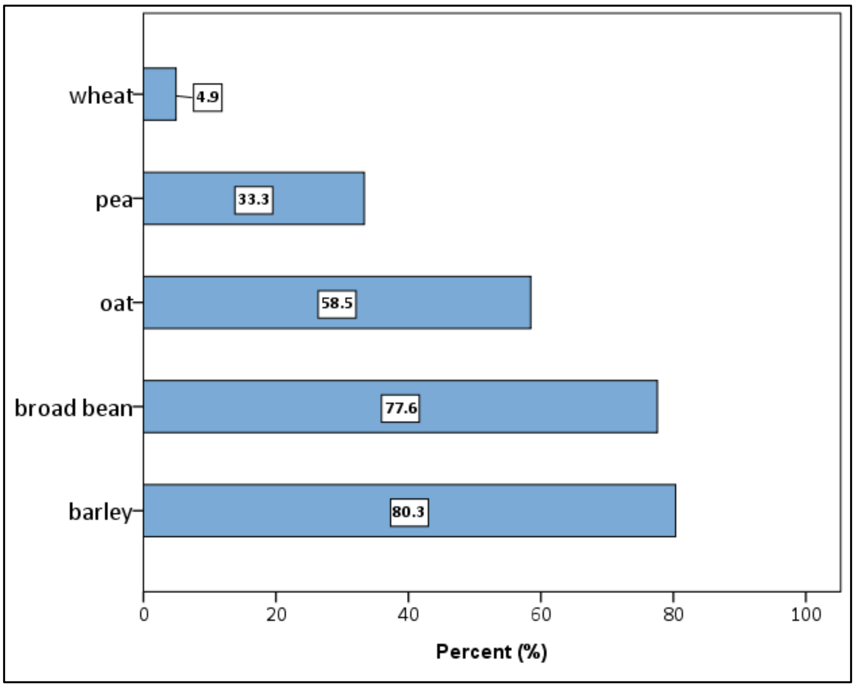

Figure 3.6 Cultivated exotic crops in the study households (n = 183)

There is one main farming season per year approximately in November. Thus, crops mentioned during the first survey (Rain-S, February-March) had been cultivated in the previous year.

In order to classify households into groups according to crop variety levels, terciles were built based on the number of cultivated crops. This resulted in low (24%), medium (52.5%), and high (23.5%) crop variety groups. For instance, more than 60% of

the participants in Arcunuma had a low crop variety. By contrast, almost 50% of the women in Aychuyo had a high crop variety (Figure 3.7).
Indeed, the crop variety differed significantly between the villages ($p < 0.001$). Specifically, Arcunuma had the lowest crop variety compared to the other three villages, followed by Ccota. Arcunuma was the most isolated village at the highest altitude. Owing to climatic and soil conditions, crop farming in this agro-ecological zone is not as widespread as in areas near Lake Titicaca. Nevertheless, 9% of the assessed households in Arcunuma cultivated more than seven crops.
The overall variety of cultivated indigenous and foreign crops also differed significantly between the villages ($p < 0.001$). Ccota had less variety of indigenous crops than Perka and Aychuyo, and Arcunuma had less than Aychuyo. Regarding exotic crops, Arcunuma had significantly less variety than the other three regions.

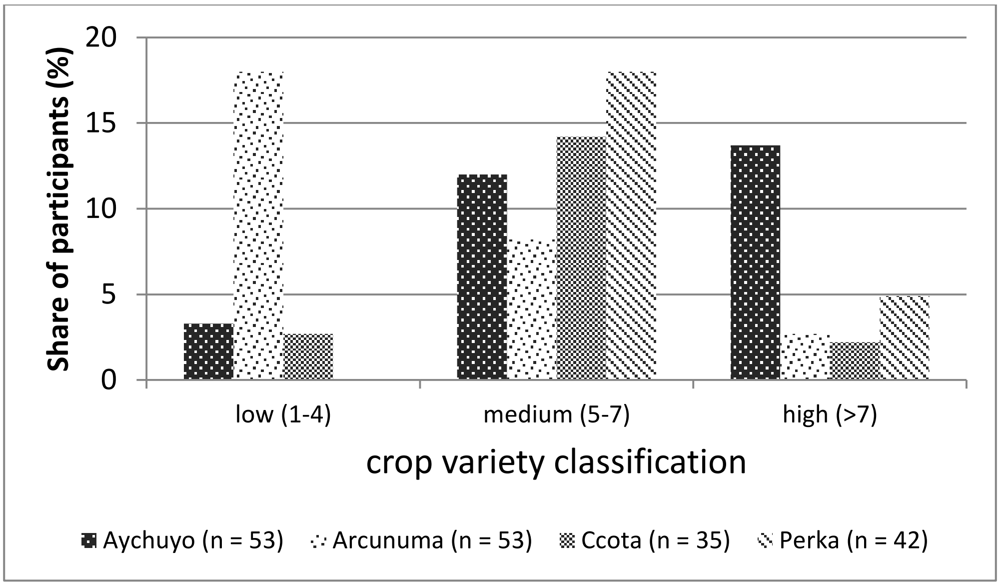

Figure 3.7 Crop variety within the villages (classification according to the number of cultivated crops and shares related to the total sample)

Although the main purpose of crop farming in the region is for subsistence, forage and sale purposes were mentioned as well. Both barley and oat are often used as fodder crops (Table 3.6). Animal husbandry was also an important agricultural activity among the participant's households. Livestock is a form of asset accumulation that can be sold in times of monetary or food shortage. Merely 1.6% of the women said they don't keep animals. Although most animals are kept for their own use or consumption, some of them e.g. sheep, llama, and alpaca are mainly kept for both their own consumption and sale (Table 3.7).

Table 3.6 Purpose of crop farming among households in the total population (%)

Crop	n	Predominantly for home consumption	Predominantly for sale	Home consumption and sale in similar proportions	Foraging
Barley	147	77.3	0.0	2.0	20.7
Broad bean	142	81.0	1.4	17.6	0.0
Isaño	73	94.6	1.4	3.0	0.0
Kañihua	30	100.0	0.0	0.0	0.0
Maize	34	100.0	0.0	0.0	0.0
Oat	107	16.8	1.9	2.8	78.5
Oca	106	95.3	0.0	4.7	0.0
Olluco	55	90.9	3.6	5.5	0.0
Pea	61	98.1	1.7	0.0	0.0
Potato	183	95.1	0.0	4.9	0.0
Quinoa	131	98.5	0.0	1.5	0.0
Tarwi	39	48.7	5.1	46.2	0.0
Wheat	9	88.9	11.1	0.0	0.0

A simple count of the animal types for each household resulted in an animal variety score that ranged from 0 to 8 and had a median (IQR) of 3 (2 to 4) animals.

According to the animal index explained in section 2.3.1, the monetary value and present animal inventory of the households were taken into account in order to set up an animal index to be included in the wealth and housing index (s. appendix Tables 9.2 and 9.3).

Fishing was another activity among 21.9% of the households, not only limited to those living near Lake Titicaca but also among the more isolated villagers. Nevertheless, fish found in the rivers are very small, and the number caught is typically for their own consumption, not for sale. Fishing in the study population was rather a seasonal activity depending on rainfalls.

Table 3.7 Purpose of animal husbandry among households in the total population (%)

Livestock farming	n (%)	Predominantly for their own use or consumption	Predominantly for sale	Their own consumption and sale in similar proportion
Alpaca	14 (7.65)	28.6	21.4	50.0
Cattle	140 (76.5)	7.9	86.4	5.7
Chicken	90 (49.2)	85.6	3.3	11.1
Donkey*	41 (22.4)	57.5	42.5	0.0
Guinea pig	35 (19.1)	82.9	8.6	8.6
Llama	48 (26.2)	18.8	16.7	64.6
Pig	78 (42.6)	19.2	53.8	26.9
Sheep	169 (92.4)	25.1	1.8	73.1

*Used as beast of burden only

3.2 Dietary diversity

As previously explained in section 2.2.1, DDS counts the number of food groups and FVS the number of food items consumed by each subject in the past 24h. Used food groups and food items have already been listed in Table 2.3. Based on the three seasonal dietary diversity scores and food diversity scores for each woman throughout the year, average DDS and FVS were calculated.

Regarding the distribution of the scores and in order to compare them across seasons, terciles were calculated and cut-off points defined for DDS and FVS. Thereafter, three groups were obtained as follows:

Food score	Low diversity	Medium diversity	High diversity
DDS	≤6	6<DDS≤7	>7
FVS	≤10	10<FVS≤12	>12

Thereby, specified cut-off points for DDS are related to the number of food groups and for FVS to the number of food items consumed during the 24h period prior to each survey. For further examinations in the following sections, these cut-off points were used.

3.2.1 Dietary diversity and food variety in the rainy season

In the first assessed season, consumed food groups ranged from 2 to 10, with a median (IQR) of 7 (6-8) food groups. FVS ranged from 4 to 17 food items, and had a mean (SD) of 10.34 (2.72) food items.

More than 50% of the participant consumed tubers, cereals, pro-vitamin A-rich vegetables and other vegetables, oil and fats, and legumes. In contrast, food groups such as eggs, fish, and pro-vitamin A-rich fruits were consumed by only a minority of women, and organ meat was not consumed at all (Figure 3.8).

Classification in low, medium, and high dietary diversity resulted in 44%, 29%, and 27%, respectively. The distribution of women in each FVS group was somewhat different than the one in each DDS group. Thereafter, 54% of the participants had low, 27% medium, and 20% high food variety (Figure 3.9). For instance, not all women within the group with high DDS had in turn a high FVS, and some women within the low FVS group had a medium or high DDS.

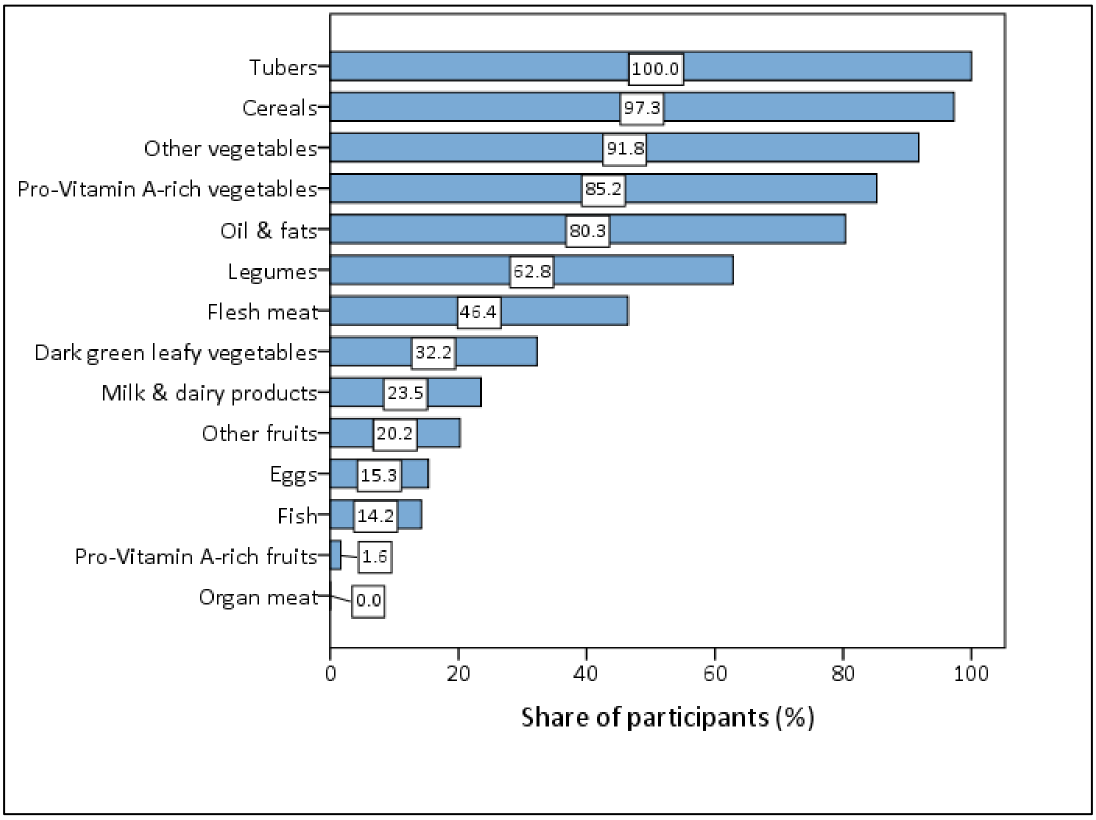

Figure 3.8 Frequency of consumed food groups in the rainy season (n = 183)

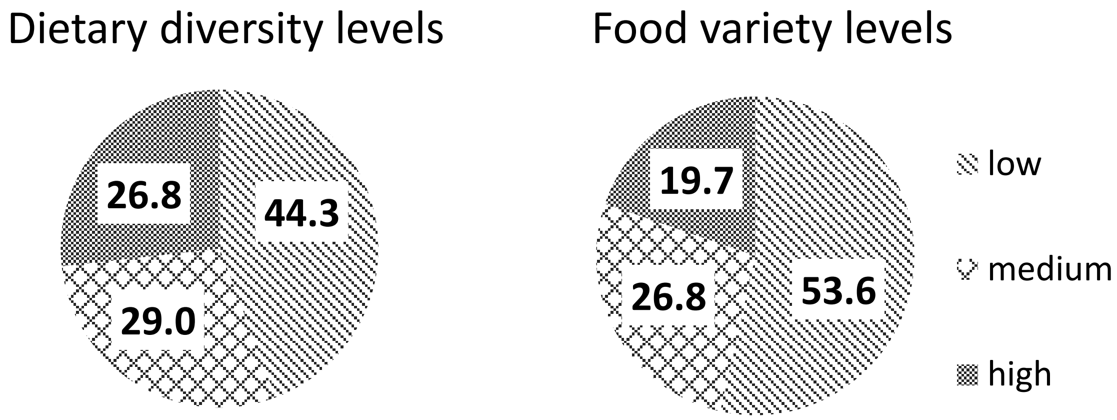

Figure 3.9 Share of participants (%) with low, medium, or high levels of DDS and FVS in the rainy season (n = 183)

While all participants consumed potatoes, either as fresh tubers or in dehydrated forms e.g. *chuño*, a few women consumed other indigenous tubers such as oca (9.3%), and no one consumed *olluco*, or *isaño*. Among the most frequently consumed cereals in this period were wheat products (66.7%), rice (49.2%), and the “cereal-like” indigenous goosefoot *quinoa* (38.3%). Wheat products included not only wheat as grain (10.9%), but also processed wheat flour (18.0%), pasta (29.0%), and bread (36.1%). Meanwhile, broad beans were eaten by 62.3% of them (>95% of the total legumes), but only a few women ate peas (3.8%). Meat was mainly from sheep (27.3%), and in a smaller proportion consumed as dried meat, either from sheep (3.3%) or from llama (3.7%).

Figure 3.10 Typical lunch in Aymara communities (Ccota).

3.2.2 Dietary diversity and food variety in the post-harvest season

The median (IQR) DDS in this season was 7 (6 to 8) food groups, and women consumed between 3 and 11 food groups, while FVS had a median (IQR) of 11 (10 to 13) and ranged from 3 to 20 food items.

In general, the frequency of certain food groups consumed such as tubers, cereals, pro-vitamin A-rich vegetables, other vegetables, and oil and fats was similar to that in the previous survey season (Figure 3.11).

Regarding DDS groups, 41.6% of the women had a low, 32.9% a medium, and 25.5% a high dietary diversity, while the share of women in FVS groups was 37.3%, 34.8%, and 28.0%, respectively (Figure 3.12).

As in the first season, potatoes were consumed by all women, but in this season further indigenous tubers were eaten as well, for instance *oca* (26.7%), *isaño* (6.2%), and *olluco* (5.6%). Wheat and wheat products, rice, and *quinoa* were eaten by 64%, 50.9%, and 37.9%, respectively. Within the wheat products, 11.2% of the women consumed the grains, 17.4% wheat flour, 31.1% pasta, and the same percentage for bread. Broad beans were the most commonly used type of legumes (54%), and fresh lamb (22.4%) was the commonly preferred type of meat. Dried lamb and llama meat made up about 16% of the total consumed food group.

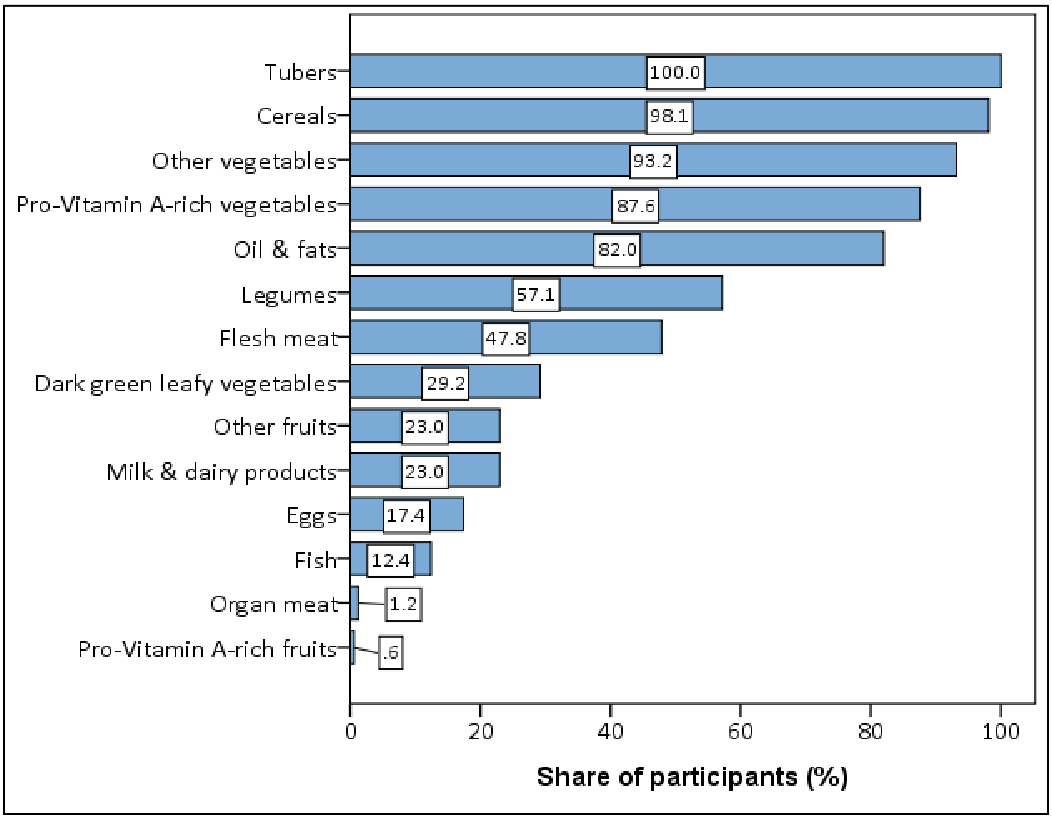

Figure 3.11 Frequency of consumed food groups in the post-harvest season (n = 161)

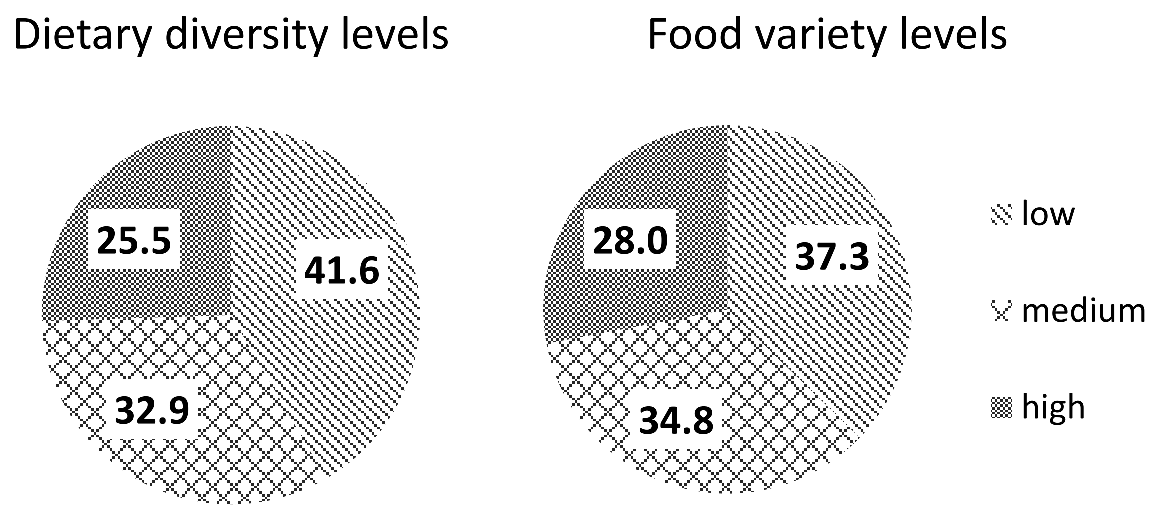

Figure 3.12 Share of participants (%) with low, medium, or high levels of DDS and FVS in the post-harvest season (n = 161)

In this season, fresh tubers are prepared in self-made ovens with hot clay pieces (Figure 3.13) until they are cooked and served with cheese or a dip made with chopped onions and chili peppers.

Figure 3.13 Preparation of fresh tubers as *huatia* in a clay oven (Aychuyo)

3.2.3 Dietary diversity and food variety in the farming season

In addition to data from the previous season, DDS and FVS were non-normally distributed. Food groups consumed by the women ranged from 4 to 10, with a median (IQR) of 7 (6 to 8) food groups. The food variety ranged from 5 to 18, with a median (IQR) of 11 (10 to 12) food items.

In contrast to the food groups consumed in the other seasons, cereals were slightly less frequently consumed than other vegetables, and the consumption of legumes increased in comparison to that of the rainy and post-harvest season. The frequency of food groups consumed is depicted in Figure 3.14.

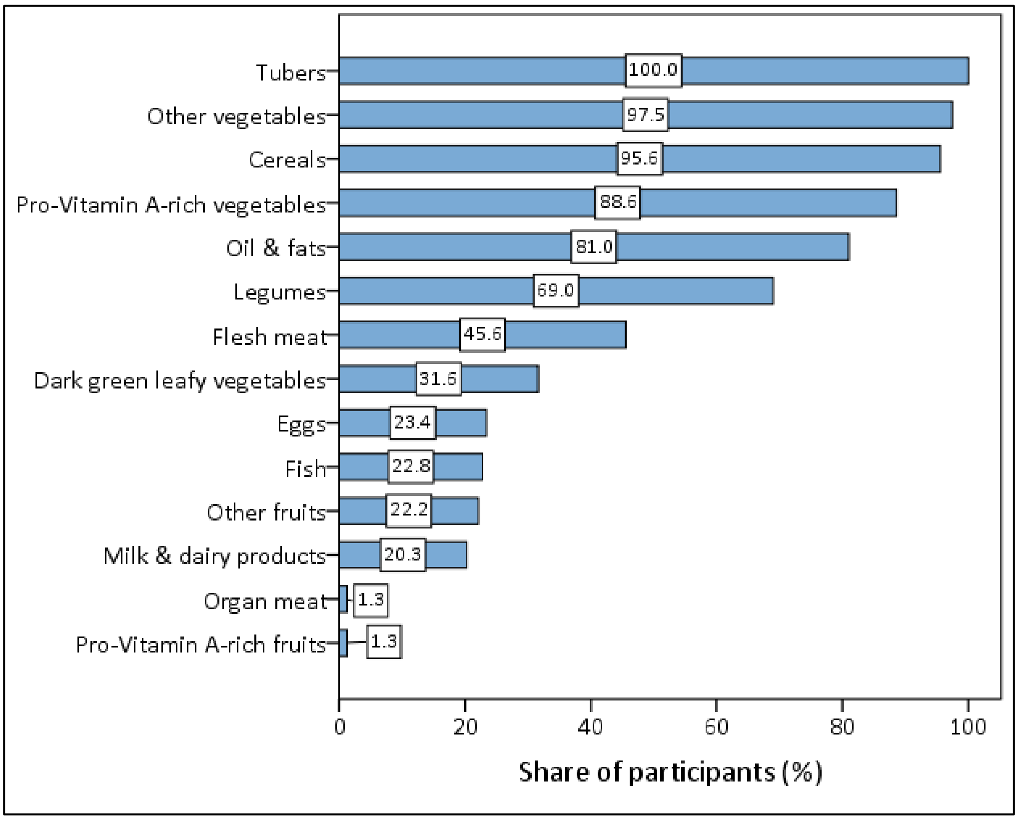

Figure 3.14 Frequency of consumed food groups in the farming season (n = 158)

The share of women in the low dietary diversity group was 34.8%, in the medium 29.7%, and in the high diversity group 35.4%. With relation to FVS, 43.7% of the participants had low, 33.5% medium, and 22.8% high food variety (Figure 3.15). In this season, wheat and wheat products accounted for 73.4% of the total consumed cereals, whereas 15.8%, 34.8%, and 38% of the women used wheat flour, pasta, and bread, respectively, and a slightly higher share of them consumed wheat as whole grain.

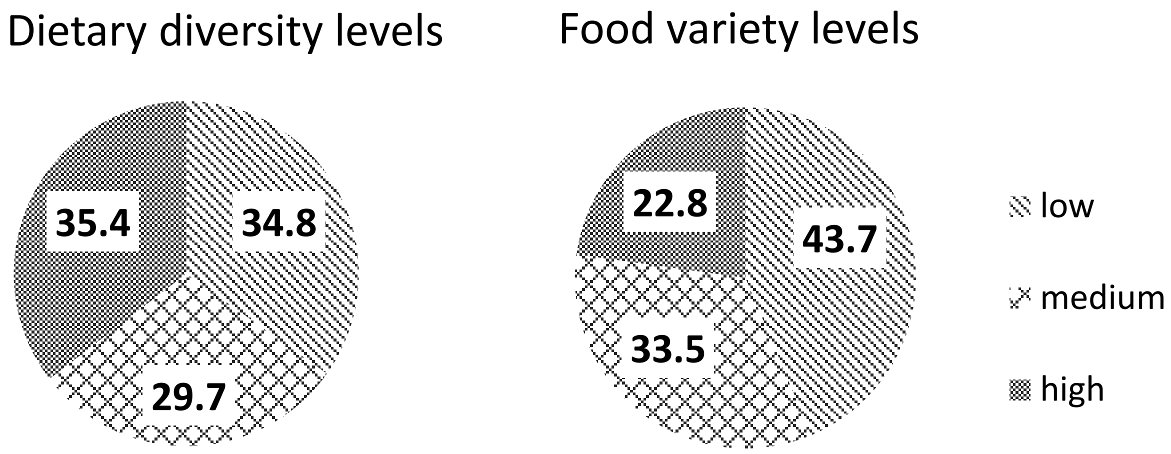

Figure 3.15 Share of participants (%) with low, medium, or high levels of DDS and FVS in the farming season (n = 158)

Furthermore, the most frequent cereals were rice (50%) and barley (41%). *Quinoa* was only used by 35% of the women. In contrast, the consumption of legumes was higher than in the prior seasons, and dried broad beans were the most consumed type (63.9%) in this food group. Potatoes, either fresh or freeze-dried, were almost the only tubers consumed in this period, whereas a few women also consumed *oca* (5.7%). Meat consumption remained similar to the post-harvest season, with fresh lamb (22.8%) as the main product within this food group.

In general, this survey period appears to be characterized by shift in the diet patterns towards bought processed products. In addition, due to the Catholic celebration of All Saints' Day and according to the tradition in the communities, many households produce homemade bread.

Figure 3.16 The farming season in one of the lake-side villages (Ccota)

3.2.4 Dietary diversity and food variety in the longitudinal study

Though it was not possible to maintain the same sample number in each season, data on about 80% of the participants was available in the three survey rounds, resulting in a cohort of 147 women. Thus, an average DDS and FVS for the year was calculated by adding the three DDS and FVS values and dividing them each by three. In order to give an overview of the similarities in the total samples of each season as well as of the cohort (and the cohort sample number in each season), Tables 3.7 and 3.8 summarize main descriptive statistics.

Table 3.8 Descriptive statistics of DDS in each survey and in the longitudinal study

Score	n	Mean (SD)	Median (IQR)	Min-max
DDS rain S	183	6.70 (1.35)	7.00 (6.00 to 8.00)	2 – 10
DDS post S	161	6.73 (1.36)	7.00 (6.00 to 8.00)	3 – 11
DDS farm S	158	7.00 (1.29)	7.00 (6.00 to 8.00)	4 – 10
DDS rain S	147	6.86 (1.30)	7.00 (6.00 to 8.00)	2 – 10
DDS post S	147	6.83 (1.35)	7.00 (6.00 to 8.00)	3 – 11
DDS farm S	147	6.97 (1.29)	7.00 (6.00 to 8.00)	4 – 10
MEAN DDS	147	6.89 (1.00)	6.67 (6.33 to 7.66)	4.00 – 9.67

Table 3.9 Descriptive statistics of FVS in each survey and in the longitudinal study

Score	n	Mean (SD)	Median (IQR)	Min-max
FVS rain S	183	10.34 (2.72)	10.00 (8.00 to 12.00)	4 – 17
FVS post S	161	11.27 (2.84)	11.00 (10.00 to 13.00)	3 – 20
FVS farm S	158	10.85 (2.16)	11.00 (10.00 to 12.00)	5 – 18
FVS rain S	147	10.69 (2.69)	11.00 (9.00 to 12.00)	4 – 17
FVS post S	147	11.50 (2.79)	12.00 (10.00 to 13.00)	4 – 20
FVS farm S	147	10.78 (2.07)	11.00 (10.00 to 12.00)	5 - 16
MEAN FVS	147	10.99 (1.96)	11.00 (9.66 to 12.33)	5.33 – 17.33

According to the cutoff points used, 21% of the women had low, 43.5% medium, and 35.4% high DDS. Meanwhile, 32.7%, 40.1%, and 27.2% had low, medium, and high FVS, respectively. Detailed distribution of the women according to the scores can be observed in Figures 3.17 and 3.18.

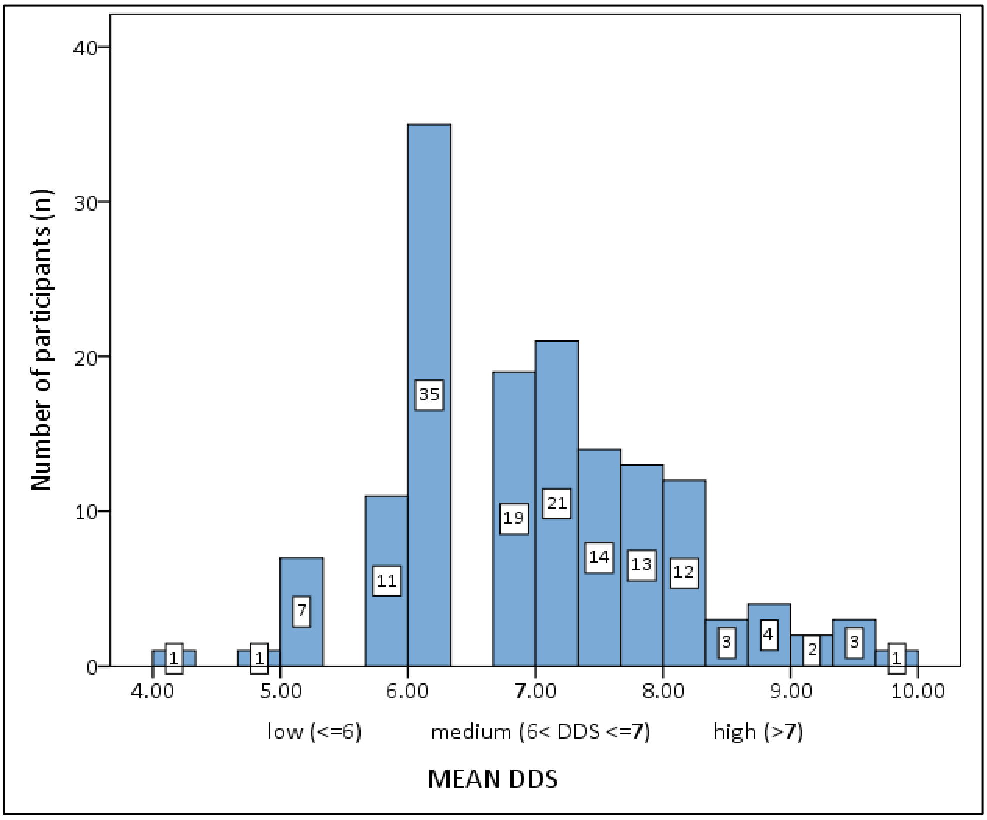

Figure 3.17 Distribution of the participating women according to mean DDS over the year (n = 147)

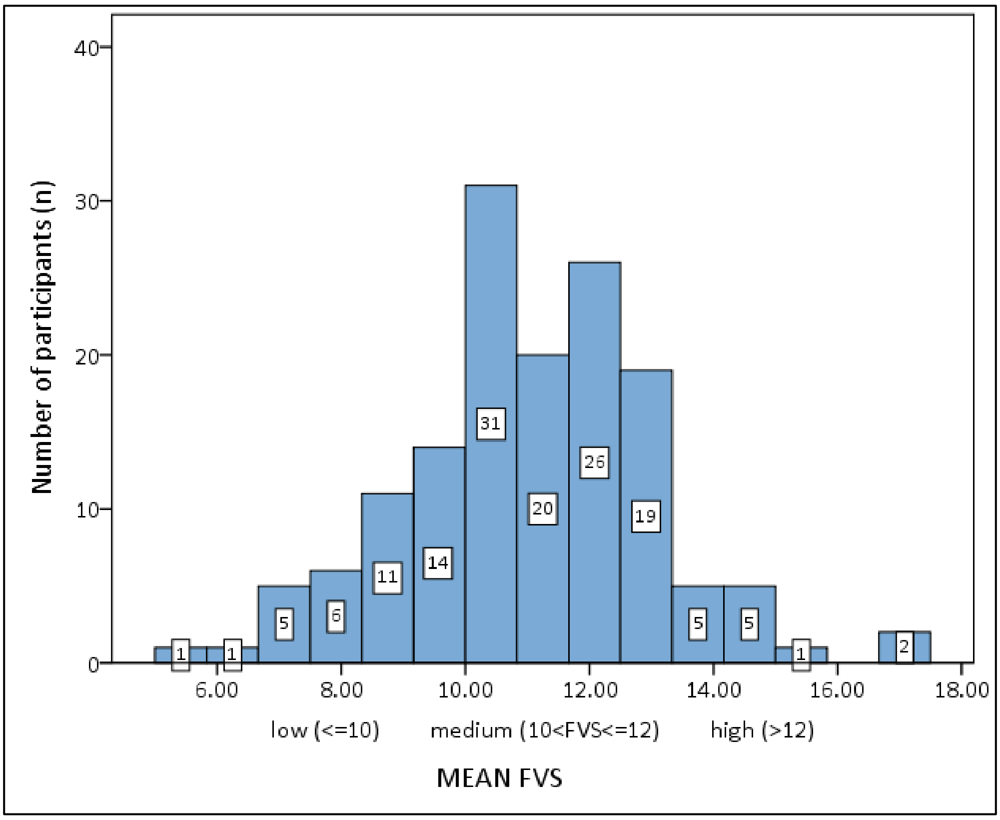

Figure 3.18 Distribution of the participating women according to mean FVS over the year (n = 147)

In general terms, the most consumed food groups in every season, i.e. food groups eaten by more than 50% of the study population were tubers, cereals, legumes, pro-vitamin A-rich vegetables, other vegetables, and oil and fats. In addition to these food groups, the upper dietary diversity group consumed flesh meat. Although somewhat less than 50%, it is worth mentioning that dark green leafy vegetables were characteristic for the upper diversity group compared to both the medium and lower groups. One has to take into account that food groups such as pro-vitamin A-rich vegetables and other vegetables are usually used in small amounts, mostly in the soups and stews commonly consumed for breakfast and dinner. Potatoes are the most important food component of almost every meal and are consumed daily as cooked tubers or as freeze-dried products (*chuño, tunta, moraya*). For lunch it is usual to eat from a common plate, mostly based on potatoes and/or *chuño*, other seasonally produced tubers, and legumes such as broad beans. Fried flat bread made of *quinoa* or wheat flour ("*tajti*") as well as a kind of steam-cooked bread made of ground quinoa or *kañihua* ("*quispiño*") are also components of a typical lunch. Depending on availability but typically less, eggs, locally produced cheese (mainly from cow milk), or dips made of onion and chopped chili can also be components of this meal.

Food groups and food items consumed by the cohort, i.e. the same women across the year, were analyzed in order to examine differences between seasons.

Overall, the diet components in terms of food groups were similar in each season. Only the consumption of legumes differed significantly across the year, specifically between the rainy and the post-harvest season at a level of 0.05. In the second survey, the consumption of legumes decreased significantly. Broad beans were consumed by more than 50% of the women in each season. Similarly, wheat products, rice, and noodles were also consumed by about 50% or more of all participants each time. The consumption of certain indigenous tubers, e.g. *oca*, *olluco,* and *isaño* was in general low and significantly higher in the post-harvest season compared to the other periods. Consumption of either “pro-vitamin A-rich fruits” or “other fruits” was rather low. Seasonal fruits such as oranges and mandarins were mostly consumed during the post-harvest season, i.e. during the winter months. Within the food group “dark green, leafy vegetables”, the consumption of traditionally used plants such as *muña* and wild mustard was significantly higher during the rainy season (Table 3.10). These herbs are prepared as infusions, mostly accompanying breakfast and dinner, but also are used for meal preparation.

Further analysis of the cohort across the year revealed that tubers, cereals, vegetables with and without pro-vitamin A, and oils and fats were commonly consumed by more than 50% of all women in each DDS level (terciles). Nevertheless, more than 50% of the participants in the middle and higher DDS levels additionally consumed legumes, and the latter group consumed flesh meat (Table 3.11).

When organ and flesh meat, eggs, milk/dairy products, and fish were included in the animal source foods (ASF), the prevalence of consumption was 76%, 75.8%, and 79.1% in each period, respectively. With respect to the cohort, similar proportions were observed, namely 73.5%, 76.2%, and 78.2%. The consumption of ASF ranged from one to three food groups in each period, but only a few participants ate more than two.

Table 3.10 Food groups and selected food items consumed by the same women and consumption differences between seasons

Food groups and items	Feb.-March Rain-S (1)	June-July Post-S(2)	Oct.-Nov. Farm-S(3)	Significant differences between seasons 1, 2, and 3
		% (n = 147)		
Cereals/grains	97.3	99.3	95.2	n.s.
Wheat products*	72.1	68.0	74.1	n.s.
Wheat grain	12.2	12.2	15.6	n.s.
Wheat flour	19.7	17.7	17.0	n.s.
Pasta	33.3	34.0	33.3	n.s.
Bread	36.7	33.3	38.1	n.s.
Rice	49.0	50.3	48.3	n.s.
Barley	38.8	36.7	43.5	n.s.
Quinoa	30.6	34.7	34.7	n.s.
Oat	10.9	10.2	6.1	n.s.
Maize	7.5	5.4	8.2	n.s.
Kañihua	2.0	2.7	0.7	n.s.
Tubers/roots	100.0	100.0	100.0	n.s.
Potato	100.0	100.0	100.0	n.s.
Oca	10.9	25.2	5.4	**1-2, 2-3**
Olluco	0.0	6.1	0.0	**1-2, 2-3**
Isaño	0.0	5.4	0.0	**1-2, 2-3**
Pro-vitamin A-rich vegetables	87.1	88.4	87.8	n.s.
Carrot	84.4	86.4	87.8	n.s.
Pumpkin	57.1	68.0	53.1	**2-3**
Dark green, leafy vegetables	29.9	29.3	32.0	n.s.
Spinach	3.4	10.9	11.6	**1-2,1-3**
Sage	9.5	9.5	13.6	n.s.
Muña	15.0	7.5	7.5	**1-2,1-3**
Wild mustard	8.8	2.7	2.7	**1-2,1-3**
Parsley	1.4	4.8	2.7	n.s.
Mint	1.4	3.4	3.4	n.s.
Other vegetables	94.6	93.9	97.3	n.s.
Onion	85.0	89.8	93.9	**1-3**
Tomato	38.8	49.0	54.4	**1-3**
Lettuce	4.8	1.4	0.7	n.s.
Celery	33.3	42.2	35.4	n.s.
Leek	4.1	9.5	5.4	n.s.
Cabbage	10.9	8.8	10.9	n.s.
Green beans	6.1	3.4	3.4	n.s.
Pro-vitamin A-rich fruits	2.0	0.0	1.4	n.s.
Mango	0.0	0.0	0.7	n.s.
Papaya	2.0	0.0	0.7	n.s.
Other fruits	21.1	23.8	21.1	n.s.
Apple	14.3	6.8	7.5	n.s.
Banana	4.8	4.1	6.1	n.s.
Grape	0.0	0.0	0.0	n.s.
Orange	0.7	13.6	3.4	**1-2, 2-3**

(continued)

Lemon	2.7	2.0	3.4	n.s.
Mandarin	0.0	6.1	0.0	**1-2,2-3**
Organ meat	0.0	1.4	1.4	n.s.
Flesh meat	40.1	46.9	44.9	n.s.
Beef	0.0	1.4	1.4	n.s.
Pork	0.7	0.0	0.7	n.s.
Sheep	27.9	22.4	23.1	n.s.
Dried sheep†	2.7	10.9	10.9	**1-2,1-3**
Chicken	1.4	2.7	1.4	n.s.
Llama	2.7	3.4	3.4	n.s.
Dried llama†	5.4	3.4	2.7	n.s.
Alpaca	1.4	2.7	2.0	n.s.
Cuy	0.0	2.0	0.7	n.s.
Eggs	17.0	17.7	23.1	n.s.
Fish	16.3	12.9	22.4	n.s.
From the lake	12.2	12.2	15.0	n.s.
From the sea	1.4	0.0	2.0	n.s.
Canned fish (sea)	2.7	0.7	6.1	**2-3**
Legumes	72.1	60.5	69.4	**1-2**
Broad bean	71.4	57.1	63.9	**1-2**
Pea	4.8	4.1	4.8	n.s.
Lentil	0.0	2.0	2.7	n.s.
Milk and dairy products	26.5	24.5	20.4	n.s.
Milk, fresh	12.9	9.5	8.2	n.s.
Milk, evaporated	4.1	2.7	2.7	n.s.
Cheese (cowmilk)	12.9	15.6	10.2	n.s.
Oil and fats	83.0	83.7	81.0	n.s.
Vegetable oil††	83.0	82.3	78.2	n.s.
animal fat	0.0	2.0	2.1	n.s.
Butter	0.0	1.4	0.7	n.s.

* flour, noodles, bread

† included in the food groups “lamb” and “llama,” respectively

†† cottonseed, sunflower, soybean

Table 3.11 Prevalence of consumed food groups* according to the dietary diversity terciles (%)

	low DDS (≤6 food groups)	medium DDS (≤7 food groups)	high DDS (≥8 food groups)
Tubers	**100.0**	**100.0**	**100.0**
Cereals/grains	**94.6**	**98.4**	**99.4**
Other vegetables	**89.2**	**95.3**	**98.7**
Pro-vitamin A-rich vegetables	**75.3**	**88.0**	**94.9**
Oil and fats	**64.5**	**83.9**	**91.7**
Legumes	38.7	**72.9**	**77.6**
Flesh meat	46.2	33.3	**55.8**
Dark green leafy vegetables	15.1	24.5	46.8
Eggs	3.2	13.5	35.9
Other fruits	10.8	16.7	35.3
Milk and milk products	11.8	23.4	31.4
Fish	9.7	15.1	24.4
Pro-vitamin A-rich fruits	0.0	0.5	3.2
Organ meat	0.0	1.6	0.7

*Average from the three survey periods in the cohort (n = 147)

3.2.5 Iron and vitamin A in food sources

Since the variables used to assess the diet are dichotomous indicators, an accurate estimation of micronutrient intake might be limited due to the qualitative nature of the food scores. Nevertheless, a general approach can be obtained when the prevalence of consumed food groups, specifically for this study, containing iron and vitamin A and/or precursors in the population is examined. For an overview about the examined population, the total sample in each survey was considered. Additionally, for the longitudinal analysis, the food groups consumed by the cohort (n = 147) were also taken into account.

(Pro-) and vitamin A sources

According to the guidelines for the use of IDDS (Kennedy *et al.* 2011) the plant-based food groups included the pro-vitamin A-rich vegetables and fruits, and the dark green leafy vegetables, whereas the organ meat, eggs, and milk/dairy products were the animal-based sources. Overall, the prevalence of consumed plants or animal-based food groups between the three seasons was not distinctive and only slightly higher in the farming season for both plant and animal sources. Plant-based sources of vitamin A were consumed by the majority of the women (>90%) in each season.

By contrast, less than 50% of the population consumed vitamin A animal sources (Figure 3.19).

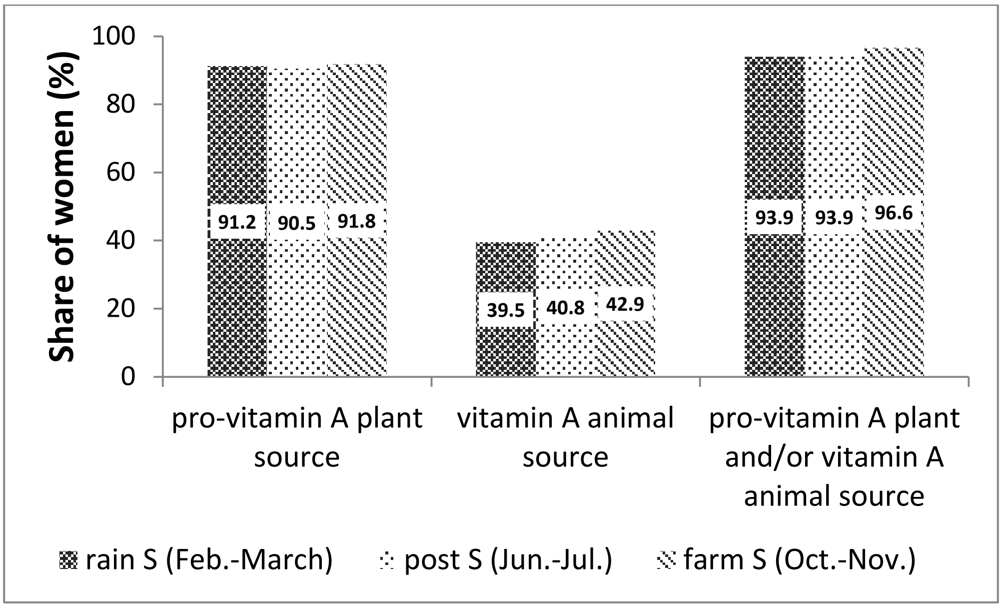

Figure 3.19 Prevalence of consumed (pro-) vitamin A across the year (n = 147) based on dichotomous variables

Similar to the cohort, a high prevalence of women that consumed pro-vitamin A plant-based sources was observed in the total sample of each survey period, but there was a lower proportion of participants consuming vitamin A animal-based food groups. Table 3.12 presents the prevalence of consumed (pro-) vitamin A in the respective study periods.

Table 3.12 Frequency (n) and prevalence (%) of consumed food groups with (pro-) vitamin A according to the survey seasons

(pro-) vitamin A source	Rain-S (n = 183)	Post-S (n = 161)	Farm-S (n = 158)
Plant-based	166 (90.7 %)	145 (90.1 %)	146 (92.4 %)
Animal-based	65 (35.5 %)	62 (38.5 %)	67 (42.4 %)
Plant and/or animal-based	170 (92.9 %)	151 (93.8 %)	153 (96.8 %)

Iron sources

Organ and flesh meat were considered iron sources in order to examine the prevalence of consumed heme iron from animal tissues in the population. In contrast to the food groups proposed as iron sources from FAO/FANTA for the percent calculation of individuals consuming those food groups, fish was not included in the iron sources because of the low iron contents in the species that were commonly eaten in the region. Hence, the prevalence of consumed iron sources related to the total sample in the post-harvest and farming seasons and the cohort across the year was similar. Only in the rainy season was the prevalence of consumption frequency in the cohort somewhat different than in the total sample. Overall, the percentage of women consuming organ and/or flesh meat was higher in the second field survey, that is, the season of abundance in terms of food diversity (Figure 3.20).

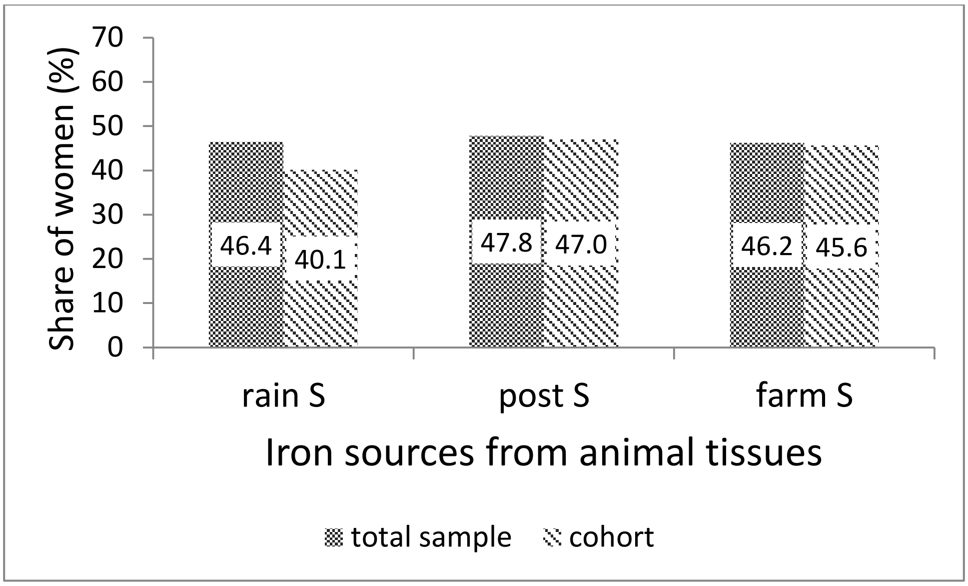

Figure 3.20 Prevalence of consumed iron sources (in terms of organ and flesh meat) over the year with respect to the total sample in the rainy (n = 183), post-harvest (n = 161), farming season (n = 158), and the longitudinal cohort (n = 147)

3.2.6 Relationships between food scores, socio-economic, and agrobiodiversity-related variables

In this section, associations between the DDS, the FVS, and several socio-economic characteristics of the population are examined considering each season but also the women's average DDS and FVS for the entire year.

<u>Relationships with continuous variables</u>

The wealth and housing index was associated with DDS in each season and was highly associated with the overall DDS calculated as an average of the three seasons (all year). The same was found in the case of FVS, indicating that wealth and housing characteristics play an important role in dietary diversity. Furthermore, there was a relationship between the food scores and the variety of overall cultivated crops as well as the variety of exotic crops. Exotic crops are those mentioned in section 3.1.4. Regarding the whole year, these two factors were associated with DDS and FVS as well. By contrast, the variety of indigenous crops cultivated was not associated with DDS or FVS at any season. Nevertheless, a significant but weak relationship was found between indigenous crops and both the average DDS and FVS.

The household size was positively correlated to DDS during the rainy season and to the average DDS, but no relationship was found in the other seasons or related to FVS.

The age of the participants was not associated with the food scores at any time. The number of months in the year with water shortage was negatively correlated with FVS during the rainy season only, and the periods of food shortage negative correlated with DDS in the rainy and farming season as well as with the overall DDS, and with FVS in the first season and the overall FVS. In each case, the increasing periods of water and/or food shortage were associated with lower DDS and FVS. Detailed results of correlations are shown in Table 3.13.

Table 3.13 Correlations between the food scores and the continuous variables in each season and throughout the year

Variables	Rain-S (n = 183)	Post-S (n = 161)	Farm-S (n = 158)	All year (n = 147)
		DDS		
		Spearman's correlation coefficient ρ		
Age	n.s.	n.s.	n.s.	n.s.
Wealth and housing index	.265 ***	.267 **	.196 *	.305 ***
Household size	.201 **	n.s.	n.s.	.189 *
Crop variety	.179 *	.164 *	.240 **	.263 **
Indigenous crop variety	n.s.	n.s.	n.s.	.181 *
Foreign crop variety	.224 **	.266 **	.252 **	.271 ***
Number of months with water shortage	n.s.	n.s.	n.s.	n.s.
Number of months with food shortage	-.186 *	n.s.	-194 *	-.256 **
		FVS		
		Spearman's correlation coefficient ρ		
Age	n.s.	n.s.	n.s.	n.s.
Wealth and housing index	.246 **	.217 **	.208 **	.268 **
Household size	n.s.	n.s.	n.s.	n.s.
Crop variety	.180 *	.217 *	.200 *	.261 **
Indigenous crop variety	n.s.	n.s.	n.s.	.193 *
Foreign crop variety	.166 *	.293 ***	.181 *	.237 **
Number of months with water shortage	-.213 **	n.s.	n.s.	n.s.
Number of months with food shortage	-.263 ***	n.s.	n.s.	-.195 **

*p<0.05 (two-sided)
**p<0.01 (two-sided)
***p< 0.001 (two-sided)
n.s. = not significant

Relationships with categorical and binomial variables

A positive correlation was observed between the food scores and access to markets, indicating that the more accessible the markets, the higher both DDS and FVS were in each season. This relationship was even stronger regarding DDS in each season and across the year. The frequency of food purchase was positively correlated with the food scores as well. However, no significant relationship was found on the overall FVS. As expected, highly positive associations were found between the food scores and the expenditures for food purchase at each study period.

Contrary to the expectations, existing home gardens were weakly associated with higher DDS in the farming season and more strongly associated with higher FVS in the post-harvest season only. Relationships between the food scores and gathering of wild plants and herbs were found merely with DDS during the farming season.

The educational level of the participant did not correlate with the food scores at any time, whereas the one of the partner and of the head of the household were positively associated, for instance with both DDS and FVS throughout the year (Table 3.14). Thus, higher educational level of the partner or the indicated head of the household was associated with higher DDS or FVS.

Relationships with nominal variables

The food scores as categorical variables, i.e. DDS and FVS levels, were used to identify relationships with the nominal variables. Given the distribution of cases within the multinomial variables, it was not possible to apply the Pearson's chi square (X^2) with all nominal variables. One condition for the accuracy of the test is that not more than 20% of the cells should count less than 5. Thereafter, a strong relationship was found between the food scores and the residences, i.e. the villages. Differences among villages are considered in the later discussion in chapter 4.

DDS and the source of income were significantly associated during the rainy and the farming season, while in case of FVS an association was identified during the post-harvest and the farming season. Further associations with nominal variables are summarized in Table 3.15.

Table 3.14 Associations between food scores and categorical variables in each season and throughout the year

Variables	Rain-S (n = 183)	Post-S (n = 161)	Farm-S (n = 158)	All year (n = 147)
		DDS		
		Spearman's correlation coefficient ρ		
Education level of the participant	n.s.	n.s.	n.s.	n.s
Education level of the partner	.163 *	.196 *	n.s.	.197 *
Education level of the head of household	.168 *	.198 *	n.s.	.218 *
Access to markets	.423 ***	.388 ***	.341 ***	.507***
Frequency of food purchase	.275 ***	.261 **	.186 *	.285 ***
Expenditures for food	.358 ***	.304 ***	.225 **	n.a.
Existing home garden	n.s.	n.s.	.169 *	n.s.
Gathering	n.s.	.197 *	n.s.	n.s.
		FVS		
		Spearman's correlation coefficient ρ		
Education level of the participant	n.s.	n.s.	n.s.	n.s.
Education level of the partner	n.s.	.176 *	.190 *	.205 *
Education level of the head of household	n.s.	.185 *	n.s.	.214 *
Access to markets	.239 **	.389 ***	.267 **	.259 **
Frequency of food purchase	.180 *	.243 **	.160 *	n.s.
Expenditures for food	.232 **	.291 ***	.214 *	n.a.
Existing home garden	n.s.	.225 ***	n.s.	n.s.
Gathering	n.s.	n.s.	n.s.	n.s.

*p<0.05

**p<0.01

***p<0.001

n.a. = not applicable, n.s. = not significant

Further relationships and trends

Besides the relationships related to both DDS and FVS, additional correlations could be found between components of agrobiodiversity and further characteristics of the main sample (n = 183). Most of the association coefficients were rather moderate. For instance, the wealth and housing index was associated with the overall crop variety ($\rho = 0.312$, $p < 0.001$) and both the variety of cultivated indigenous crops ($\rho = 0.203$, $p = 0.006$) and exotic crops ($\rho = 0.325$, $p < 0.001$). Interestingly, the yearly length of periods with water shortages was significantly correlated with the length of food shortages ($\rho = 0.418$, $p < 0.001$), namely the longer the water shortage periods, the longer the periods of food scarcity. Furthermore, the crop variety of the farmers was inversely correlated with the periods of water ($\rho = -0.200$, $p = 0.003$) and food shortage ($\rho = -0.351$, $p < 0.001$). As expected, the latter correlation seems to confirm the importance of homestead production for food security. Though they were weaker, a negative association was also found between the periods of food shortage and both the indigenous ($\rho = -0.296$, $p < 0.001$) and exotic crop varieties ($\rho = -0.253$, $p < 0.001$).

Given the ordinal nature of some variables used and in order to examine whether the order of the groups are meaningful (Field 2009) in regards to the overall DDS and FVS from the three surveys, the more powerful non-parametric Jonckheere-Terpstra Test (J-T) was applied instead of the Kruskal-Wallis-H Test (K-W). Hence, according to the expectations, the greater the wealth and housing index and the closer and easier the access to the markets, the greater the DDS and FVS, and these results were highly significant. In a similar way, the J-T Test revealed that the food variety tended to be larger the more varied the cultivated crops and the higher the education level of the household's head. By contrast, the age, the length of the food and water shortage, and the education level of the participants showed neither increasing nor decreasing trends in the food scores. For simplicity, Table 3.16 gives an overview of certain variables examined.

Table 3.15 Associations between food scores and nominal variables in each season and throughout the year

Variables	Rain-S (n = 183)	Post-S (n = 161)	Farm-S (n = 158)	All year (n = 147)
		DDS		
		$X^2(df)$		
Marital status	n.a.	n.a.	n.a.	n.a.
Head of household	n.s.	n.s.	n.s.	n.s.
Main occupation of participant	n.s.	n.a.	n.a.	n.a.
Main occupation of the partner	n.s.	13.034(6)*	n.a.	n.a.
Main occupation of head of household	n.a.	n.a.	n.a.	n.a.
Source of income	14.883(6)*	n.s.	15.477(6)*	n.a.
Land tenure	n.s.	n.s.	n.a.	n.a.
Village	41.749(6)***	27.130(6)***	26.734(6)***	47.397(6)***
		FVS		
		$X^2(df)$		
Marital status	n.a.	n.a.	n.a.	n.a.
Head of household	10.919(4)*	n.s.	n.s.	n.s.
Main occupation of participant	n.a.	n.a.	n.s.	n.a.
Main occupation of the partner	n.a.	19.549(6)**	n.a.	16.547(6)*
Main occupation of head of household	n.a.	n.a.	n.a.	n.a.
Source of income	n.s.	13.672(6)*	16.296(6)*	n.a.
Land tenure	n.s.	n.s.	n.a.	n.a.
Village	40.587(6)***	30.905(6)***	18.437(6)**	29.244(6)***

*p<0.05, **p<0.01, ***p<0.001, n.a. = not applicable, n.s. = not significant

Table 3.16 Trends between selected ordinal variables and the food scores DDS and FVS*

Variable	DDS rain S	DDS post S	DDS farm S	DDS all year	FVS rain S	FVS post S	FVS farm S	FVS all year
Age levels	-	-	-	-	-	-	-	-
p	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Wealth and housing index	3.403	3.024	1.979	3.305	3.205	2.179	2.082	2.850
p	0.001	0.002	0.048	0.001	0.001	0.029	0.037	0.004
Access to mar-kets	6.222	5.197	4.662	6.498	3.802	5.094	3.058	4.018
p	**	**	**	**	**	**	0.002	**
Education of the participant	-	-	-	-	-	-	-	-
p	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Education of the HH's head	2.175	2.384	-	2.563	-	2.256	-	2.494
p	0.030	0.017	n.s.	0.010	n.s.	0.024	n.s.	0.013
Crop variety	2.771	2.763	2.938	3.678	2.211	3.071	1.971	2.834
p	0.006	0.006	0.003	**	0.027	0.002	0.049	0.005
Length of food shortage	-	-	-	-	-1.967	-	-	-
p	n.s.	n.s.	n.s.	n.s.	0.049	n.s.	n.s.	n.s.
Length of water shortage	-	-	-	-	-2.494	-	-	-
p	n.s	n.s.	n.s.	n.s.	0.013	n.s.	n.s.	n.s.

*The values are Z-scores of the Jonckheere-Terpstra-Test for *a priori* ordinal variables using DDS and FVS as dependent variables
** $p < 0.001$

3.3 Nutritional status

3.3.1 Anthropometric measurements

Based on the measures of height and weight, BMI was calculated for each survey round, and women could then be classified into underweight, overweight, or normal range. Table 3.17 shows relevant data of the anthropometric measures as well as BMI in each season. Height was measured once in the first survey.

Table 3.17 Statistics of the anthropometric measurements and BMI according to each survey season

Variable and statistics	Feb.-March (n = 143)	June-July (n = 105)	Oct.-Nov. (n = 98)
Height (m)			
Mean (SD)	1.55 (0.05)		
Median (IQR)	1.54 (1.51 to 1.58)		
Minimum	1.45		
Maximum	1.70		
Weight (kg)			
Mean (SD)	54.8 (8.8)	53.6 (7.7)	54.2 (8.6)
Median (IQR)	53.5 (49.0 to 59.0)	53.5 (48.0 to 58.0)	53.5 (48.0 to 58.5)
Minimum	38.5	38.0	37.5
Maximum	81.2	77.5	81.0
MUAC (cm)			
Mean (SD)	26.8 (2.6)	27.1 (2.6)	26.6 (2.8)
Median (IQR)	26.6 (25.4 to 28.6)	27.0 (25.3 to 28.8)	26.5 (24.4 to 28.5)
Minimum	21.0	20.8	20.6
Maximum	34.2	34.4	33.8
BMI (kg/m²)			
Mean (SD)	22.8 (3.3)	22.2 (3.2)	22.6 (3.2)
Median (IQR)	22.3 (20.4 to 24.8)	22.5 (20.6 to 24.6)	22.2 (20.2 to 24.6)
Minimum	16.3	17.3	15.8
Maximum	33.4	31.5	30.9

In general, about 70% of the women had normal BMI. Different than expected regarding the poverty level in the region, the share of underweight women was less than 10%. Conversely, more than 20% were overweight or even obese (Table 3.18).
BMI and MUAC were strongly correlated in each season ($r_{\text{rain S}} = 0.868$, $r_{\text{post S}} = 0.892$, $r_{\text{farm S}} = 0.878$, $p < 0.001$). The effect size of these relationships was large. In the same way, there was a high correlation between MUAC and the women's weight each time ($r_{\text{rain S}} = 0.835$, $r_{\text{post S}} = 0.828$, $r_{\text{farm S}} = 0.858$, $p < 0.001$).

Table 3.18 BMI levels according to the WHO classification in each season

BMI classification	Feb.-March (n=143)	June-July (n=105)	Oct.-Nov. (n=98)
Underweight (BMI < 18.50 kg/m²)	7.0%	9.5%	9.2%
Normal range (18.50 - 24.99 kg/m²)	69.2%	67.6%	69.4%
Overweight (25 – 29.99 kg/m²)	20.3%	19.0%	19.4%
Obese (BMI > = 30 kg/m²)	3.5%	3.8%	2.0%

Although results from the mixed models revealed significant differences throughout the year, suggesting that seasonality has an impact on the anthropometric indicators, changes in the anthropometric measurements across the year were rather slight. The mixed model analysis considered all missing values without pregnant women, resulting in a sample of 152 women. Overall, weight, MUAC, and BMI in the farming season showed the lowest values, and the pairwise comparison between seasons confirmed that the nutritional status indicators assessed in the last survey were significantly lower than in the previous two periods (Table 3.19).

Table 3.19 Mean weight, MUAC and BMI in each survey and seasonality over the year*

Nutritional status indicators	Rain-S (1)	Post-S (2)	Farm-S (3)	p	Significant pairwise comparisons**
Weight (kg)	54.8 (53.4; 56.2)	53.9 (52.7; 55.3)	53.8 (52.4; 55.2)	0.008	1-2; 1-3
MUAC (cm)	26.8 (26.4; 27.3)	27.1 (26.7; 27.5)	26.4 (25.9; 26.8)	< 0.001	1-2; 1-3; 2-3
BMI (kg/m²)	22.8 (22.3; 23.3)	22.7 (22.1; 23.2)	22.4 (21.9; 22.9)	0.012	1-3; 2-3

*Estimated marginal means (95% CI), and corresponding significance using the mixed model for repeated measures with season as fixed factor and weight, MUAC, and BMI as dependent variables (n = 152)
**Significance at the 0.05 level

Regarding bivariate correlations with either the food scores, socio-demographic or economic variables, only the SES i.e. the wealth and housing variable, the age, and the education level of the respondent revealed weak but significant associations with the anthropometric measurements in the first survey. For instance SES was associated with all measures and BMI at the 0.05 and 0.01 level, the women's age only with MUAC and BMI at the 0.05 level, and their educational level showed a relationship with all nutritional status indicators except for stature at both the 0.05 and 0.01 level (Table 3.20).

Table 3.20 Relationships between selected socio-economic and demographic characteristics and the anthropometric measurements of the first cross sectional survey (n = 143)*

Variable	Height	Weight	MUAC	BMI
Age	-0.102, n.s.	0.117, n.s.	0.190, p = 0.023	0.178, p = 0.033
Wealth and housing index	0.175, p = 0.037	0.245, p = 0.003	0.201, p = 0.016	0.204, p = 0.015
Education level of the HH's head**	0.152, n.s.	0.126, n.s.	0.060, n.s.	0.093, n.s.
Educational level of the partner***	0.236, p = 0.005	0.123, n.s.	0.160, n.s.	0.051, n.s.
Education level of the participant	0.036, n.s.	0.205, p = 0.014	0.194, p = 0.020	0.227, p = 0.006

* Bivariate correlations, Spearman's coefficient rho
**According to the available data, n = 132
***Only referred to those participants who stated being married or living together with the partner, n = 118.

3.3.2 Biochemical parameters

Hemoglobin

In order to evaluate Hb concentrations, measured values were adjusted according to the altitude using the equation of section 2.3 related to the statistical assessment of iron status.

In general, the mean Hb in each season was within the normal level. This was similar in the group of women who had complete Hb data in each season (Table 3.21). Nevertheless, the prevalence of anemia under consideration of WHO cut-offs was higher than 30% in all seasons.

Moreover, in the second and the third survey periods, percentages of participants with Hb values below cut-off were even higher than 40% (Figure 3.21).

Regarding data of the same women presented in all three seasons (n = 67), the proportion of participants with anemia in the rainy season was significantly lower than in the posterior one (post-harvest season) at the 0.05 level (p = 0.039). Despite the higher share of anemic women in the farming season compared to the rainy one, this difference was not statistically significant. Similar to the total samples at each time, the prevalence of anemia in this cohort accounted for 30%, 47.8%, and 43.3% in each season, respectively.

Table 3.21 Statistical data of hemoglobin concentrations (g/L) in the samples of each survey season and in the cohort*

Season	n	Mean (SD)	Median (IQR)	95% CI	Min.-Max.
Rain-S	143	123.3 (14.4)	125.5 (115.7-132.0)	120.9-125.7	63.9-149.9
Post-S	105	120.7 (12.8)	120.6 (112.3- 127.9)	118.2-123.1	79.9-154.6
Farm-S	98	121.1 (13.2)	120.9 (110.9 -131.6)	118.4-123.7	92.1-155.1
Rain-S	67	124.7 (14.9)	126.6 (117.5-133.1)	121.1-128.4	63.9-149.0
Post-S	67	121.4 (13.2)	120.9 (112.6-128.1)	118.2-124.6	85.9-154.6
Farm-S	67	121.8 (12.8)	121.1 (110.9-131.6)	118.7-124.9	92.1-155.1

*Hb concentrations are equivalent to sea level values after correction using altitude adjustment.

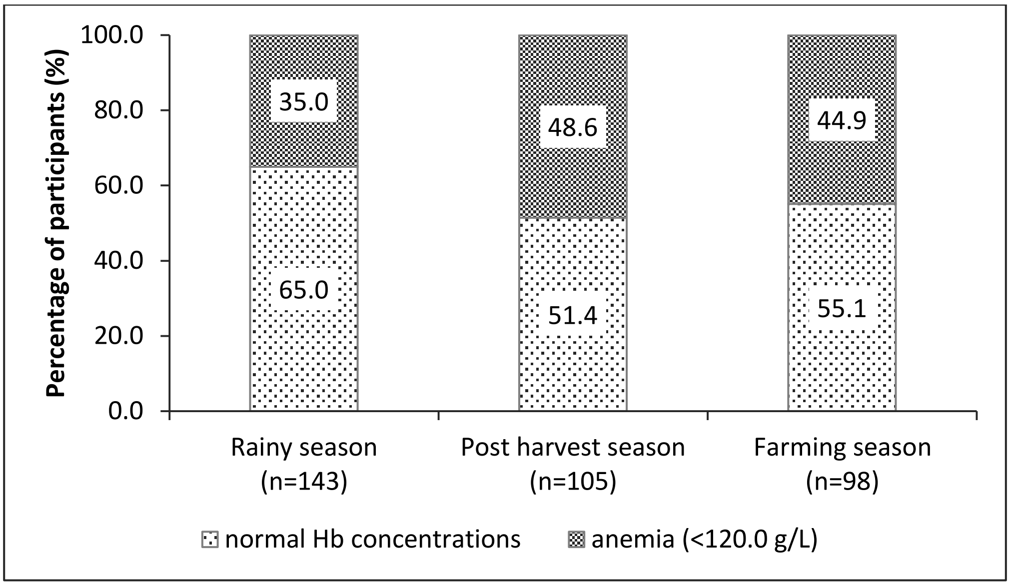

Figure 3.21 Prevalence of anemia in each survey season

Additionally, mild (110-119 g/L), moderate (80-109 g/L), and severe (<80 g/L) levels were identified in the samples of each season within the group of women with anemia. Thereafter, two women in the first and one in the second survey round had severe anemia according to WHO classification (WHO 2011). In the rainy season the shares of women with either mild or moderate anemia levels were smaller than in the next seasons. The shares of women with mild and moderate anemia increased noticeably in the post harvest season and remained similar in the last survey round. Figure 3.22 shows pie graphs with the different Hb levels at each survey time. Similar proportions were observed in the cohort (n = 67) as well (s. appendix Figure 9.1). There were no statistically significant differences between villages at each survey time.

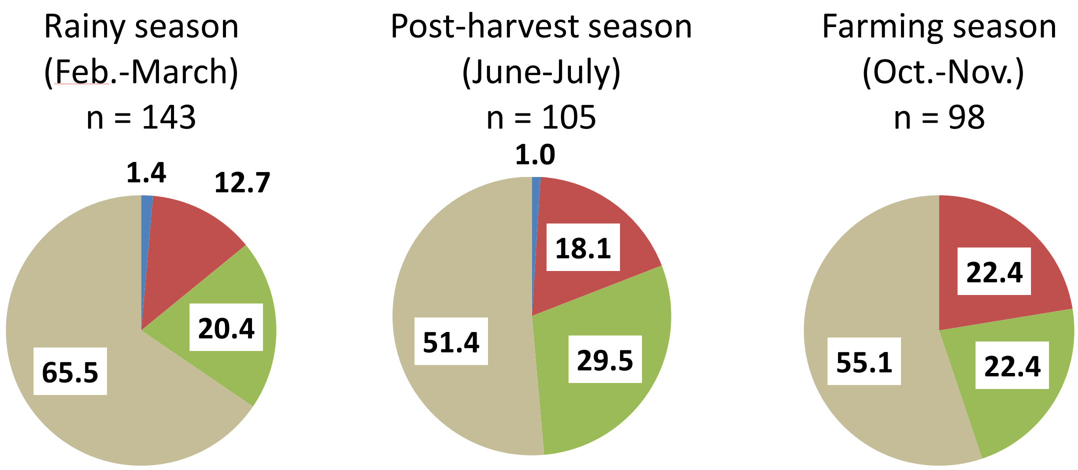

Figure 3.22 Percentages (%) of women with normal Hb and different levels of anemia according to the WHO classification in each season (grey = non-anemia, green = mild anemia, red = moderate anemia, blue = severe anemia)

Relationship between hemoglobin and other variables

Though there were no differences between the anemic and healthy women related to AGE, SES, DDS, and FVS at any time, some associations were found not only between hemoglobin concentrations and certain food groups but also the gathering depending on the assessed season. In Table 3.22 the bivariate correlations related to Hb in each survey round are summarized. Thereafter, vitamin A sources (plant and animal-based) and the gathering of edible plants/herbs appeared to be significantly associated to higher Hb concentrations in the first survey. Meanwhile, animal foods in general but also vitamin A-rich foods were positively correlated to Hb concentrations in the second one, while in the last survey no linear correlations were found between Hb and the selected food sources or gathering activities. No associations were found between iron sources (defined in section 3.2.5) and Hb at any time.

As previously described, most women traditionally gather fresh herbs and wild plants during the rainy time of the year, but they continue gathering over the year regardless of the fresh or dried condition of the plants. Due to the observed lowest anemia prevalence during the rainy season and the associations between Hb and the gathering of herbs and plants, an independent sample t-test was conducted to identify Hb differences between women who did this activity and those who did not. There was a significant difference in the mean (SD) Hb concentration of gathering (n = 118), 124.6 (14.6) mg/l, and not gathering (n = 25) conditions, 117.1 (13.6) mg/l; t (df) = -2.386

(141), p = 0.018. In the following two seasons, though, this group difference was not significant.

Table 3.22 Bivariate correlations between Hb and dietary ordinal variables grouping certain food groups and gathering of herbs and edible wild plants according to the survey seasons*

Variable	Rain-S (n = 143)	Post-S (n = 105)	Farm-S (n = 98)
ASF**	.047, n.s.	**.275, p = 0.004**	.149, n.s.
All VA sources***	**.199, p = 0.017**	**.218, p = 0.026**	.123, n.s.
VA animal source	.084, n.s.	**.256, p = 0.008**	.138, n.s.
VA plant source	.161, n.s.	.019, n.s.	.081, n.s.
Gather	**.228, p = 0.006**	.013, n.s.	-.174, n.s.

*Spearman's rho coefficients and corresponding significance values
** Animal source food included organ and flesh meat, eggs, fish and milk and dairy products
*** Vitamin A-rich food groups included plant (dark green leafy vegetables, VA rich vegetables and fruits) and animal-based (organ meat, eggs, and milk and dairy products) food groups

Following one of the study objectives, it was of interest to investigate whether the qualitative gained information related to the diet could predict the overall Hb and iron status. Thus, in a first exploring step, some of the most relevant diet-related variables were selected for multiple regression models with Hb as the dependent variable. Additionally, for the second and third survey periods, available data on infection status and sTfR concentrations were used. Table 3.23 shows the models that best explained the variance controlling for all other variables. Compared to the second and third surveys, the corresponding model for the first one included dietary dichotomous variables (consumed = 1 / not consumed = 0) such as flesh meat, vitamin A-rich animal and plant-based food groups, and the previously mentioned gathering of edible plants. The results revealed that the age and the gathering of herbs/edible plants had a significant positive predicting effect on the Hb concentrations. Contrary to expectations, the model showed a negative, statistically significant effect of the flesh meat consumption after checking all selected variables.

By contrast, the sTfR concentration and the consumption of vitamin A-rich animal food (eggs, milk and milk products, and organ meat) were the only significant predictors of Hb adjusted for all selected variables in the season of food abundance, whereas the age and the infection status appeared to significantly influence the participant's outcome variable during the planting season.

Table 3.23 Influencing factors on Hb in each cross sectional survey*

Model	Rain-S			Post-S			Farm-S		
	B	Beta	p	B	Beta	p	B	Beta	p
Constant	100.234		< .001	116.553		< .001	107.842		< .001
Age	.267	.166	.039	.200	.145	.123	.386	.234	.020
sTfR	-	-	-	-1.848	-.294	.003	.979	.116	.268
Infection	-	-	-	-.016	< .001	.996	-13.751	-.251	.017
Flesh meat	-5.248	-.182	.028	1.106	.043	.672	.779	.029	.768
VA-rich food (animal)	4.277	.145	.078	5.034	.194	.038	3.871	.146	.137
VA-rich food (plants)	6.957	.139	.084	6.554	.128	.177	-3.984	-.088	.381
gathering	10.180	.269	.002	.299	.011	.916	-4.061	-.140	.164
R^2	.142			.202			.172		

*Multiple linear regression models with Hb as the dependent variable

Soluble transferrin receptor (sTfR)

In both the post-harvest and farming seasons, sTfR values were not normally distributed. Among the women with valid values in the post-harvest season (n = 105) sTfR ranged from 3.00 to 15.87 mg/L and had a median (IQR) of 5.98 mg/L (4.97 to 6.97 mg/L), whereas in the farming season, available data of sTfR (n = 98) ranged from 2.79 to 11.06 and had a median (IQR) of 4.76 mg/L (3.90 to 5.82).

According to the cut-off point used for sTfR (> 8.3 mg/L), 12.4% of the women in the post-harvest season and 4.1% in the farming period could be considered iron-deficient. If anemia and elevated sTfR were considered at the same time for iron-related anemia, 8.6% and 3.1% of the participants could be identified, respectively.

Comparisons between the two seasons using the Wilcoxon signed-rank test for related samples resulted in statistically highly significant differences: $z = -5.46$, $p < 0.001$, $r = -0.62$. Therefore, the median sTfR in the post-harvest period (5.86 mg/L) was higher than the median sTfR in the farming season (4.72 mg/L). Figure 3.23 shows the corresponding boxplots.

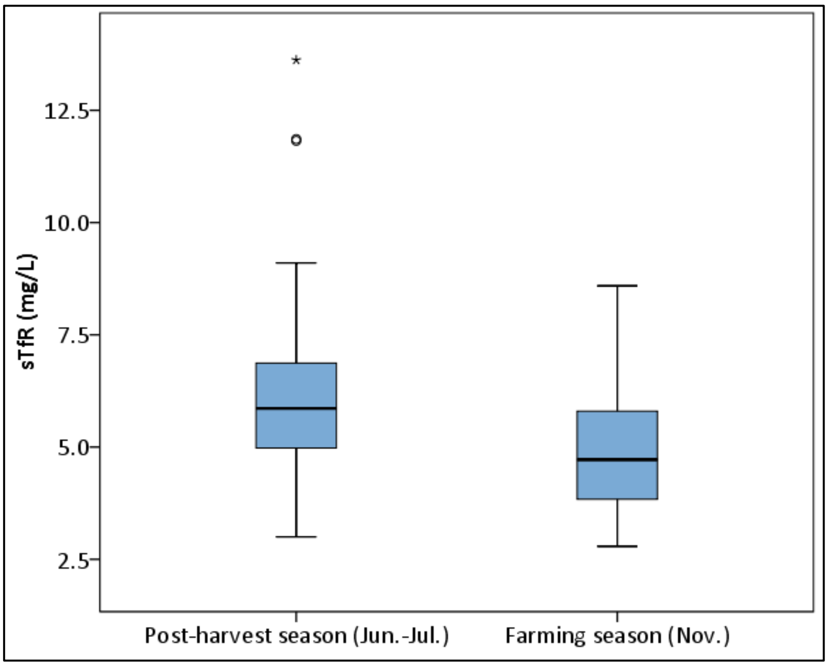

Figure 3.23 Median concentrations of transferrin receptor in both the post-harvest and farming seasons (n = 78)

As described above with the total samples of the second and third cross-sectional surveys, similar patterns were observed in the cohort (the same women involved in both seasons, n = 78) as well. In this case six women (approx. 8%) were identified as iron deficient in the post-harvest period, while only one woman (1.3%) showed elevated sTfR above the cut-off point in the farming period.

Although sTfR was negatively related to Hb in the post harvest season, i.e. the higher the sTfR the lower the Hb and vice versa, the bivariate correlation between both continuous variables was weak and not statistically significant ($\rho = -.168$, $p = 0.087$, n = 105). Nevertheless, a highly significant association between both the continuous Hb variable and the binomial variable set according to the TfR cut-off point (normal = 0, elevated sTfR /poor iron status = 1) was found ($\rho = -0.278$, $p = 0.004$, n = 105).

The mean sTfR concentrations according to the anemia levels from WHO revealed higher values in the more serious anemia levels, that is, the levels with lower Hb. concentrations. With the exception of one single woman with severe anemia who had a markedly elevated sTfR concentration, moderately and mildly anemic women showed normal sTfR values (<8.3 mg/L). By contrast, this pattern was not observed in the third survey, and there was no relationship between both Hb and sTfR in this period. This fact suggests that the etiology of anemia in the region might be attributed to additional factors different than those related to dietary iron deficiency.

There were no associations between sTfR and food scores, socio-economic variables, or anthropometric indicators at any time. However, there was a significant difference in sTfR concentrations according to the village in the farming season, p = 0.005. Thereafter, Perka showed the lowest median sTfR concentration (4.04 mg/L), followed by Aychuyo (4.64 mg/L), while Ccota and Arcunuma had the highest values (5.13 and 5.03 mg/L, respectively). Statistically significant were the differences of Perka-Ccota (p = 0.037) and Perka-Arcunuma (p = 0.005). Nonetheless, mean concentrations in each group were below the cut-off point.

Association between iron- and inflammation-status

Differently than reported in the literature, sTfR seemed to be influenced by inflammation. Hence, sTfR was correlated with CRP and AGP in both the post-harvest and farming seasons (Table 3.24).

Table 3.24 Bivariate analysis between sTfR and infection indicators*

Inflammation indicator	Post-S (n = 105)		Farm-S (n = 98)		Cohort (n = 78) Post-S		Cohort (n = 78) Farm-S	
	ρ	p	*ρ*	p	*ρ*	p	*ρ*	p
AGP	.440	< 0.001	.435	< 0.001	.467	< 0.001	.349	0.002
CRP	.202	0.039	.219	0.030	.021	0.854	.168	0.141

*Spearman's correlation coefficients and corresponding *p* values.

Due to the observed correlations between sTfR and the infection indicators, further examinations on the associations between sTfR, Hb and the indicators of subclinical infection were done using multiple regression analysis with sTfR as the dependent variable after previous transformation to log sTfR because of its non-normal distribution. Stepwise, explanatory variables were added into the model, beginning with Hb, CRP and AGP. Since there was no association between Hb, sTfR, and the participant’s age, this continuous variable was not included in the regression models. The results revealed a strong predicting effect of AGP ($p < 0.001$), which in turn explained a large proportion of the total variance in the model, namely about 23% and 25% in each season respectively. The other APP protein, CRP, significantly predicted sTfR concentrations after inclusion in the second model together with Hb only in the farming season ($p < 0.05$) but its predicting effect disappeared after inclusion of AGP in the model. Hemoglobin had a negative association with sTfR, and its predicting effect was only significant in each model during the post-harvest season ($p < 0.05$). More detailed information from the regression analysis is summarized in Table 3.25.

Table 3.25 Hemoglobin and subclinical infection as influencing factors on iron status measured with sTfR*

Step	Model 1			Model 2			Model 3		
	B	Beta	p	B	Beta	p	B	Beta	p
Post-S									
Constant	2.579		< .001	2.592		< .001	2.011		< .001
Hb	-.007	-.286	.003	-.007	-.292	.003	-.005	-.217	.017
CRP				.002	.063	.510	-.005	-.137	.172
AGP							.542	.428	< .001
R^2		.082			.086			.227	
Farm-S									
Constant	1.476		< .001	1.389		< .001	.667		.018
Hb	.001	.041	.690	.001	.061	.544	.003	.147	.110
CRP				.031	.207	.042	-.026	-.177	.134
AGP							.834	.609	< .001
R^2		.002			.044			.253	

*Multiple linear regression models with sTfR as the dependent variable

Posterior inclusion of the continuous variable RBP and further nutrition related variables e.g. the dichotomous gathering, consumption of ASF, or VA sources in the model previously proposed resulted in almost unchanged variance and not significant predicting effect on sTfR.

Retinol binding protein (RBP)

After excluding 15 (14.5%) women in the post-harvest and 30 (30.6%) in the farming season due to inflammation, RBP values for 90 and 68 women were available in the post-harvest and farming seasons, respectively.

In the post-harvest season RBP had a mean (SD) of 1.41 (0.31) µmol/L and ranged from 0.79 to 2.22 µmol/L, while the mean (SD) RBP in the farming season was 1.22 (0.33) µmol/L and ranged from 0.54 to 2.05 µmol/L.

About 12% of the women in the post-harvest and 25% in the farming season had a marginal vitamin A status (0.7<RBP<1.05 µmol/L). Moreover, two women (2.9%) had VAD (RBP<0.7 µmol/L) in the last survey period.

Regarding those women with available RBP data in both assessed survey periods, a group of 67 women were considered. There was a significant change of mean RBP between the post-harvest (mean RBP = 1.42 µmol/L) and the farming season (mean RBP = 1.22 µmol/L), t (df) = 5.049 (66), $p < 0.001$, $r = 0.528$, indicating that the VA status worsened from one season to the next (Figure 3.24).

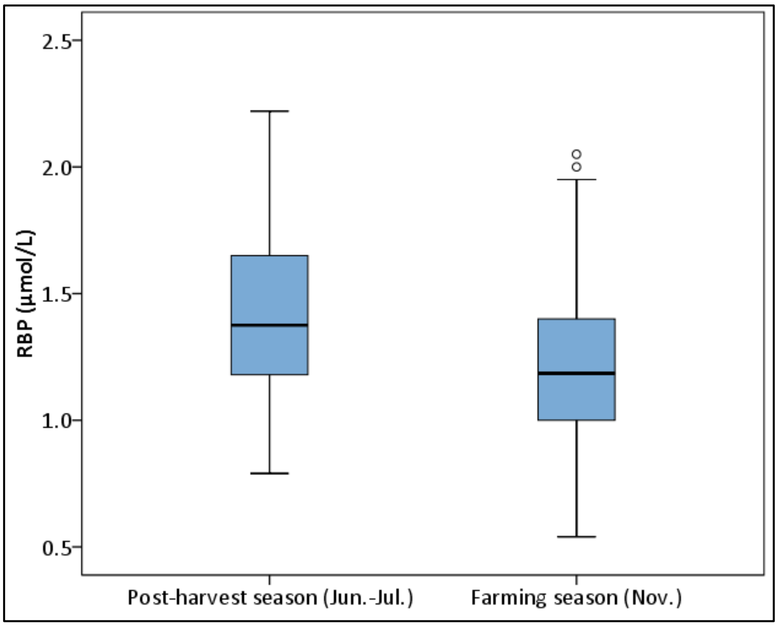

Figure 3.24 Retinol binding protein of the same women in the two assessed seasons (n = 67)

The VA status according to the RBP concentrations was not correlated with socio-economic variables, anthropometrics or iron status indicators. However, the one-way ANOVA revealed significant group differences among villages in the second survey, F (3, 86) = 4.046, p = 0.10. Thereby, Perka had (1.26 µmol/L) significantly lower mean values than Arcunuma (1.52 µmol/L), p = 0.046, and also Aychuyo (1.49 µmol/L), p = 0.029. This pattern could not be found in the third assessed season, and the group differences were not statistically significant. There also was a difference between women who gathered herbs and wild plants in the post-harvest season. Thereafter, the mean RBP (1.48 µmol/L) of those participants who gathered edible plants was significantly higher than of those who did not (1.26 µmol/L), t (88) = 3.319, p = 0.001, r = 0.33. Although similar results were found in the third survey, this difference was not statistically significant. Moreover, RBP concentrations were positively correlated with the number of animal food groups that were identified according to the 24h recalls and also associated with the gathering of herbs/edible plants (Table 3.26).

Table 3.26 Bivariate correlations between RBP concentrations and dietary ordinal variables grouping certain food groups and the dichotomous variable "gathering of herbs and edible wild plants" according to the survey seasons*

	Post-S	Farm-S
ASF**	**.286, p = 0.006**	.090, n.s.
All VA sources***	.148, n.s.	.047, n.s.
VA animal source	.005, n.s.	.010, n.s.
VA plant source	.185, n.s.	.145, n.s.
Gathering (yes/no)	**.332, p = 0.001**	.017, n.s.

*Spearman's rho coefficients and corresponding significance values
** Animal source food included organ and flesh meat, eggs, fish, and milk and dairy products
*** Vitamin A-rich food groups included plant (dark green leafy vegetables, VA-rich vegetables, and fruits) and animal-based (organ meat, eggs, and milk and dairy products) food groups

4 Discussion

Each section within this chapter aims to consecutively answer the four study questions. The complexity of the topic can be understood after integration of all components, i.e. agricultural characteristics, diet, demographic and socio-economic factors influencing the dietary diversity and food variety, and the nutritional status as indicator of nutrition security.

Section 4.1 is focused on the current utilization of the agricultural biodiversity in the region. This important background is supplemented with the dietary situation explained in the next section. Hence, in section 4.2 the dietary composition is evaluated based on the DDS and FVS not only in terms of the number of consumed food groups or food items but also the quality of the diet. Special emphasis is given to the consumption of indigenous food, and the general consumption patterns found in the study are then linked to selected socio-economic and demographic characteristics. Because associated determinants of the dietary diversity and food variety are of interest to understand issues and constraints of food security in isolated settings worldwide, the results from the statistical models are discussed in detail in section 4.3. Finally, the nutritional status of the study population measured with anthropometric and biochemical indicators is discussed in the section 4.4. Furthermore, the links between the measured food scores and the nutritional status of this indigenous population are discussed as well.

4.1 Natural resources for food security

Extensive research on Andean crops in the past and recent years have shown their great nutritional potential to reduce micronutrient malnutrition and to tackle non communicable diseases of modern societies (National Research Council (U.S.). Advisory Committee on Technology Innovation 1989; Glorio *et al.* 2008; Repo-Carrasco-Valencia *et al.* 2010). Not only limited to this nutritional area, using indigenous knowledge and ancient but efficient cropping systems adapted to the geographical conditions of the region, the great crop diversity and variety cultivated by the farmers may be a chance to preserve the biological diversity and therefore the environment.

Because the inventory of the diversity of each crop cultivated by the farmers in the field would have gone beyond the scope of the study, they were not assessed at all. Nonetheless, many authors have been and still are concerned with the nutritional contribution and contents of bioactive compounds of the native Andean crops and their different genotypes (Repo-Carrasco *et al.* 2003; Campos *et al.* 2006; Burgos *et al.* 2007; Glorio *et al.* 2008; Repo-Carrasco-Valencia *et al.* 2010). Regarding the crop variety cultivated by the studied households, namely up to 13 crops including native tubers, legumes, and cereals, one might assume that the overall diet of this population should be varied as well. In deed, a diet composed of native potatoes, *quinoa* (*Chenopodium quinoa*) or *quinoa* leaves, and *tarwi* (*Lupinus mutabilis*) could contribute to a balanced diet in terms of not only energy and protein but also several micronutrients such as iron calcium and phosphorus. Beyond the cultivated indigenous and exotic crops, animal husbandry and a huge variety of gathered herbs seem to contribute to the household's diet as could be identified in this study. However, agricultural biodiversity does not necessarily have to be concordant with the variety "on the plate". Additionally, the dependence on local markets to supply the household with other foods that are not produced by them such as vegetables and fruits was observed in all interviews with the participants.

Considering the points mentioned above, the first question is: What food sources are being currently utilized by the study population?

Overall, the most frequent species grown were potato, followed by the "exotic" barley and broad bean, and two indigenous plants, *quinoa*, and *oca* (s. Figures 3.5 and 3.6 in section 3.1.4). In general, crops were cultivated on a small scale on *chacras* (plots of land), farther from or closer to the houses, mainly for their own consumption in terms of food supply. Only oat, grown by 58% of the total sample (n = 183), was mainly used as a fodder crop, and *tarwi* was grown by 21% but was used for both their own consumption and sale.

Without exception, all recruited women in the first survey round indicated at least one crop, namely potato, being grown in their fields. Even though cultivation of indigenous crops was wide-spread in the studied villages, the participants had an average of three out of the eight types identified in their fields. Meanwhile, three out of five types of "exotic" crops were grown on average. Despite the overall cultivated crop variety, differences between consumption and cultivation could be observed. Hence, the consumption prevalence of certain crops tended to be somewhat lower than the stated frequency of cultivation among the participants, suggesting that availability of food in terms of homestead production does not mean full use of these staple crops. On the one hand one has to consider that neither cultivated amounts nor food portion sizes were assessed, since attention was given to the degree of dietary diversity. On

the other hand, the repeated measures over the year may allow one to identify eating patterns and seasonal differences. This point is discussed in more detail in section 4.2 in which seasonal differences and consumption prevalence of certain foods are the main focal points. In order to highlight the differences between cultivated and consumed crops, Table 4.1 summarizes the average consumption prevalence of certain crops over the year for the cohort. For instance, potato was cultivated by all households and consumed in all seasons, while *quinoa* was cultivated by 68% of the households, but only consumed by less than 35% of them according to the 24h recalls among the corresponding women. In contrast, although cultivated by only 6% of the households, wheat as whole grain was consumed by around twice this number.
In addition, some native crops such as *oca, isaño, olluco, tarwi* and *kañihua* are traditionally grown but at a very small scale and mostly seasonally consumed, namely during the harvest and shortly after the harvest season.

Table 4.1 Percentages of cultivated and consumed crops in the cohort sample (%, n = 147)

Type of crop	Cultivated	For home consumption only*	Consumed**
Potato	100.0	93.9	100.0
Broad bean	84.4	79.8	54.4
Barley	80.3	82.5	39.7
Quinoa	68.0	98.0	33.3
Oat	62.6	16.3	9.1
Oca	59.2	95.4	13.8
Isaño	42.9	95.2	1.8
Pea	38.8	94.7	4.6
Olluco	32.7	89.6	2.0
Tarwi	24.5	44.4	0.0
Maize	23.1	100.0	7.0
Kañihua	10.2	100.0	1.8
Wheat	6.1	88.9	13.4

*Related to the women's household growing the respective crop
**Average of the three survey periods according to the 24h dietary recalls

In chapter 3 an overview of all results were presented, taking into account the whole study population. It has been argued that ethnicity plays a key role in food choices, and therefore it has an impact on food consumption. This pattern has been observed not only in low and middle income countries (Ogle *et al.* 2001; Torheim *et al.* 2004; Keding *et al.* 2012) but also in wealthier societies (Devine *et al.* 1999). The current study tried to concentrate on a homogeneous population during the planning stage, and was careful to choose subjects from one ethnic group. Nonetheless, even among the selected villages, group differences related to agricultural activities were identified. Thus, it is worth illustrating these differences in order to better understand agricultural and dietary patterns of this Peruvian subpopulation.

As noted in section 3.1.4, the overall crop variety differed according to the women's place of residence ($p < 0.001$), whereby Arcunuma and Ccota had the lowest variety compared with the other two villages (Figure 4.1).

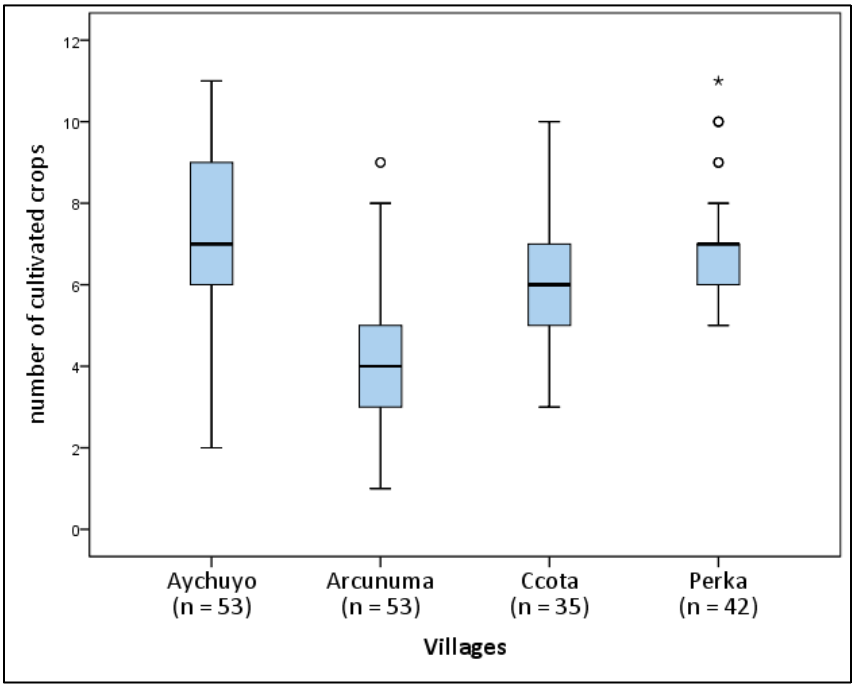

Figure 4.1 Differences between villages according to the number of crops grown ($p < 0.001$)

Moreover, significant differences in livestock inventory and types of animals kept were found between them as well ($p = 0.001$ and $p < 0.001$, respectively). Thus, the overall livestock variety differed significantly between Ccota and both Aychuyo ($p = 0.002$) and Arcunuma ($p < 0.001$), whereby Ccota had the lowest variety of animal types. Figures 4.2 and 4.3 present the differences between the villages according to the livestock inventory and variety of animal types.

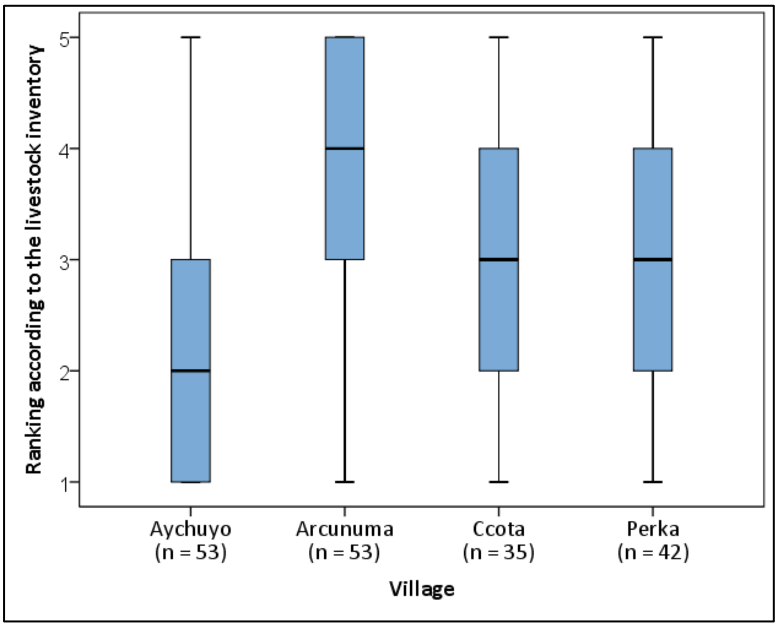

Figure 4.2 Differences in livestock inventory between the villages (p < 0.001)

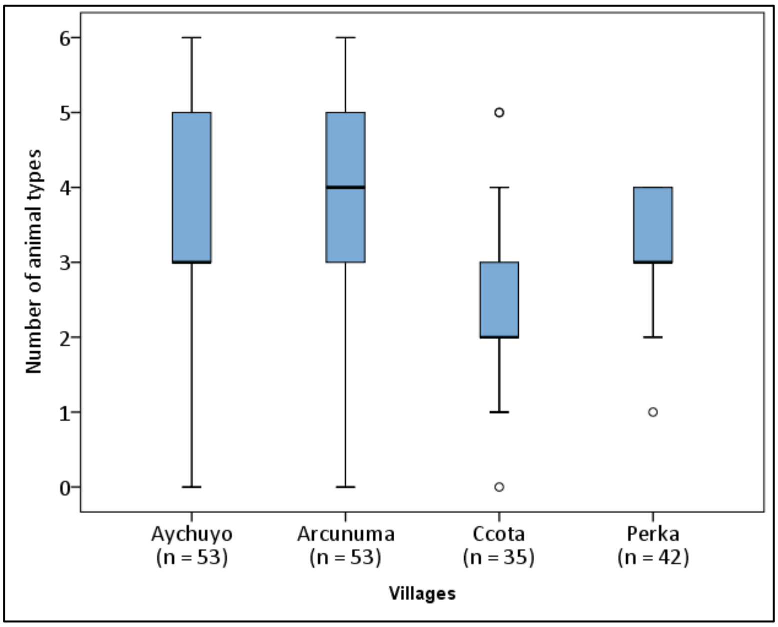

Figure 4.3 Differences in livestock variety between the villages (p < 0.001)

Although located close to each other, disparities even between Ccota and Perka were also found. For example, on average, two types of indigenous crops were cultivated in Ccota compared to four in Perka. The pairwise comparison showed that the difference between both lake-side villages was also statistically significant ($p = 0.005$). Overall, Aychuyo and Perka had the greatest variety compared to Arcunuma and Ccota (Figure 4.4).

In relation to foreign crops, Arcunuma had the lowest diversity compared to the other three villages ($p < 0.001$). All other villages had almost similar crop variety (Figure 4.5). One reason for such significant differences in crop and livestock farming are due to the agro-ecological zones where the villages are situated. In spite of the ethnical homogeneity and similar eating habits, the geography of the communities markedly influences the agricultural activities. The Altiplano ("high plain") area has been divided into three agro-ecological zones by Pulgar Vidal and Tapia, among other authors (Swinton *et al.* 1999): lakeside (up to 3,850 masl), Suni (3,850 – 4,000 masl) and Puna (above 4,000 masl). After this definition, climatic and geographic characteristics differ according to the distance away from Lake Titicaca and have a distinctive impact on the natural resources and farming systems.

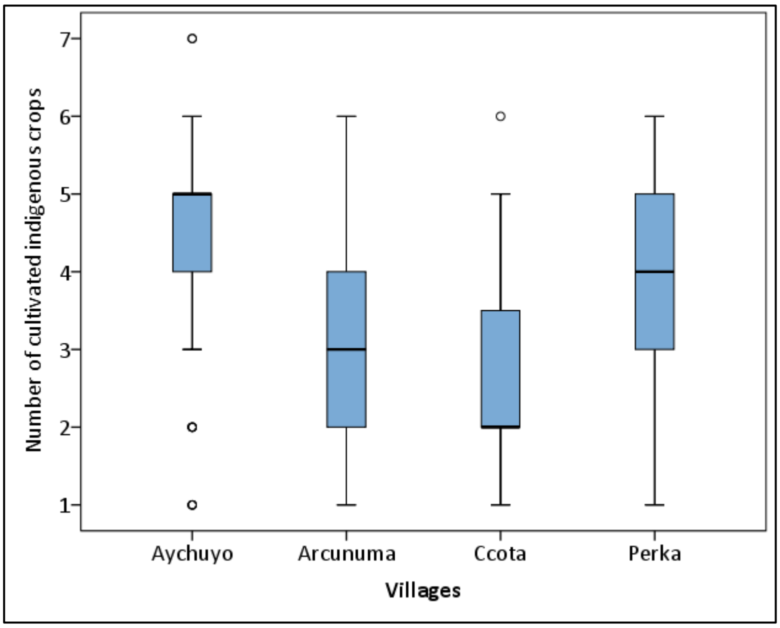

Figure 4.4 Median differences on indigenous crop variety between the villages (p < 0.001)

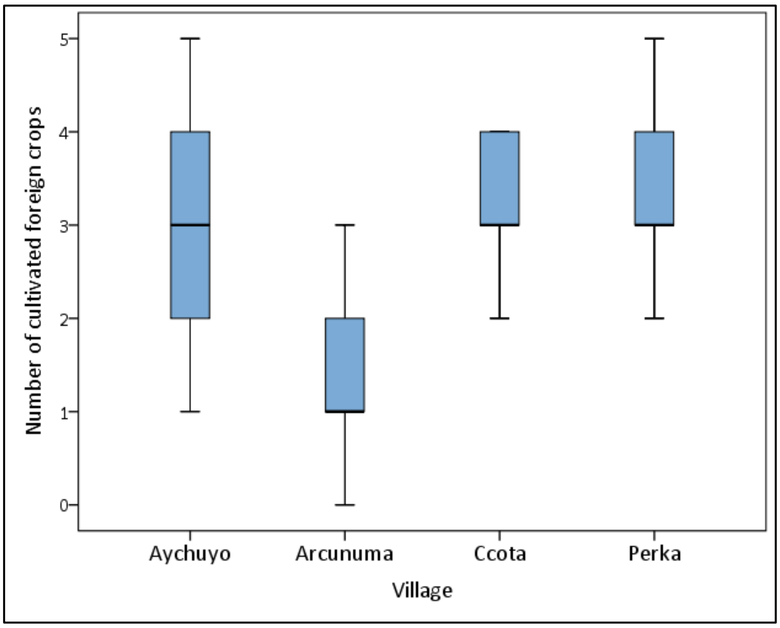

Figure 4.5 Median differences on exotic crop variety between the villages (p < 0.001)

Thereafter, Arcunuma, located at approx. 4,100 masl, belongs to the Puna zone and was the most distanced village with the lowest diversity of cultivated crops. Instead, herding sheep, llamas, and cattle was often reported. Indeed, this zone is characterized by natural pastures with extensive livestock farming systems and limited crop variety. By contrast, Aychuyo, at lower altitude (3,850 m) and situated closer to the lake, had the highest crop variety but the lowest ownership of livestock. The other two villages are also "lake-side" zones below 3,850 masl. In this zone, crop plantings are wide-spread; the crop land is characterized by strong defragmentation, and livestock inventory relies on animals such as cattle, pig, and poultry (Swinton *et al.* 1999).

Nonetheless, the agro-ecological zones are not the only influencing factor of agricultural production. In terms of food availability, other authors that explored similar Andean communities have agreed that isolation and the general low socio-economic status of many communities play an important role, and differences even between communities situated close to each other can exist (Picón-Reátegui 1978). In the case of Perka and Ccota, the latter had more frequent public transportation, and the villagers could reach even the capital of the province, Puno, in approx. 20-30 min. by bus (otherwise longer by foot) compared to Perka, with very limited transportation and a long walking distance to the city. In Ccota, some food stores could also be found. However, soda beverages, pasta, sweets, and other refined carbohydrates were the main products offered in these shops.

Aychuyo was located near a more commercial zone, and crop farming was very frequent among the households. In general, farmers did not cultivate the same types of crops in each village, and some differences in the types of animals kept were also identified. The consequences of these differences will be discussed in more detail in sections 4.2 and 4.3, where consumption patterns and determinants of the dietary diversity and food variety are the main focal points. In order to characterize each village, the most common types of crops and livestock are shown in Table 4.2.

Table 4.2 Characterization of the studied areas after crop and livestock farming (>50% of the respective population and in descending frequency)

Farming activity	Aychuyo (n = 53)	Arcunuma (n = 53)	Ccota (n = 35)	Perka (n = 42)	All participants (n = 183)	Cohort (n = 147)
Crop farming	Potato	Potato	Potato	Potato	Potato	Potato
	Broad bean	*Quinoa*	Broad bean	Broad bean	Broad bean	Barley
	Oca	Barley	*Quinoa*	Barley	Barley	Broad bean
	Oat	*Kañihua*	Oat	*Quinoa*	*Quinoa*	*Quinoa*
	Tarwi		Pea	Oca	Oat	Oat
	Olluco			Oat	*Oca*	*Oca*
	Isaño			*Isaño*		
	Barley					
Husbandry	Sheep	Sheep	Sheep	Cattle	Sheep	Sheep
	Pig	Cattle	Cattle	Sheep	Cattle	Cattle
	Guinea pig	Llama		Pig	Poultry	
	Poultry	Poultry		Poultry		

As pointed out in section 3.1.4, the use of the definitions "exotic" and "indigenous" in this work emphasizes the difference between crops known before and after the influence of the Spanish Conquest in 1532. In this cultural context, it should be mentioned that nowadays many "exotic" crops such as broad bean and barley are regarded as "traditional" in the region because of the early introduction into the country after the Spanish influence. Over the next centuries, the inclusion not only of several staple crops but also of domestic animals such as sheep, pig and cattle influenced the ancient culture and resulted in a culinary mixture throughout the country. Thus, besides the indispensable potato, many typical dishes in the study region contain for instance broad bean and sheep meat among other "exotic" ingredients.

Beyond the productive function of animal husbandry for the farmers in such areas of the Altiplano, Campero mentions such functions as economic security, manure, traction, and transport, but also their cultural importance (Simianer *et al.* 2004). Savings via asset accumulation is a means of delaying the consumption of what one might need in the future (Byron 2003). These considerations were also the reason for including livestock as a component into the wealth and housing index. Regarding the purpose of livestock farming for each household, cattle and pig had commercial uses i.e. they were mainly kept for sale, and half the women or more stated that llama, alpaca, and sheep were kept for both their own use and for sale in similar proportions. This suggests that livestock farming is not only used as food but as a cash source when other food items and household needs have to be met. Thus, the statements from the aforementioned scholars can be confirmed. However in the study population, only slight and insignificant changes in the inventory system could be identified over the three seasons. Moreover, many households tended to replace the missing types of animals, or they still had some of other types. Consequently, because the ranking system considered the weighed value of all existent animals, individual changes were not identified.

In addition to the cropping and livestock systems ensuring food supply, home gardens for horticulture and fruits are also regarded as a good strategy for food security (Marsh 1998; Talukder *et al.* 2010). However, such gardens were not usual among the studied households (23%), and only a few types of horticulture were grown on them (s. Table 3.4). The most commonly cultivated vegetables were onions and lettuce. Only a few women cultivated other species, for instance carrot, beetroot, garlic, or spinach but also coriander, parsley, peppermint, and oregano.

Indeed, among the women who had home gardens 12% were from Aychuyo. This outcome and the fact that vegetables and, to a lesser extent, fruits were nonetheless consumed by the participants according to the 24h recalls point out that besides their homestead food production, local markets play a role supplementing their diet with other foods.

The collection of herbs and wild plants was frequent among all participants (82.5%). The advantages of food sources from the wild to supply micronutrient intakes have been stressed by some authors (Grivetti *et al.* 2000; Ogle *et al.* 2001). Thus, it appeared that this rural population still maintains traditional practices that may have a positive effect on health from a dietary perspective. Nevertheless, its practice was not the same in all places: about half the women in Perka stated that they did not gathered any plants prior to the first survey. This proportion was similar in the next two survey periods. In the other three villages gathering was practiced in a similar proportion over the year (s. appendix Table 9.4). The difference in gathering practices between the villages was significant in all three seasons ($p < 0.001$). The greatest variety of herbs mentioned by the women was found in the first survey, namely the rainy season. Specifically in the Andean context, the use of plants not only for food but also for medicinal purpose is an important part of the culture that has been highlighted by other authors (Macía *et al.* 2005; De-la -Cruz *et al.* 2007).

Conclusions

Within this section one main finding was that the foremost subsistence agriculture identified in the region plays an important role for staple food production. Among the most commonly cultivated indigenous food crops were native potato, *quinoa* and *oca*. Meanwhile, barley and broad beans were the most important crops among the exotic plants. However, dark green leafy, red, or yellow-fleshed vegetables and fruits were hardly grown. Besides potato, *quinoa,* and *oca*, the share of households growing other indigenous food crops was rather low. Livestock farming was also part of the agricultural activities among the population, and potentially offers access to animal source food, for instance meat from sheep, llama, alpaca, and chicken, and further products e.g. milk, cheese, and eggs.

The most considerable differences in farming activities among households were related to the agro-ecological zone where the villages were located. Thus, crop farming was more diverse in the zones near the lake because of the more favorable climatic conditions. Small domesticated animals also were the main components of the livestock among households located at lower altitudes. In contrast, the more distanced and more highly located residences concentrated on a few crops and significantly larger herds of sheep, cattle and/or camelids. This was reflected in the animal index constructed to be included in the housing and wealth index of the present study.

Home gardening for horticulture was not usual, and consequently the consumption of vegetables and fruits appears to be strongly dependent upon markets. Fishing was almost limited to the places located near the lake. In contrast, the traditional widespread gathering of edible plants points out that the natural resources are still being used by this population, foremost during the rainy season, which was in turn also the pre-harvest period.

4.2 Dietary diversity and food variety

In isolated settings in which fortified food or supplementation programs are not available diversification of the diet may be a key component to prevent or reduce micronutrient deficiencies. Quantitative dietary assessments are often time and cost-expensive and face some limitations due to cultural behavior and attitudes among the population. Therefore, recent research attempts to develop simple but valid proxy indicators in order to identify diet quality problems or subgroups at risk of micronutrient deficiency and efforts in the development of guidelines have also been made (Kennedy *et al.* 2011; Arimond *et al.* 2010). Compared to complex quantitative dietary assessments, qualitative food scores may provide important information in a shorter time by using simple questionnaires. In this context, the use of simple but reliable tools may be valuable to monitor progress on the dietary situation or to target interventions to specific groups (Savy *et al.* 2005). Specifically while working in developing countries, the willingness of the subjects to answer long questionnaires may be limited, and this may lead to inappropriate answers. Also the estimation of portion size may be difficult in cultural settings where eating from a common plate is usual. Moreover, food scores have been proved to reflect the overall dietary quality (Arimond *et al.* 2010; Savy *et al.* 2005; Torheim *et al.* 2004; Ogle *et al.* 2001) and to be a proxy indicator of food security (Hoddinott *et al.* 2002; Ruel 2003).

In the Latin American context, however, fewer studies have been conducted using dietary scores. In Brazil, the availability of healthy vs. unhealthy food groups (Bezerra *et al.* 2011) was evaluated at household level including urban and rural areas, but great interest was given to the relationship between diversified diet and obesity. In the Amazon of Peru a traditional food diversity score was used as a tool for predicting the nutrient adequacy for the Awajún, an indigenous group (Roche *et al.* 2007). However, comparisons to these studies are difficult due to methodological differences in the applied scores. Literature review done for the current research revealed that there has been no research conducted in rural areas of the Andes using DDS and FVS as developed by the current guidelines.

<u>*Diet composition measured with DDS and FVS*</u>

In the following discussion within this section and for comparison purposes, the sample size of the longitudinal study was taken into account. With a median DDS of 6.7 out of 14 food groups and a median FVS of 11.0 out of 61 identified food items over the three seasons, Aymara women show a medium diversity somewhat higher than the scores calculated for some African populations. Nevertheless, FVS suggests that very few food items are commonly used compared to the ample variety available in the field, the environment, and from the local markets. Savy and her research team (Savy *et al.* 2005) found that women in a rural area of Burkina Faso had rather low DDS and FVS (5.1 food groups and 8.3 food items respectively). Meanwhile, Keding and her team found similar results in rural Tanzania, with a DDS of 6 and FVS of 8.3 (Keding *et al.* 2012). The main difference from the present study is that two additional food groups were considered, namely drinks and condiments used by the former researcher team and sugar and beverages by the latter. In the present study, food groups considered were those contributing to a balanced diet in terms of macro- and micronutrients as proposed by the FAO (Kennedy *et al.* 2011). However, 14 food groups instead of nine as in the women dietary diversity (WDDS) were considered as most appropriate in this context. In general, food scores are usually adapted or simplified according to the research's aim and the target population such us urban and/or rural, women, children, or households. A minor drawback, however, could be the lack of consensus about which cut-off points should be the most appropriate using the food scores to identify subjects with low, medium, or high dietary diversity and therefore being able to evaluate subjects or population groups at risk of nutrition insecurity or those with low dietary quality. For analysis purposes, DDS and FVS data are often divided in terciles. Once the diversity levels of the target population are determined, the next indispensable step should be the evaluation of the consumed food groups and food items according to the diversity levels. Therefore, cut-offs may vary depending on the cultural context, and this condition makes it difficult to set overall recommendations.

Regarding the most consumed food groups among the population (> 50%), the overall dietary composition was based on six food groups:

1. Tubers, consumed by all women in each survey.
2. Cereals, whereby a high proportion (approx. 71% in average for all seasons) of the women consumed refined wheat flour, pasta, or bread. Almost half of them consumed rice, while local grains such as *quinoa* was consumed by about one third of the participants.
3. Pro-vitamin A-rich vegetables, with modest amounts of carrots and pumpkin commonly added to soups and stews.
4. Other vegetables such as onion and tomato, often used as condiment for many of the traditional dishes.

5. Legumes, with an average of 67% of the women who consumed then throughout the year, and the highest proportion found in the rainy season (Feb.-March).
6. Oil and fats, whereby on average 83% of the women consumed vegetable oils, and less than 3% used lard or butter.

The proportion of women who consumed these food groups was similar in each season. There is a markedly almost vegetarian diet with low consumption of ASF, even in those villages in which livestock farming was more frequent among the households. Also the prevalence of consumed dark green leafy vegetables and fruits is remarkably low. Not only in similar communities of Peru, but also for instance in a rural community of highland Ecuador, animal foods, fruits and vegetables were found to account for a small proportion of the diet (Berti *et al.* 1998). Within the group of cereals, more than 50% of all women consumed wheat-derived products and rice in each season (s. Table 3.10).

Besides the general diet, which was strongly tuber and cereal-based, differences between the women with the lowest and the highest diversity could be also identified. Thereafter, the lowest DDS tercile showed the strongest plant-based diet with only five food groups consumed by more than 50% of the women and very few of them consumed eggs, fish, milk, fruits, and dark green leafy vegetables. In contrast, the highest tercile was characterized by seven food groups consumed by more than half the women within this level. Flesh meat and legumes were consumed in addition to the food groups consumed by the lowest tercile. Other animal products were also more frequently consumed in this group according to the average of all 24h recalls (s. Table 3.11), suggesting a better dietary quality than their counterparts with the lowest DDS.

With relation to another commonly consumed food group, namely oils and fats, there is a general agreement that their contents in the native diet of Andean highland communities is very low (Mazess *et al.* 1964; Picón-Reátegui 1978; Berti *et al.* 2010). Regardless of the role of fat as an energy supplier, the absorption of fat-soluble vitamins such as vitamin A also depends on dietary fat intake. Even though food scores are focused on diversity and not on food amounts, the repeated observations in three different periods of the year and the visits in the communities while conducting the questionnaires were in accordance with the agreements from the aforementioned scholars about the small amounts of oil used for cooking. Moreover, about 36%, 27%, and 22% of the women within the low, medium, and high DDS levels for all year did not mention consuming oil/fat. During the surveys, special attention was given to ask accurately for all components of the eaten meals reported by the women in order to avoid omitting any food item. Therefore, the consumption prevalence of oils and fats estimated with the DDS reflects the general infrequent use of this food group in many households.

Regarding the meat consumption, differences in the type and frequency could be observed. On average, about 44% of the women consumed meat at all times. The most commonly consumed meat was lamb (33% on average over the year), compared to the autochthonous camelids llama and alpaca that were considerably less frequently consumed, mainly as dried meat *charqui*[6]. Llama and/or alpaca meat and *charqui*, also available at the local markets, were only consumed by few women (7% in average over the year), and almost only in the more isolated village Arcunuma.

Due to the differences between villages in terms of crop and livestock farming, home gardening, and gathering practices, it is not surprising that DDS and FVS differed between them as well. Keding and her team also found different DDS and FVS between three districts of Tanzania and underscored major regional and minor seasonal differences of dietary habits possibly influenced by ethnicity, agro-ecological zones and nutritional habits (Keding *et al.* 2012). In the present study, the general characteristics of the diet among the participants were supposed to be similar due to the same ethnicity, but the differences in consumed food groups and food items suggest that not only the agro-ecological zones but also the integration to market systems and presumably eating habits influence the dietary diversity and food variety. For instance, Aychuyo and Perka showed a great variety in cultivated crops and a high proportion of households keeping sheep, pigs and poultry (s. Table 4.2). However, the consumption of ASF was lower in Perka than in Aychuyo. Moreover, the former had a more time-consuming way to the local markets than the latter, and this might enable or inhibit the purchase of additional food to complement the diet. Consistent with this assumption the proportion of women consuming dark green leafy vegetables and fruits in Aychuyo was higher than in Perka in each season.

The overall results obtained about the dietary composition and culturally related nutritional habits are consistent with other studies conducted in similar Andean communities (Mazess *et al.* 1964; Picón-Reátegui 1978; Leonard *et al.* 1988; Leonard *et al.*

[6] Dried and salted meat commonly found in certain Latin American countries such as Peru and Bolivia. This form of freeze drying was used to preserve the meat for a long period and was already known in Pre-Columbian times (Mateo *et al.* 2009).

1993; Berti *et al.* 1998; Berti *et al.* 2010). Even in the past as in the present time, traditional eating habits in the region remain similar and rely on the consumption of local cultivated tubers, grains, and legumes. Since vegetables and fruits are hardly grown, their consumption and also the use of oil/fats and identified refined carbohydrate (wheat flour, pasta, bread, sugar) in the diet point to the influence and importance of the local markets.

Seasonality of dietary diversity and food variety

In many poor regions of the world, seasonality may implicate an adaption of the dietary consumption, changes in dietary patterns towards inadequate nutrient intake, and negative consequences on the individual's health and nutritional status (Savy *et al.* 2006). Therefore, it was of interest to examine seasonal variations in the dietary diversity of the Aymara women.

Different than expected, the mean DDS of the participants was almost similar in every season regardless of the total sample size for each survey or the cohort (s. Table 3.8). At the first glance, the dietary situation of the Aymara women reflected with DDS did not show seasonal changes. This was confirmed with the mixed model that included all available cases of the three surveys and tested seasonality which was not statistically significant. In a similar way, the Friedman's two-way ANOVA that considered related samples i.e. the longitudinal group of women (n = 147) was not significant either. The distribution of the women according to the DDS showed certain extreme values, for instance in the rainy season with the lowest score of two food groups. Surprisingly, even in the period of food abundance (June-July) low scores for three and four food groups could be observed among the participants (Figure 4.6). Some possible reasons can explain these results. The first one suggests that women presumably maintain similar diet patterns in terms of food groups across the seasons. In this case, seasonal differences are expected to be related to food quantity rather than to dietary diversity. The next aspect is referred to the period in which the surveys were conducted. Because of logistical reasons, the first survey was set to begin late February after the carnival festivities. According to the collected information, the food shortage usually persists until February. It would be reasonable to expect a more limited dietary diversity. Given the present results, however, only slightly and statistically insignificant differences were found between the first and second surveys. Regarding the DDS in the third season surveyed, although a greater proportion of women reported usual food scarcity, the distribution of DDS did not show markedly lower values. Savy and her research team also found that the period of cereal shortage in rural Burkina Faso did not coincide with lower dietary diversity. Moreover, the authors suggested coping strategies of women using wild foods and other available foods during the rainy season in which the survey was conducted (Savy *et al.* 2006).

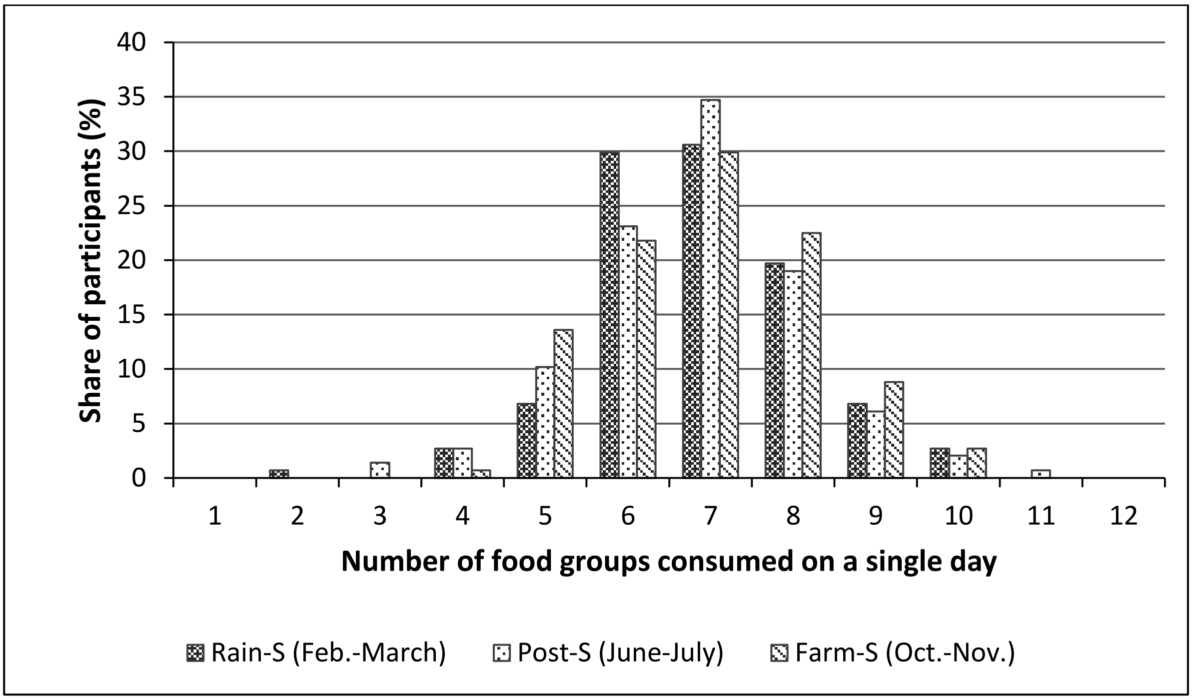

Figure 4.6 Distribution of the population according to the DDS in a given season (n = 147)

Lack of seasonality in DDS has also been reported by Hatløy *et al*. in rural and urban areas of Mali at the household level (Hatløy *et al.* 2000).

Using FVS, more detailed information was obtained about specific food items consumed in each period. In this case, not only FVS as food score but also the consumption of certain food items showed seasonal changes. Even though not distinctive, the seasonality of FVS was confirmed with the mixed model ($p = 0.001$) for all available data and with the Friedman's test ($p = 0.006$) for the cohort sample. Further pairwise comparisons between the marginal estimated means revealed significant differences in FVS. Hence, the food variety in June-July was significantly higher than the one in February-March ($p < 0.001$) and in October-November ($p = 0.013$). Figure 4.7 depicts the distribution of the FVS in each season.

However, since DDS represents the number of food groups consumed over the previous 24h, further attention should be given to the specific food groups that were consumed in each period. Thereafter, the food group "legumes" revealed a seasonal change between the rainy (Feb.-March) and the post-harvest (Jun.-Jul.) periods, p = 0.017. Further comparisons between seasons revealed that the proportion of women that consumed legumes in February-March was the highest (72.1%) compared to June-July and October-November (60.5% and 69.4%, respectively), but the differences were statistically significant between the first and the second season only (p = 0.019). The most commonly consumed legume was the broad bean. The seasonal change of broad beans was quite similar to the food group “legumes” (p = 0.003).

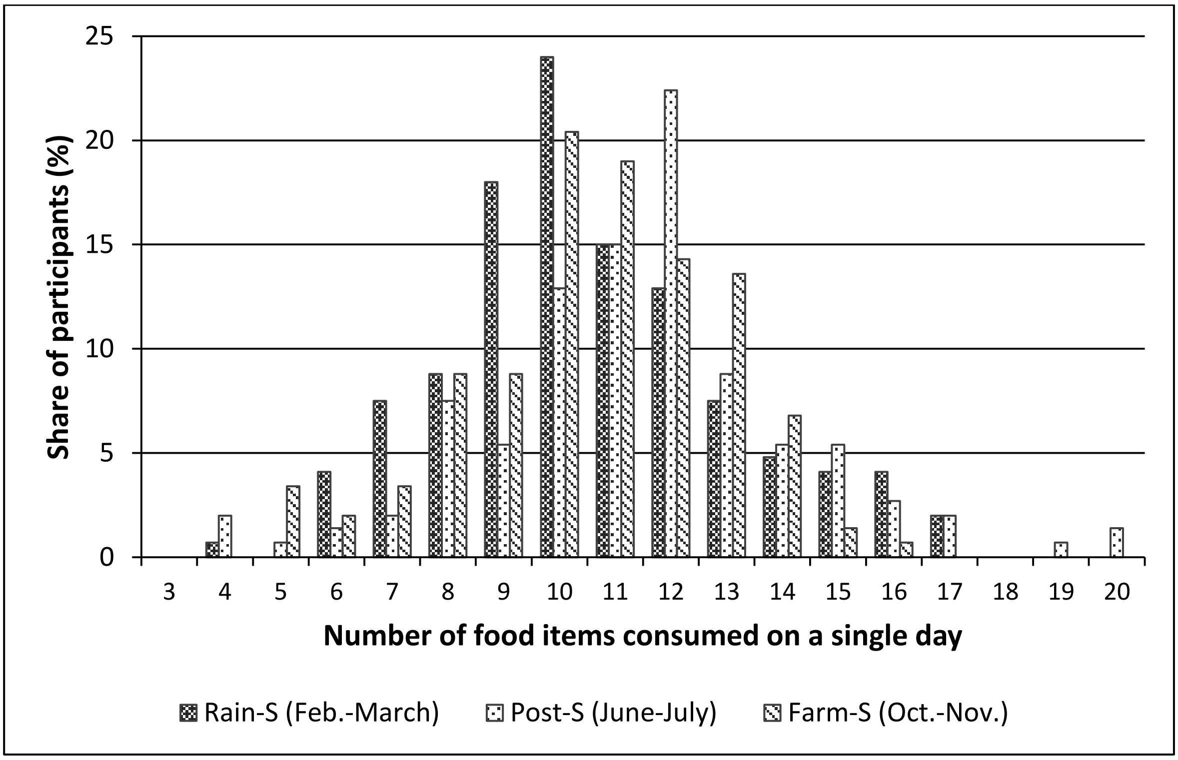

Figure 4.7 Distribution of the population according to FVS in a given season (n = 147)

Specifically, the proportion of participants that consumed broad beans was statistically higher in the first season than in the second one, p = 0.002 (Table 3.9). The consumption prevalence of legumes (i.e. broad beans) was similar in the beginning of the year as well as in the farming season (Oct.-Nov.). This coincides with the period of food shortage indicated by many women (November until February). It has to be noted that the perceived “food shortage” for the women was related to the depletion of their own produced and stored staple food, mostly tubers and cereals. In rural areas from Benin and Burkina Faso, a similar behavior during the periods of cereal scarcity has been reported. Thus, a dietary shift towards the consumption of pulses (Van Liere MJ in Savy et al. 2006), or an increased consumption of wild foods were observed (Savy *et al.* 2006). Additionally, broad beans were one of the crops that began to be harvested during the first season, and it was observed that green broad beans were often used in stews and also eaten raw as a snack when collected from the field. In the posterior survey periods, only dried stored broad beans were reported.

As expected, due to the harvest that even continued during the second survey in some households, the food variety was the greatest in this period. After potatoes, the most frequently cultivated crops were barley, broad beans, and *quinoa* (s. Tables 3.5 and 3.6). Nevertheless, food variety also means that several food items may belong to the same food group, and these changes are not identified with DDS. Hence, FVS was more sensitive to seasonal variation. Certain food items showed a seasonal nature, i.e. they were consumed merely or mainly in one season. For instance some indigenous species such as *olluco* (*Ullucus tuberosus*) and *isaño* (*Tropaeolum tuberosum*) were merely consumed in the post-harvest season with 6% and 5% of the women who mentioned consuming them, respectively. Meanwhile, although identified in all surveys, *oca* (*Oxalis tuberosa*) was mainly consumed in the post-harvest season by 25% of the women. With respect to this finding, the consumed seasonal crops do not seem to differ from traditional patterns observed and reported by other scholars (Mazess *et al.* 1964; Berti *et al.* 1998). Mazess and Baker, for instance underscored the low seasonal variation in some kind of foods e.g. *chuño*, barley, wheat flour, meat, and onion, while most of the highland tubers such as *olluco* and *oca*, but also dairy products are seasonal foods.

With regard to fruits, the proportion of women who stated that they consumed them was low. Nevertheless, the frequency of consumed citrus fruits e.g. oranges (around 14%) and mandarins (6%), was significantly higher in the post-harvest period compared to the other two seasons with few or no women who consumed them ($p < 0.01$). It has to be noted that citrus fruits are typical for the winter period in the region (June-August). A seasonal change within the pro-vitamin A-rich vegetables could also be identified. Therefore, the proportion of women who consumed pumpkin was significantly higher in June-July (68%) than in October-November (53%). Within the food group of dark green leafy vegetables and according to the 24h recall, *muña* (*Minthostachys mollis*) and wild mustard (*Brassica campestris*) were mostly consumed in February-March, and frequency differences between this and the other two seasons was significant at the 0.05 level. As confirmed with the list of edible plants gathered by the women during the rainy period, these two plants were some of the most commonly mentioned (s. Box 1 p 103). It has to be emphasized that even when some food items were rather used as herbal infusions, they also were frequently used for culinary purpose. Given the frequency of consumption in certain periods of the year, omitting them in the food scores could result in neglected information when associations with health and nutritional status have to be examined. This was the reason for inclusion of these plants into the dark green leafy vegetables. Additionally, *quinoa* leaves were consumed by only one participant. It is worth mentioning that the international interest in *Chenopodium spp.* is growing increasingly due to its nutritional value not only as a grain crop but as a leafy vegetable (Repo-Carrasco *et al.* 2003; Bhargava *et al.* 2008).

Within the types of meats consumed by the women, a significant difference was identified in the consumption prevalence of *charki* from sheep or dried sheep. The highest prevalence was found in the post-harvest and farming seasons (s. Table 3.10). Nevertheless, only a few women reported the consumption of this product.

Regarding the farming or sowing season, it coincided with the beginning of the food shortage. The increasingly stronger dependence on markets seems to lead to the consumption of other food items in order to replace certain ones consumed in prior months. Hence, the consumption of canned fish, onion, and tomato according to the 24h recall was more frequent in October-November. The consumption prevalence of tomato and onion increased from the beginning of the study until the last survey period. The difference between February-March and October-November was statistically significant for onion and tomato, respectively (s. Table 3.10). Although fish, regardless of canned or fresh from the sea or from the lake, was not frequently consumed in the population, the consumption prevalence of local fish was similar in all seasons with around 13% on average. In contrast, even though consumed by few women, the frequency of canned fish was higher by the end of the year (6%) compared to February-March (approx. 3%) and June-July (<1%) (s. Table 3.9). In deed, joining some meals together with the participants and their families allowed the observation that in this time of the year, canned or local fresh fish, prepared with chopped tomatoes, chili, and onion, was usually served with the main dish containing for instance potatoes, *chuño*, and dried broad beans.

<u>Utilization of indigenous food</u>

Regarding the consumption of indigenous crops such as *quinoa*, *kañihua* (*Chenopodium pallidicaule*), maize, *olluco* (*Ullucus tuberosus*), *isaño* (*Tropaeolum tuberosum*), *oca* (*Oxalis tuberosa*) and *tarwi* (*Lupinus mutabilis*) throughout the year, in general, a small proportion of women stated that they consumed them in each of the three surveys. Taking *tarwi* as the first example, although its cultivation was reported, no consumption was identified in any of the three survey periods. This could be due to the fact that *tarwi* was more commonly grown in Aychuyo, and it is usually consumed as snack than as component of the meals. However, its consumption was not stated in the surveys. Moreover, a considerably high proportion of the households reported *tarwi* as being grown for sale. It also has to be mentioned that a single 24h recall used for the construction of the food scores does not necessarily cover all consumed food items in the whole season, and infrequent food items such as *tarwi* can remain unreported. A second example is *quinoa*. It was grown by 68% of the participants' households, but reported only by about 33% of them over the year. One reason could be the consumption fluctuation during the days while conducting the dietary assessments. However, almost the same women were those who consumed this crop in each survey. In general, the food groups selected by each participant tended to be similar over the year. This suggests that besides food availability, eating habits also play a role in the selection of the diet's components.

A third example is the case of *kañihua*, an indigenous grain widely cultivated by the Incas at the time of the conquest but nowadays only grown in the Peruvian and Bolivian Altiplano (s. Box 1 p 103). In this study, it was only grown by about 10% of the households, but consumed by not more than 2% in each season. While only one woman in Ccota, one of the villages near to the lake, stated growing this grain, *kañihua* was only produced in Arcunuma, the most highly situated village in this study. Considering wheat and including its derived products (e.g. bread, noodles, and flour) resulted in a large proportion of participants that consumed either one or all wheat derivate foods in the three surveys. Palatability reasons and individual eating habits can also be the answer to this outcome. During informal group discussions with the participants a frequent statement was that always consuming their own produced food is monotonous. Another statement was that *quinoa* and other traditional foods are time and energy-intensive in their processing and preparation before they can be consumed. Instead, noodles or rice can be prepared within a few minutes and are perceived as popular among other household members such as children and young adults (s. Box 2 p 110). Some authors have explained dietary changes in many indigenous populations worldwide as result of –among other reasons – commercialization and an increasing reliance on market food (Kuhnlein *et al.* 1996). The dependency on markets, however, does not guarantee a more diversified and balanced diet in terms of energy and micronutrients. Thereafter, micronutrient deficiencies and co-existing of obesity and degenerative diseases may be the result.

In spite of the availability and affordability of meat from camelids such as llama and alpaca, there was a low prevalence of consumption in all survey periods. One reason for the underutilization of llama and alpaca meat in spite of their favorable nutrient composition is that they have historically been and are still marginalized as “food of the poor” (Healy 2004). Purchase of the other meat sorts implies monetary power, while the price of llama or alpaca meat in the local markets is more affordable for low income households. In the last century, the nutritional value of llama and other camelids’ meat has been revaluated because of their high protein and low cholesterol content which makes this product interesting for the international markets as exotic or organic meat (Campero 2004). Another indigenous animal is the guinea pig, whose consumption did not play a role among the participants, even when they can be easily kept and are a good protein source and cash income for the household (Lammers *et al.* 2009) (s. Box 1 p 103).

Box 1. The nutritional potential of selected Andean foods

1. Potato (*Solanum tuberosum spp*): The center of domestication of this crop and the richest gene pool is found in the Andes, with an estimated number of 2,000 to 3,000 varieties [1]. In general, though the nutrient content may depend on and vary according to the variety of potato, the most important nutrients are dietary fiber, ascorbic acid, potassium, and total carotenoids [2]. Moreover, studies on the chemical composition of native potato varieties have revealed that this important food crop can supply one with several micronutrients such us Zn, Fe, and dietary antioxidants [3,4] (Gabriela Burgos *et al.* 2007; Andre *et al.* 2007)
2. *Quinoa* (*Chenopodium quinoa* Willd.): The nutritional value of this pseudo cereal relies on the unusual and favorable composition between oil and protein. Because of the high protein quality, *quinoa* in combination with other cereals might be a good meat substitute. Additionally, this grain is rich not only in minerals such as calcium, iron, zinc, magnesium and manganese but also in other bioactive compounds such as vitamins E and B2, and fatty acids such as linoleic acid (Omega 6) and linolenic acid (Omega 3)[5].
3. *Kañihua* (*Chenopodium pallidicaule* Aellen): This is another native Andean pseudo cereal and as in the case of *quinoa*, its composition of essential amino acid is similar to the milk protein, casein. Its potential use for weaning food mixtures can contribute to solving malnutrition among children [6]. The high dietary fiber content is another beneficial property of this crop for the local diet and a good alternative to traditional cereals at the international level [7]. Recent studies have also shown high contents of antioxidants and polyphenolic compounds which might be beneficial for health [8].
4. *Tarwi* (*Lupinus mutabilis*): This leguminous species is considered the soybean of the Andes because of its high contents of oil and protein. Due to anti-nutritional substances, the seeds require processing before consumption. The nutritional value is not only important in the traditional consumption forms of this food crop but also for industrial utilization, for instance for bread-making, improving the nutritional composition of the product [9].
5. Camelids: among the Andean camelids, the llama (*Lama glama*) and alpaca (*Lama pacos*) are domesticated species with a high importance as a protein source for the Andean population. The reduced fat and cholesterol contents are further beneficial properties for human nutrition, which are increasingly appreciated by consumers from North America and Europe [10].
6. Guinea pig (Cavia porcellus): This species of livestock is less common but suitable for meat production to improve household nutrition. Furthermore, this small non-ruminant animal can be easily kept near the family and be a potential source of cash income in the context of rural smallholders [11].
7. Local plants: There are a broad number of wild, edible native plants in the Andes. Little is known about many of them in most cases. For instance, even about the most widely distributed and well-known species *Minthostachys mollis* (*muña*) only a few studies are available at all. For instance, the South American mint *Minthostachys* plays an important role in the region and is used for medicinal, aromatic, culinary, and commercial purposes [12]. However, in general, even in tables on food composition (e.g. the Peruvian food composition database) less detailed information is reported concerning micronutrient contents of edible indigenous herbs.

[1] (Brush *et al.* 1981),[2] Burlingame *et al.* 2009,[3] Burgos *et al.* 2007, [4] Andre *et al.* 2007, [5] Vega-Gálvez *et al.* 2010, [6] Repo-Carrasco *et al.* 2003, [7] Repo-Carrasco *et al.* 2009, [8] Peñarrieta *et al.* 2008, [9] Jacobsen and Mujica 2006, [10] Cristofanelli *et al.* 2005, [11] Lammers et al. 2009, [12] Schmidt-Lebuhn 2008

Associations between consumption patterns and selected socio-economic and demographic characteristics

Beyond the food items included in the DDS and FVS, excluded food items were also considered in order to evaluate the use of purchased, processed foodstuffs throughout the seasons. Hence, the extent of non-local products compared to traditional foods could be analyzed. Additionally, based on the information gained on agricultural production and the dietary assessments, the consumption of certain foods over the year was further examined as well as differences within sources of income, SES levels, and the villages. Since fruits and vegetables reported in the dietary assessments were purchased by almost all women, this group was examined as well, but separately from the category "commercial foodstuffs". Fruits and vegetables considered are those listed in Table 2.3., with the exclusion of local and culinary plants. The selected food items for both categories "traditional" and "commercial foodstuffs" are listed in Table 4.3.

Table 4.3 List of traditional food items and commercial foodstuffs available in the region

Traditional food items	Commercial foodstuffs
Potato	Wheat
Quinoa, quinoa leaves	Wheat flour
Broad bean	Pasta
Barley	Bread
Oca	Rice
Tarwi	Maize flour
Kañihua	Evaporated milk
Olluco	Sea fish
Maize	Canned fish
Isaño	Vegetable oil
Fresh milk (from cow)	Butter
Fish from lake	Coffee
Lamb, *charki* from lamb	Black tea
Llama, *charki* from llama	Sugar and sweets
Alpaca, *charki* from alpaca	Soda drinks, beverages
Guinea pig	
Choqa	
Local plants	
Culinary plants	

In general, the median (IQR) of four local foods (3 to 5) out of 22 on average for all seasons suggests that in spite of the variety in available local crops and livestock, resources are not fully utilized. Additionally, the low productivity because of small-scale farming systems is presumably not sufficient to supply food needs of the households throughout the year. No significant seasonal change in the number of utilized local foods was found. There were no significant differences in the median number of used local foods between the villages, income source groupings or levels of SES. Similarly, the number of purchased commercial foodstuffs at the population level did not show changes over the three seasons (s. appendix Tables 9.5 and 9.6). However, differences between sources of income in the rainy and farming season (both $p < 0.01$) revealed that women who stated that their households earned income from monthly salary/wages or from both agricultural and an additional activity in the month before the survey purchased slightly more commercial foods than women who earned income coming from agricultural activities only or from seasonal/unskilled activities (Figure 4.8).

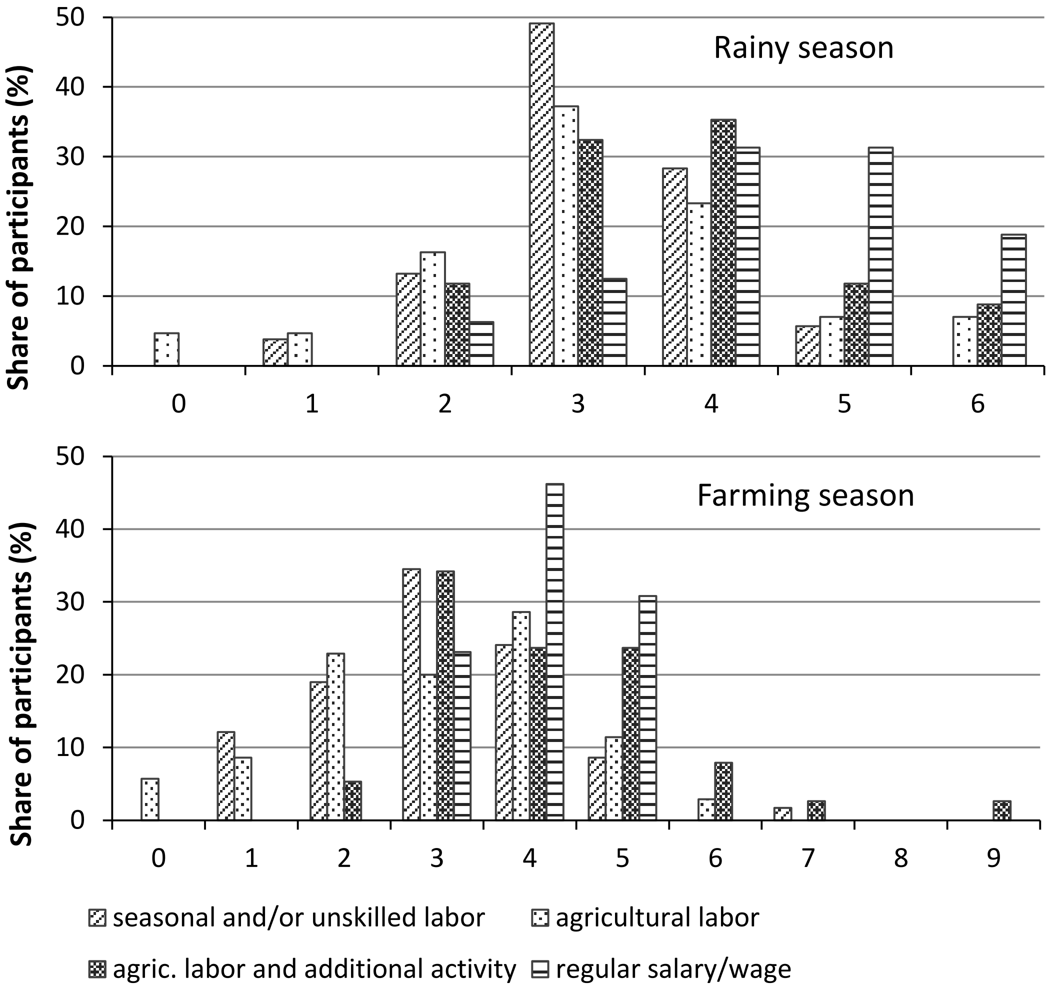

Figure 4.8 Number of purchased commercial foodstuffs and distribution according to the source of income ($p < 0.01$)

The SES also played a significant role. Thus, women in the low and middle level purchased fewer processed foods than the wealthier women, and this pattern was similar in all three survey periods ($p < 0.01$) (Figure 4.9).

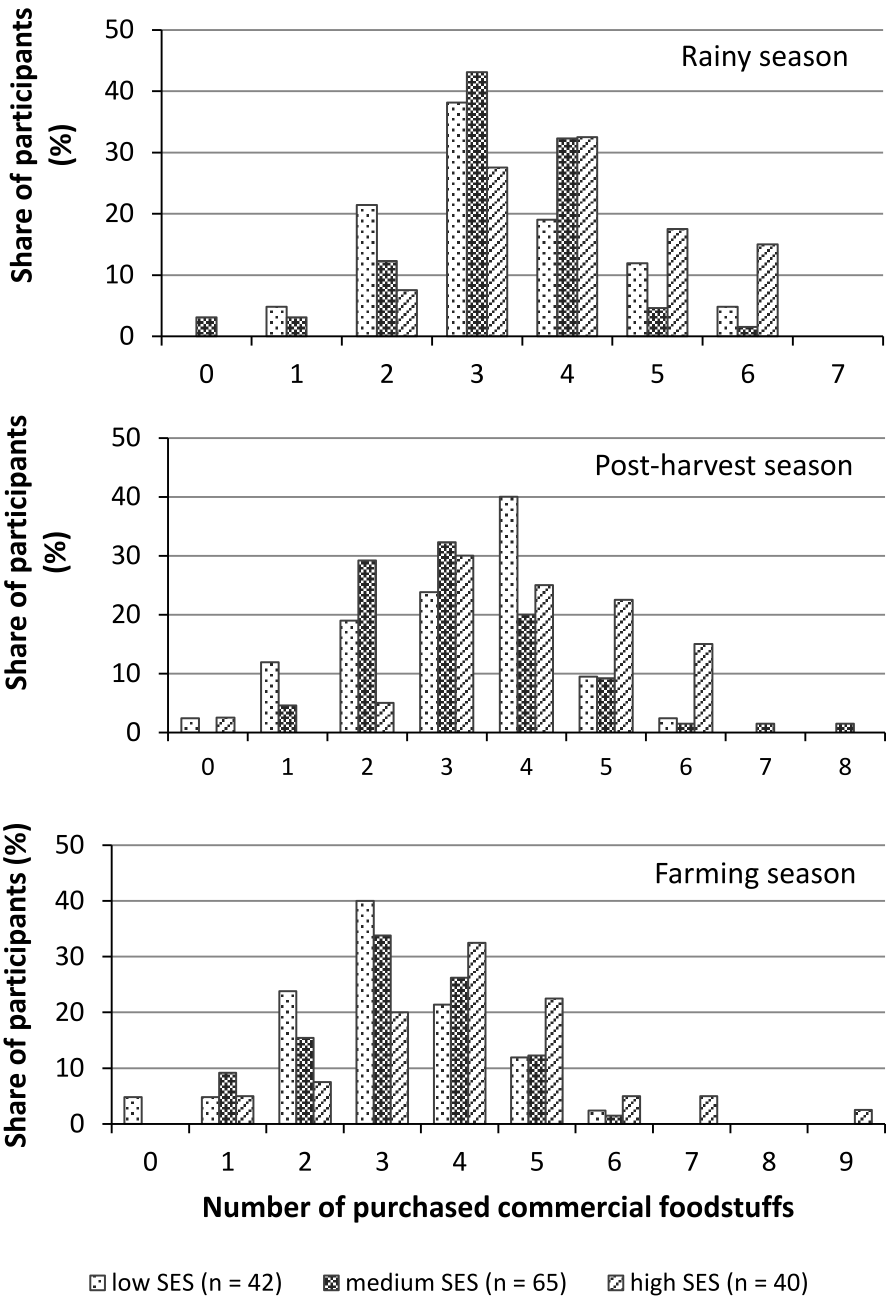

Figure 4.9 Proportion of the participants with a certain number of purchased commercial food over the year and according to SES levels

One relevant aspect regarding the composition of the diet in the developing world is the influence of market systems on eating habits and whether the integration to those systems is disadvantageous or not. In an earlier study, changing dietary patterns in a similar Andean population were examined, and the authors agreed that non-local foods were replacing traditional items (Leonard *et al.* 1988). Additionally, wealthier families were found to purchase a great variety of local and non-local products to supplement their own produced foods, while the poorer households relied on more inexpensive but less nutrient-dense items (e.g. sugar and flour). Byron found among Tsimane's households of lowland Bolivia that the upper third in average monthly income used more market foods than the middle or lower income groups (Byron 2003). In another community of Puno, Graham reported that wealthier women consumed more commercial food during the harvest and post-harvest season than their poorer counterparts, spacing out the consumption of local food over the year (Graham 2004). The present findings are in line with patterns observed in the aforementioned studies.

Also consistent with these present consumption patterns, Berti and Leonard underscored the replacement of own produced staples with store-bought grain such as rice and wheat in a rural community of highland Ecuador in a study conducted near the end of the '90s (Berti *et al.* 1998). The increasing exposure of rural settings to the market systems, even when they can be a good option to diversify the diet, seems to bring the risk of neglecting traditional food, and consequently, increasing the consumption of foodstuffs with low nutrient density.

The place of residence also showed differences in the rainy season, and this result was consistent in the next two seasons (all three seasons $p < 0.001$). In this case, the results revealed that slightly more commercial foodstuffs were purchased by the participants in Aychuyo during each season compared to their counterparts from the other three communities (s. appendix Table 9.5). Considering that Aychuyo had the nearest distance to markets, as noted above, the influence of the "Western life style" is reflected through this outcome.

Different from local and commercial foodstuffs, vegetables and fruits purchased in each period showed seasonal variation (Figure 4.10). In general, the participants used significantly more vegetables and fruits in the post-harvest season than in the other two seasons ($p < 0.001$).

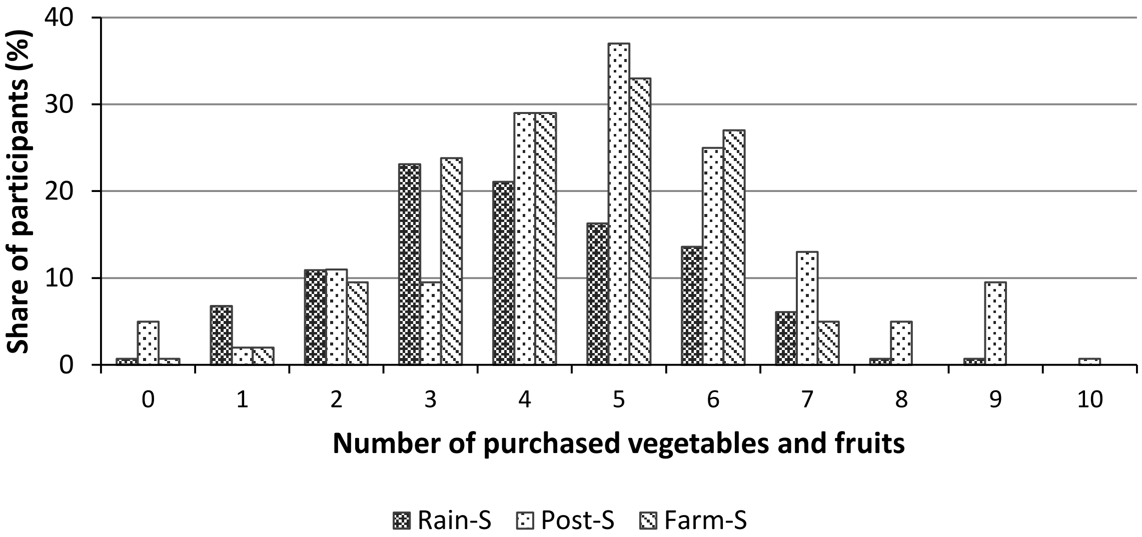

Figure 4.10 Distribution of the participants depending on the number of vegetables and fruits purchased and used in each season

Additionally, only during the rainy season did the number of purchased vegetables and fruits vary significantly between the villages ($p < 0.001$) and the SES level ($p = 0.027$), but between the types of income sources no significant differences were found. In Aychuyo a greater number of vegetables and fruits were consumed and reported as purchased compared to the other villages. Likewise, women from households with higher SES levels used more food items within these food groups than their counterparts in the medium or the lower SES levels (s. appendix Table 9.7). As previously mentioned, the rainy season was the period before harvest. Thus, overall results suggest that wealthier households could afford additional food even in times of scarcity and did not rely only on local food.

The importance of monetary power to food intake and nutritional well-being of subsistence farmers has been discussed by Graham in another rural community of Puno. She underscored the transformation of subsistence agricultural economies and the role of money in her study population. Hence, the energy stress among women was linked to the interaction of SES and seasonality. In the same study, she discussed the issue of being “cash poor” in this small farming community. Consequently, agricultural practices *per se* were not sufficient to fulfill food needs of the studied population (Graham 2004).

Aymara people are apparently undergoing a nutrition transition in favor of nontraditional foods and refined products that may worsen their health and nutritional status. On the one hand, relying on local markets seems to be indispensable to supplement their diet with micronutrient-rich food items if those are not available through homestead production. On the other hand, the potential of local biodiversity in the study region should not be neglected. In this cultural setting, important components of the dietary diversity and food variety still are the crop and livestock farming activities of the households. However, the low productivity of agricultural activities, regardless of the agro-ecological zone, results in a strong dependence on local markets which in turn are substantial for supplying a broader variety of food if the households don't produce enough and can afford additional food. Nevertheless, the increasing influence of markets without adequate nutrition education will probably continue to cause a shift from traditional to "Western" eating patterns rather than encouraging the use of their own local food.

Several interventions in other developing countries have shown that increasing the awareness of available food resources and empowering communities to make good use of local biodiversity may lead to successful micronutrient intervention programs (Frison *et al.* 2006).

DDS and FVS in the Andean context

The qualitative assessment of the food groups and food items eaten in the previous 24h before the surveys and the used calculated food scores have proved to be a good tool to describe the overall diet characteristics of the study population. Nonetheless, while assigning the food items into the food groups, some drawbacks emerged. For instance, *quinoa* and *kañihua* were assigned to the cereal group even though they botanically don't belong to this group, and their nutritional composition differs somewhat from the common cereal grains. Thus, the consumption of *Chenopodium spp.* can supply the population with high quality protein, dietary fiber, fatty acids, and minerals (s. Box 1 p 103). The next point to be mentioned was the identification of some kinds of edible clay while conducting the 24h recalls: *p'asa* and *ch'aqo.* They are dissolved in water, seasoned to taste, and consumed as a dip for fresh potatoes and other local tubers. In one study conducted in Puno, the consumption of unusual sources of nutrients was also found (Mazess *et al.* 1964). Even in the present times, these types of clay are commonly found in the local markets as small pieces. Geophagy has been practiced among Andean inhabitants since ancient times. The usage of such clays has been found in regions with a high consumption of bitter potatoes and other crops containing anti-nutrients. Thus, a digestive property has been assumed (Browman 2004). The contents of minerals such as K, Mg, and Fe suggest that these items are also consumed as dietary supplements. They also have been said to be an unusual source of calcium (Baker *et al.* 1963).

Because of the numerous native potato varieties produced in the region and the fact that different varieties were components of the same meal or consumed over the day, it may be cumbersome and less practicable asking for each variety consumed and assigning some of them to the "tubers" and other varieties to the "pro-vitamin A-rich vegetable" food groups. Nevertheless, while applying a dietary assessment method such as the DDS and FVS, it has to be considered that potatoes are the main staple crop of many Andean populations and their nutritional contribution should not be disregarded. In addition, the traditionally processed freeze-dried potato, chuño, although assigned to the "tuber" group, may show lower contents of protein and Zn, similar iron-, but higher levels of calcium than fresh potatoes (Burgos *et al.* 2009).

Box 2. Aymara attitudes towards food and health

The following is a list with some of the most common statements of the women during the research period over the three seasons:

- ✓ The older generations ate more *quinoa, kañihua*, barley. Nowadays, younger people prefer market food such as rice, noodles, flour.
- ✓ *Quinoa* requires treatment before being used for cooking (because of the saponine content).
- ✓ Grandparents used to collect wild plants while herding. Now the children prefer to eat cookies and sweets.
- ✓ Fruits are mostly purchased for the children's lunch snack at school (one woman in Aychuyo).
- ✓ Fresh meat from alpaca is popular for festivities, birthday celebrations, etc.
- ✓ Younger people are aware that they don't gather wild plants as their parents and grandparents used to do.
- ✓ Grandparents used to barter, but now it is usual to sell livestock for cash. If supplementary food is needed, one can find it in the market (one woman in Arcunuma).
- ✓ Young people don't like *quinoa* anymore (one of the older women in Arcunuma)
- ✓ Awareness of our own produced food should be desirable.
- ✓ Food is also medicine.
- ✓ Our own produced cheese, milk, and eggs are often bartered for "unhealthy food".
- ✓ Because the properties of herbs and other plants are not known any more, they (a young woman and her family) don't gather anything.
- ✓ School feeding is not good for the children because they eat different food than they get at home. This is the reason why children don't like "our own food" anymore (a woman in Perka).
- ✓ Barter trade is rather practiced within the village (a woman in Perka).
- ✓ Our own produced food is good and healthy but it is not enough.
- ✓ The type of soil is not appropriate for growing fruits as in the cities.
- ✓ Our own produced food is not enough, and therefore market food is also added for the taste.

Conclusions

The diet in the study population was characterized by a strong consumption prevalence of local tubers, mainly potato, non-local cereal products, and legumes. Although carrots, pumpkin, and onion were the most commonly used vegetables, the overall consumption prevalence of dark green leafy vegetables and fruits was strikingly low throughout the year, even in places close to markets and thus with access to a potentially greater variety of food. Additionally, the consumption prevalence of animal food sources was also markedly low in each season, namely less than 50% of the population. The main source was fresh or dried meat, mostly consumed by the women living in the highest village with greater herding of livestock and less varied crop farming. Based on these findings, it is presumed that the intake of several macro- and micronutrients for instance protein, fat, vitamin A, B12, folate, Ca, and heme iron, does not meet the individual nutrient requirements.

Further differences in consumption patterns revealed that the consumption prevalence of processed commercial food, but also vegetables and fruits, had a strong relationship to the physical access to local markets. In general, women living in environments with food sources from their own production and from markets had higher DDS and FVS than women living under opposite conditions.

The markedly high consumption prevalence of non-traditional foods (e.g. pasta, wheat flour, bread, and rice) might explain the present displacement of certain indigenous foods even if available “in the field” and at markets as well. In addition, wealthier women, women living near local markets, and women earning income from monthly salaries/wages, or from agricultural and additional non-farm activities consumed/purchased more processed foods than their poorest counterparts. Significantly more vegetables and fruits were consumed by wealthier women and those with easy access to markets.

Findings within this section suggest that regional and socio-economic rather than seasonal factors have an impact on the dietary diversity of the population. In this way, similar findings in African context (Keding *et al.* 2012) could be corroborated.

Food variety but not dietary diversity showed seasonal changes. Thereafter, food variety was the highest during the post-harvest season, in part due to the consumption of additional indigenous minor crops. Although changes in quantity are likely to occur, a similar individual diversity of consumed food groups throughout the year points out that eating habits also play a role in diet composition.

4.3 Influencing factors on the food scores

While already in the previous section regional and socio-economic rather than seasonal differences appeared to influence the consumption of certain food groups, in this section the influence of several factors on DDS and FVS within different models will be discussed. As previously shown, several bivariate correlations could be identified between the dietary scores and environmental, socio-economic, and demographic characteristics (s. section 3.2.6). However, modeling different scenarios with selected agrobiodiversity, demographic, and socio-economic indicators and controlling for each other was of interest to understand impact factors on the participant's dietary diversity and food variety.

Associations between DDS, FVS and socio-economic factors have been investigated by other authors before (Hatløy *et al.* 2000; Hoddinott *et al.* 2002). However, these studies focused on determinants associated at the household level. At the individual level, such associations have been examined as well (Torheim *et al.* 2004; Savy *et al.* 2006; Keding *et al.* 2012). While these studies were conducted in an African context, little is known in the present study region. In order to explore what factors determined the DDS and FVS in the present cultural setting, possible predicting factors were analyzed using General Linear Models (s. section 2.3). Moreover, since the seasonal variations can influence the impact of demographic and socio-economic factors on the dietary diversity (Savy *et al.* 2006), each season was analyzed separately.

As noted in section 2.3, using DDS and FVS as dependent variables, the three models were constructed in each season and adjusted for the following covariates: age, SES (the wealth and housing index), the number of household members, and the length of food shortage (number of months with perceived food shortage). The number of cases may vary in each model due to missing values; otherwise the available data of the three cross-sectional surveys were used in the analysis. Further examinations to test interactions between factors resulted in combinations with very few cases and were therefore less reliable for interpretation. Thus, the main effects on DDS and FVS adjusted for the used covariates will be discussed in the following.

Determinants of DDS and FVS in the rainy season

During February-March, also the pre-harvest period, the size of the household, SES, and the length of the food shortage played the major role in dietary diversity (model 1). Hence, the number of household members and the socio-economic status showed a positive significant effect on DDS ($p < 0.05$ and $p < 0.01$, respectively), while the length of food shortage influenced the dietary diversity negatively (s. appendix Table 9.8). After inclusion of the place of residence and the source of income from the previous month (model 2), the length of food shortage did not influence DDS anymore, but instead the new included variables. Taking into account the education level of the household's head (model 3), the place of residence was highly significant, and the final model explained 32% of the variation of DDS, slightly more than the previous model (Table 4.4).

Table 4.4 Determinants of DDS during the rainy season*

	Model 1 (n = 179)		**Model 2 (n = 178)**		**Model 3 (n = 164)**	
	p	**Partial η²**	***p***	**Partial η²**	***p***	**Partial η²**
Corrected model	< .001	.166	< .001	.319	< .001	.324
Intercept	< .001	.273	< .001	.360	< .001	.369
Age (y)	.956	.000	.508	.003	.514	.003
Household size (Number of household members)	**.013**	.035	**.025**	.030	.064	.023
SES (wealth and housing index)	**.001**	.061	**.040**	.025	.197	.011
Length of food shortage (months)	**.004**	.047	.317	.006	.227	.010
Crop variety**	.543	.007	.286	.015	.542	.008
Gathering (yes/no)	.303	.006	.621	.001	.721	.001
Place of residence (village)			**< .001**	.117	**.001**	.105
Income source***			**.020**	.058	.052	.051
Education level of the head of the household†					.217	.030
R²	.166		.319		.324	

*GLM using DDS as dependent variable

**Low (1-4), medium (5-7), high (>7)

*** Seasonal labor, agricultural labor, agric. and additional activity, monthly wage/salary

†<3y primary school, completed primary school, completed secondary school, higher degree

In other words, under consideration of all other factors and covariates, the place of residence was a relevant determinant of dietary diversity. As previously noted, this factor combined two components: the agro-ecological zone, and access to markets. Previous tests including the access to markets (close, medium, and difficult) or the altitude instead of the villages did not increase the proportion of variance explained. Indeed, the pairwise comparisons among marginal mean DDS resulted in a highly significant difference between participants living in Aychuyo, the village with a broad variety of food resources from agriculture and with a close distance to local markets, and Arcunuma, the village with limited food resources and a long distance to markets (s. appendix Table 9.8). Models 2 and 3 explained an almost similar proportion, namely 32%, of the variation of DDS, respectively, compared to approx. 17% in the first model. In this case, the models suggest that DDS may be explained by certain factors depending on the combination of them in the model and the goodness of fit is higher considering not only variables of agricultural diversity but also socio-economic and care capacity indicators.

After including education in the third model, only the place of residence had a significant effect on DDS, but the model explained only slightly more of the variation of DDS. The specific characteristics of each village seem to be of importance for the dietary diversity of the women. Replacing this factor through access to markets or the altitude resulted in a lower goodness of fit for the whole model, confirming the impact of the environment in combination with other food resources e.g. local markets.

In the case of food variety, some results were consistent with the dietary diversity. As with DDS, the household size, SES, and the length of food shortage showed a significant effect in model 1. It must be noted that SES included information about livestock inventory. Since there was no statistically significant association between consumed animal source foods and ownership of livestock, animal husbandry was supposed to be a component of the household's assets for potential monetary power in order to smooth out consumption in difficult times (Valdivia 2004), for instance, by meeting their food needs if necessary. However, in the second model, the length of scarcity periods instead of the SES level showed an additional main effect on FVS, along with the household size, the place of residence and the income source. Hence, food scarcity had a negative effect on FVS, while the number of household members showed a positive effect on this food score (The parameter estimates are shown in appendix Table 9.9). Consequently, after controlling for other variables in the model, if the households experience a long period with depletion of stored staple crops, and the next harvest period is still to be expected, the diet in terms of food variety seems to reflect this limitation as well. However, the household size appeared to be a protective factor on the women's food variety in this period of the year.

In the third model, the main effect of the length of food scarcity remained significant as well, along with the place where the women lived. The last model explained approx. 34% of the variation of FVS (Table 4.5).

Table 4.5 Determinants of FVS during the rainy season*

	Model 1		Model 2		Model 3	
	p	**Partial η^2**	***p***	**Partial η^2**	***p***	**Partial η^2**
Corrected model	< .001	.158	< .001	.323	< .001	.341
Intercept	< .001	.172	< .001	.227	< .001	.220
Age (y)	.383	.004	.836	.000	.888	.000
Household size (Number of household members)	**.029**	.028	**.007**	.043	.089	.020
SES (wealth and housing index)	**.005**	.045	.061	.021	.133	.015
Length of food shortage (months)	**< .001**	.083	**.046**	.024	**.040**	.028
Crop variety**	.794	.003	.115	.026	.229	.020
Gathering (yes/no)	.836	.000	.515	.003	.714	.001
Place of residence (village)			**< .001**	.133	**< .001**	.133
Income source***			**.035**	.051	.095	.042
Education level of the head of the household†					.294	.025
R^2	.158		.323		.341	

*GLM using FVS as dependent variable
**Low (1-4), medium (5-7), high (>7)
*** Seasonal labor, agricultural labor, agric. and additional activity, monthly wage/salary
†<3y primary school, completed primary school, completed secondary school, higher degree

The negative effect of food shortage periods was consistent in each model explaining FVS, suggesting that before the next harvest starts, certain limitations in the variety of food items are experienced by those participants with longer scarcity periods without their own produced staple crops available. This, in turn, could mean a certain limitation in the variety of available local tubers, cereals, or legumes, which made up a great proportion of the total number of consumed food items. In contrast, this factor does not affect the dietary diversity if other households' characteristics allow the access and consumption of different food groups, for instance better SES, a larger size of the household, and the villages' food resources from agriculture and markets. Excluding education from the models, that is, considering Models 1 and 2 only, the household size played a role in both food scores.

Even when additional pairwise comparisons were not significant (with adjustment after Bonferroni), the overall significant effect of the income sources in Model 2 showed that the marginal mean FVS of participants whose households had a regular or monthly salary/wage at their disposal were also the highest, followed by participants with income sources coming from agricultural and non-farm activities, from agricultural activities only, or from seasonal/unskilled labor (s. appendix Table 9.9).

Before the harvest, local food scarcity is an issue in many households. However, it also seems to be important how large the household is, what geographic and social characteristics the community has, and from what sources the household could generate income. In households with numerous members, diversification of activities in the slack season can be beneficial for income generation (Ellis 2000) and thus to satisfy their food needs.

Determinants of DDS and FVS in the post-harvest season

Regarding Model 1 with agricultural characteristics adjusted for the covariates, the SES, the crop variety, and gather practice had a significant effect on DDS, whereas the place of residence turned out to be the major single explaining factor in Model 2 adjusted for all other variables. This effect disappeared, however, when the education level of the household's head was added into the model, and this factor had a highly significant effect on DDS in the third model (Table 4.6).

This outcome suggests that education of the head of household had a regulating effect on the dietary diversity during this period. According to the pairwise comparison between educational levels, a larger number of food groups were consumed by the women with better educated heads in their households compared to women whose household's head had a very basic education (< 3 years primary school).

Table 4.6 Determinants of DDS in the post-harvest season*

	Model 1 (n = 156)		Model 2 (n = 156)		Model 3 (n = 143)	
	p	**Partial η²**	***p***	**Partial η²**	***p***	**Partial η²**
Corrected model	< .001	.176	< .001	.250	< .001	.310
Intercept	< .001	.293	< .001	.338	< .001	.328
Age (y)	.798	.000	.827	.000	.664	.002
Household size (Number of household members)	.603	.002	.928	.000	.821	.000
SES (wealth and housing index)	**.008**	.047	.066	.024	.413	.005
Length of food shortage (months)	.197	.011	.599	.617	.772	.001
Crop variety**	**.008**	.064	.127	.029	.058	.044
Gathering (yes/no)	**.039**	.029	.130	.016	.057	.029
Place of residence (village)			**.019**	.068	.090	.050
Income source***			.617	.012	.708	.011
Education level of the head of the household†					**.005**	.096
R^2	.176		.250		.310	

*GLM using DDS as dependent variable
**Low (1-4), medium (5-7), high (>7)
*** Seasonal labor, agricultural labor, agric. and additional activity, monthly wage/salary
†<3y primary school, completed primary school, completed secondary school, higher degree

Regarding the influencing factors on the FVS, consistent with the results of DDS for the present season, the same determinants were significant explaining the food variety in Model 1. Yet, after inclusion of additional demographic and socio-economic factors, the place of residence and the gather practice influenced the FVS (Model 2). In the third model, only gathering had a significant effect on the food variety, but the model explained only 27% of the variation of FVS, suggesting that more factors might also determine the food variety during the post-harvest season (Table 4.7).

Table 4.7 Determinants of FVS in the post-harvest season*

	Model 1 (n = 156)		Model 2 (n = 156)		Model 3 (n = 143)	
	p	**Partial η²**	***p***	**Partial η²**	***p***	**Partial η²**
Corrected model	< .001	.161	< .001	.262	< .001	.273
Intercept	< .001	.214	< .001	.271	< .001	.246
Age (y)	.231	.010	.129	.016	.478	.004
Household size (Number of household members)	.716	.001	.758	.001	.768	.001
SES (wealth and housing index)	**.017**	.038	.201	.011	.501	.004
Length of food shortage (months)	.650	.001	.597	.002	.533	.003
Crop variety**	**.012**	.058	.336	.015	.272	.020
Gathering (yes/no)	**.033**	.030	**.039**	.030	**.026**	.039
Place of residence (village)			**.027**	.062	.056	.058
Income source***			.192	.033	.523	.018
Education level of the head of the household†					.401	.023
R²	.161		.262		.273	

*GLM using FVS as dependent variable
**Low (1-4), medium (5-7), high (>7)
*** Seasonal labor, agricultural labor, agric. and additional activity, monthly wage/salary
†<3y primary school, completed primary school, completed secondary school, higher degree

Even though the univariate tests between the SES levels and both the dietary diversity and food variety showed significant associations throughout the year (s. Table 3.13), many other factors may interact and influence each other “in the real world”. A possible reason for the lack of significant effect of the selected socio-economic factors in this season may be of traditional nature. It is reasonable to expect that in this time of the year, all households consume their own produced food as the first option to meet food needs. Besides wealth and monetary power, non-monetary trading e.g. “*trueque*” (barter trade) is known to buffer cash limitations in many Andean regions (Martí *et al.* 2007; Ferraro 2011). During the surveys, a very small number of women reported barter trade as option to get additional food if needed. This was the reason why barter was not considered for further examinations. Yet, it is probable that more women practiced barter trade in an informal and occasional form than perceived, leading to under-reporting.

In this season, after controlling for all selected confounders, the relevant difference in DDS among the participants seems to be the educational level of the household's head. Though a large proportion of households had a male head, and the women's partner showed an overall better educational level, there was a significant association between the women's education and the one of their corresponding partner (spearman's rho $\rho = .604$, $p < 0.001$). The present outcome, in turn, would imply that these women were more likely to make better food choices if the head of the household had higher educational levels. In other words, they are more likely to adequately combine their own produced food with additional items from different food groups using their monetary power and further non monetary options in order to diversify the household's diet. Further comparisons between educational levels after adjustment with Bonferroni revealed that the mean DDS of women with "better educated head of households" was significantly higher than all other education groups. Additionally, even if not always significant, DDS and FVS increased with a better educational level of the head of the household in each survey period (s. appendix Tables 9.8 – 9.13).

In light of the fact that meals consumed by the women were mainly prepared by themselves and thus it may also reflect the dietary diversity of other household members such as younger adults and children, the present results show evidence of the impact of the education component in order to improve the quality of the household's diet. The positive influence of education on dietary diversity has also been reported by another research team in rural Burkina Faso. Yet, different from the present results, the significant effect of this factor was found during the period of cereal scarcity, suggesting a protective function in this cultural setting (Savy *et al.* 2006).

In general, the third model explaining DDS accounted for approx. 31% of its variation. In contrast, FVS was poorly explained by the used models, suggesting that further components may influence the food variety in this season. However, the gathering of plants as food sources and its relevant effect on FVS should not be disregarded, since edible wild plants may contribute significantly to the overall micronutrient intake (Ogle *et al.* 2001) and are part of agricultural systems and of the human diet in many cultures worldwide (Grivetti *et al.* 2000). In addition, the importance of wild and underutilized plants not only as food sources but also as medicine has been stressed by many authors (Grivetti *et al.* 2000; Macía *et al.* 2005; Cordeiro 2012).

<u>*Determinants of DDS and FVS in the farming season*</u>

During this period, the results obtained in all three models revealed that the level of crop variety cultivated by the farmers had a significant impact on dietary diversity when considering all other selected factors. This, in turn, suggests that women with sufficient self-produced stored food (e.g. tubers, cereal grains, and pulses), even available in this period of the year, could reach a broader dietary diversity compared to those who had a limited cultivated variety and, presumably, not enough staple food to save and store for scarcity periods. Moreover, the place of residence also played a role in both model 2 and 3. In the third model, the inclusion of the education component resulted in a better goodness of fit, explaining 26% of the variation of DDS. However, education was not a significant influencing factor on the dietary diversity in this season (Table 4.8).

Table 4.8 Determinants of DDS in the farming season*

	Model 1 (n = 154)		Model 2 (n = 152)		Model 3 (n = 141)	
	p	**Partial η^2**	***p***	**Partial η^2**	***p***	**Partial η^2**
Corrected model	.002	.139	< .001	.238	.001	.260
Intercept	< .001	.370	< .001	.416	< .001	.348
Age (y)	.488	.003	.384	.005	.706	.001
Household size (Number of household members)	.765	.001	.739	.001	.988	.000
SES (wealth and housing index)	.101	.018	.436	.004	.805	.000
Length of food shortage (months)	.261	.009	.857	.000	.357	.007
Crop variety**	**.002**	.079	**.044**	.044	**.047**	.048
Gathering (yes/no)	.355	.006	.402	.005	.583	.002
Place of residence (village)			**.005**	.089	**.004**	.102
Income source***			.298	.026	.522	.018
Education level of the head of the household†					.270	.031
R^2	.139		.238		.260	

*GLM using DDS as dependent variable
**Low (1-4), medium (5-7), high (>7)
*** Seasonal labor, agricultural labor, agric. and additional activity, monthly wage/salary
†<3y primary school, completed primary school, completed secondary school, higher degree

With respect to the determinants of FVS during this season, three influencing factors could be identified in the third model, namely the length of food shortage, the place of residence, and the education level of the household's head. This model accounted for approx. 24% of the variation of FVS, while both Models 1 and 2 poorly explained the food score, with 8% and 19% respectively (Table 4.9). Moreover, in spite of the negative bivariate correlation between the length of food scarcity and FVS, the former showed a positive effect on food variety after controlling for all other factors (s. appendix Table 9.12). Presumably, the initial food scarcity and stronger dependence on market food leads to purchase of foodstuffs which otherwise would not be bought if enough stored food was available. At this point, the educational level might be protective, modulating the food choices.

Table 4.9 Determinants of FVS in the farming season*

	Model 1 (n = 154)		Model 2 (n = 152)		Model 3 (n = 141)	
	p	**Partial η²**	***p***	**Partial η²**	***p***	**Partial η²**
Corrected model	.078	.082	.003	.194	.003	.239
Intercept	< .001	.286	< .001	.326	< .001	.269
Age (y)	.693	.001	.411	.005	.859	.000
Household size (Number of household members)	.203	.011	.441	.004	.422	.005
SES (wealth and housing index)	**.030**	.032	.195	.012	.728	.001
Length of food shortage (months)	.488	.003	.055	.026	**.026**	.039
Crop variety**	.069	.036	.524	.009	.323	.018
Gathering (yes/no)	.554	.002	.563	.002	.909	.000
Place of residence (village)			**.002**	.099	**.002**	.113
Income source***			.165	.036	.210	.036
Education level of the head of the household†					**.049**	.061
R^2	.082		.194		.239	

*GLM using DDS as dependent variable
**Low (1-4), medium (5-7), high (>7)
*** Seasonal labor, agricultural labor, agric. and additional activity, monthly wage/salary
†<3y primary school, completed primary school, completed secondary school, higher degree

It is worth mentioning that the modifying effect of the season on the relationship between the food scores and the single selected factors over the year was also explored using mixed models for the longitudinal design of the study. Hence, interactions between season and place (village), and source of income, respectively, showed a significant effect on food variety (both tests $p < 0.01$), but not on dietary diversity (s. appendix Tables 9.14 and 9.15). Moreover, since the study aimed to explore several influencing factors on DDS and FVS within a model in each season, more attention was paid to the outcome of the GLM tests.

Comparing results with other studies

In general, DDS and FVS in this study were determined by different patterns of influencing factors according to the explored season, and this suggests that the period of the year is also relevant in order to find critical issues influencing the access and utilization of food at the intra-household level. DDS and FVS were sensitive to women's characteristics of their environment and households. Some of these results are in line with findings in other cultural settings. For instance, comparisons of women's DDS between seasons were also examined by Savy and coworkers, namely between the beginning and the end of the cereal food shortage in rural Burkina Faso (Savy *et al.* 2006). They found less marked differences between mean DDS according to socioeconomic characteristics in the period of greatest food shortage than in the beginning and agreed that the latter was the most sensitive period to identify vulnerable groups. In the present study, the end of the food shortage corresponded to the survey in February-March, and more socioeconomic factors were significantly associated with DDS and FVS than in the beginning, i.e. October-November. Ideally, the food scores as proxy indicators of food security should help identifying vulnerable groups, and enable the development of programs adapted to the individual needs of the target population. At the household or individual level, it is of interest to identify, for instance, critical periods for food access throughout the year. In the indicator guide from FANTA, Swindale and Bilinsky recommend collecting the data during the period of greatest food shortage i.e. prior to the harvest (Swindale *et al.* 2006). Given the evidence from other studies such as the one in Burkina Faso, there is no general agreement on what should be the most adequate period to capture food insecurity data. However, according to the present results, most of the associations and determinants of DDS and FVS were found at the end of the food shortage, i.e. the rainy season. Moreover, regarding the distribution of women according to low, medium, and high levels of DDS and FVS in the cross sectional sample (s. Figure 3.9), the highest proportion of women in the lowest food diversity and food variety group were found in this period.

Similar patterns were found in the cohort sample as well (s. appendix Figure 9.2 and 9.3).

At the individual level, Torheim *et al*. found associations between DDS and the SES levels, and also the sector of residence in rural Mali. Thereafter, increasing SES was associated with a higher dietary diversity, and the more isolated sectors also had the lowest diversity (Torheim *et al.* 2004). At the household level, Hatløy *et al*. found associations between the DDS, FVS, and the SES in urban and rural areas in Mali (Hatløy *et al.* 2000). In a study carried out by Savy *et al*. in rural Burkina Faso, higher dietary scores were related to higher property levels (Savy *et al.* 2006). In addition, the used indicators of SES in each study differed somewhat from each other, but they basically are constructed on household possessions, and livestock. In the present study, additional information on housing and infrastructure characteristics complemented the constructed variable, and relevant associations with the food scores and several indicators were comparable to associations found in other studies already mentioned in this section.

Another impact factor identified in the rainy season was the income source before inclusion of education in the explored models. Thereafter, women with income from regular wages or from agricultural and additional off-farm activities showed the highest DDS and FVS during this time (s. appendix Tables 9.8 and 9.9). Therefore, it is likely that households with regular wages in the month before the survey normally have enough monetary power to afford a certain variety of food if needed. Similarly, agriculture and non-farm activities seem to ensure the food security of the households due to diversification of income sources. A positive association between higher DDS and heads of households with a secondary occupation different than agricultural work has also been found in the African context (Savy *et al.* 2006; Keding *et al.* 2012). However, during the post-harvest and farming season, no relevant associations between income source and the food scores were found.

Less conclusive were the results obtained for the determinants of FVS in the post-harvest and for DDS and FVS in the farming season, suggesting that further factors may also influence the level of dietary diversity or food variety. Even though socio-economic factors play a relevant role in many aspects of modern life, rural populations often show their own livelihood systems, which are not usually captured by conventional economics models (Ellis 2000). As already suggested, non-monetary trading such as barter among villagers may contribute to diversifying the diet beyond activities related to monetary power, and further research on this topic would be desirable to understand indigenous livelihood systems. Nevertheless, in many of the explored models, the role of the place where the women lived was clearly relevant for explaining the dietary diversity and food variety. Thus, the village with the largest mean DDS and FVS was in turn the one with a greater crop variety, and with the easiest access to markets due the nearest distance and infrastructure (frequent public transport between village and market). At the same time, the lowest DDS and FVS were found on women living in the more isolated village located at a higher altitude, with limited crop variety and whose women could access the next market with difficulty because of the long distance and lack of public transport to it. Due to the fact that comparable studies using the selected food scores are not existent in other Andean regions, it is not possible to make overarching conclusions related to dietary diversity issues. Yet, based on findings from other authors on food availability (Picón-Reátegui 1978; Graham 2004), it is likely to confirm the importance of agricultural food resources and infrastructure e.g. physical access to markets in similar places of the region during times of limited food availability.

One additional aspect shown in the explored models after controlling for confounders was the positive effect of the head of household's educational level on the women's dietary diversity in the post-harvest season and on the food variety during the farming season, i.e. the initial period of the food shortage. In this way, women with low dietary diversity and low food variety had in turn a head of household with low educational level (< 3 years primary school). However, education in terms of schooling years or higher degrees does not necessarily imply that individuals possess nutritional knowledge. Similar to the outcomes in this Andean context, the head of household's educational level was found to be an influencing factor of the women's diet in Burkina Faso, whereas the women's educational level was not (Savy *et al.* 2005). This could be confirmed in this study with the lack of association between the food scores and the educational level of the participants. Savy's research team also agreed that the women's education is presumably not the best indicator to evaluate women's knowledge, but the care they receive may improve the quality of their diets. Hence, the educational level of the household's head might be a protective factor in difficult times (Savy *et al.* 2005). In the present Andean context, contrary to this finding, education rather than economic factors appears to be beneficial in times of food abundance, leading to better food choices.

Conclusions

Based on bivariate relationships between the food scores and some factors involved in food and nutrition security, the influence of these factors on DDS and FVS within a model was explored. Therefore, age, size of the household, SES, and the length of food shortage periods were used as covariates, while crop variety, place of residence (village), income source and education of the household's head were added in the model stepwise. Thus, the dietary diversity and food variety were influenced by different factors in each season. According to the models, the results revealed that the food scores were influenced not only by food resources from agrobiodiversity alone, but by socio-economic and care capacity factors.

The models performed for the rainy season could best explain the food scores, accounting for 32% and 34% of the variance of DDS and FVS, respectively. Checking for all other factors, the location of the villages (including agro-ecological zone and access to markets) influenced the DDS significantly. Meanwhile, the FVS was positively influenced by the place of residence and negatively by the length of food scarcity.

In the post-harvest season, the educational level of the head of household had significant impact on DDS, while economic factors did not play a role. Therefore, higher educational levels might ensure a more diversified diet. With respect to food variety, only gathering had a positive impact, and it is likely that consuming such additional edible plants might contribute to a more balanced diet in terms of micronutrients. However, both models poorly explained DDS and FVS, suggesting that additional factors may influence the food scores during food abundance.

During the farming season or the initial period of food scarcity, the place of residence and the crop variety of the households showed a significant influence on DDS, while, education, residence and the length of food scarcity modulated the food variety.

Overcoming periods with limited food availability is an issue of environment for one's own food production and social infrastructure, e.g. access to markets implies certain cash power, while the impact of the educational level of the household's head appears to be relevant in periods of food abundance in order to select appropriate and nutritious food.

4.4 Nutritional assessment

Following the model of nutrition security presented in section 1.1, the nutritional status of the women will be discussed, taking into account the findings obtained through the anthropometric and biochemical measures. On the one hand, specific characteristics of the population and the cultural context have to be considered. On the other hand, the following discussion will also take into account the outcome from recent and older studies carried out in similar regions of the Andean highland. Finally, the findings from further international research works in which the nutritional status has been related to food scores will be compared to the present study.

4.4.1 Anthropometry

Based on the available data of the first cross sectional survey, namely 143 women, the mean body height, 1.55 m, was slightly taller than the one reported in the National Demographic and Family Health Survey of 2004 – 2006 for Peruvian women (1.52 m), whereas the mean weight with 55 kg was below the reported value of 58 kg (INEI *et al.* 2007). Due to some sampling differences, the results should be compared with caution. In the national survey, women of childbearing age with at least one child < 5 years throughout the country were included, whereas the present study included rural Aymara women in same age range with or without young or older children.

With respect to the specific Andean context, extensive literature about anthropometry and nutritional status in various similar regions exits, yet limitations in the selection of comparable studies are due to the fact that many studies examined foremost growth patterns and development of children, while studies with the adult population included male and female subjects in a wider range of age than the present work. The selected female population of some of these relevant studies and their results are listed in Table 4.10. At the first glance, regardless of the research year, BMI among the samples appears to be similar with the exception of a higher BMI in Argentinean women. Furthermore, the present study shows the largest height among the women, while Leatherman and Leonard reported lower values in a similar population of Puno 15 and 20 years ago. At this point it should be mentioned that socio-economic changes in Andean regions over the past decades might also have influenced the growth patterns of the inhabitants. Although Leatherman reported no secular trends in adult stature in a Quechua region of Puno from the 80’s compared to the height among the same population 20 years before, significant changes in age of maturation, and peak growth velocities being around two years earlier in adolescents were found (Leatherman *et al.* 1995), suggesting that the present generations, that is, 40 years later, might have experienced some growth changes, in other words, present populations with somewhat higher adult stature than in the past.

The mean BMI was 22.8 kg/m² and thus within the normal range, while the national survey states a slightly higher value for women in the Peruvian highland, 24.5 kg/m² (INEI *et al.* 2007).

When BMI levels according to WHO were considered, 7% of the women was underweight (BMI < 18.50 kg/m²), 20.3% overweight and even 3.5% obese, while the rest was within the normal level (69.2%). Though not highly distinctive, an increasing trend in BMI was related to the age (Jonckheere-Terpstra Test, $p = 0.034$), but not to the categorical variable "educational level" of the participant as defined in 3.1.1. Similar results are found in the National Survey. Thus, BMI varied from 21 to 23 kg/m² for the youngest and oldest groups, respectively. Furthermore, the highest mean BMI (SD) was found among women in better-off households defined according to the wealth and housing variable, 24.0 (3.5) kg/m², whereas the one in the lowest SES level was 22.5 (3.4) kg/m², and the tendency of increasing BMI according to SES was statistically significant (Jonckheere-Terpstra Test, $p = 0.021$) (s. appendix Figure 9.4). Additionally, the SES was positively associated not only with BMI but also with all anthropometric measures ($p < 0.05$), while the education level of the partner was merely correlated to the height of the participants ($p < 0.01$), and no associations were found with the educational level of the head of household. The results from the bivariate correlations were previously presented in section 3.3.1, Table 3.20. Similar relationships showing direct correlations between anthropometric indicators and education but also SES have been reported in other studies conducted in other low and middle income countries, for instance rural Bangladesh (Baqui *et al.* 1994) and low income Mexican populations (Fernald 2007).

Further analysis revealed statistically significant differences in weight, MUAC and BMI between women with lower education (< 3y primary school) and those with more than three years of schooling or a higher educational level, while the stature was similar in both groups and did not show statistical significance. Since there was no difference in height, the physiological and ethnic background of all participants could be assumed to be similar (Table 4.11).

Table 4.10 Female populations in the present and other related studies*

Population	Year	n	Age (y)	Height (cm)	Weight (kg)	MUAC (cm)	BMI (kg/m²)
Argentina's highland[1)]	2008	294	40.8(15.7)	151.8 (5.4)	59.8(12.4)	26.4 (4.1)	26.3 (6.0)
Bolivian Aymara[2)]	2002	210	28.5 (5.2)	149.1 (11.3)	52.0 (7.3)	22.9 (8.1)	23.2(2.5)
Ecuadorian highland[3)]	2004	39	20-49	146.7	49.9	25.7†	23.1
Peruvian Quechua[4)]	1995	140	23+*	147.2 (4.8)	50.1 (6.6)	-	23.2
Peruvian Quechua[5)]	1991	18	20-40*	147.4 (5.9)	50.3 (4.8)	24.2 (1.3)	23.3
Peruvian Aymara[6)]	*2007*	*143*	*33.9 (8.9)*	*154.9 (5.0)*	*54.8 (8.8)*	*26.9 (2.6)*	*22.8 (3.3)*

[1)]Romagueda *et al.* 2008, [2)]Bindon & Vitzthum 2002, [3)] Macdonald et al. 2004, [4)]Leatherman 1995, [5)]Leonard 1991,[6)]present study,.
* In order to compare the studies, the corresponding data related to similar age groups were selected. When the mean (SD) was not specified, the average was calculated from the available data or the age range was given.
† Related to n = 36.

It is worth mentioning that the educational level of the participants was inversely correlated to their age ($\rho = -0.540$, $p < 0.001$, $n = 143$) and positively to the educational level of their partners ($\rho = 0.591$, $p < 0.001$, $n = 118$) and the one of the head of the household ($\rho = 0.668$, $p < 0.001$, $n = 132$). The negative relationship between age and literacy has also been reported in another study carried out on women in rural Andean Ecuador (Macdonald *et al.* 2004) and might be due to the improved educational policies in the continent during the past decades and the national efforts aiming to improve access to education for both boys and girls. Thus, some of the oldest participants in this study were more likely to have fewer years of schooling than their younger counterparts.

Table 4.11 Nutritional status indicators by educational level of the participants*, n = 143

Nutritional status indicators	<3 years primary school (n = 29)	Complete primary school or higher education (n = 114)	*t*	p
Height (m)	154.7 (5.1)	155.1 (5.1)	-0.34	0.733
Weight (kg)	51.1 (7.2)	55.7 (9.0)	-2.53	**0.013**
MUAC (cm)	25.8 (2.7)	27.1 (2.5)	-2.38	**0.018**
BMI (kg/m²)	21.4 (3.2)	23.1 (3.2)	-2.58	**0.011**

*Mean (SD) by educational levels, and comparisons using the Student's T-Test

In order to explain the nutritional outcome taking into account the age, the education variables (women, partners, and the head of the household), and the socio-economic status defined here with the wealth and housing variable, some regression models were tested (Table 4.12). Step by step, one additional predictor variable was added to the regression models. Thereafter, the most important predictors of BMI and MUAC in each model remained the women's age and their educational level ($p < 0.01$), whereas the influence of SES and the educational level of the partner or the head of the household did not play a significant role within the regression models. By contrast, besides the age and the education of the respondents, the SES was a significant predictor of their weight ($p < 0.05$), but after adding the other variables, the women's age was no longer significant. In other words, an increasing age and educational level of the participants in the case of BMI and MUAC, and also an increasing SES in the case of weight positively influenced the nutritional status indicators used.

In this cultural setting, the identified relationships suggest that, adjusted for the selected variables, the educational degree of the women and – to a smaller extent -- the increasing wealth situation of the households might influence the nutritional status of the women. Though not all, most of the bivariate correlations found in the first cross-sectional study were also found in the following two survey rounds (s. appendix Tables 9.16 and 9.17). Finally, the results are consistent with findings of other studies worldwide in which the dynamic of the nutritional status, the educational level, and the SES of women were explored. Therefore, the impact of certain socio-economic and demographic factors on the nutritional status and energy intake of children and adults has also been discussed in earlier studies carried out not only in similar rural Andean populations (Leonard *et al.* 1988; Bindon *et al.* 2002; Macdonald *et al.* 2004; Graham 2004) but also in other cultural settings. Specifically for women of childbearing age, for instance, Subramanian and his research team found a positive association between SES and BMI, and SES and overweight, in a cross-sectional analysis in 54 low- to middle-income countries among women aged 15-49. They pointed out a higher prevalence of BMI and overweight in the higher socio-economic groups in spite of generally increasing BMI as a public health concern even in poorer socioeconomic groups (Subramanian *et al.* 2011). Though more related to the probability of under-nutrition, Ahmed and coauthors identified not only SES but also the years of schooling received as predictors of women's BMI in rural Bangladesh, whereby women of wealthier households were less likely to have chronic energy deficiency than women of poorer households (Ahmed *et al.* 1998).

In the developing world, it appears to be evident that women of wealthier households are rather likely to have a better nutritional status and even over-nutrition problems than their counterparts in the lowest SES and that women's improved education is an important determinant of the nutritional status. Moreover, a study about Aymara women in rural Bolivia reported that higher educational levels and occupational status were also associated with higher measures of nutritional status indicators than those with lower education and occupation (Bindon *et al.* 2002). As discussed above, in rural, low-income populations, women's nutritional status seems to be increasingly influenced by an improved household economy and education. The opposite phenomenon is well known to occur in high-income populations in which women's obesity and nutrition-related chronic diseases are inversely correlated to socio-economic status and education levels. In recent years, however, similar patterns have been observed in wealthier areas of Latin America, showing evidence that overweight/obesity and the involved health risks are affecting people with low SES and educational level as well (Fleischer *et al.* 2008). However, even within the same country, certain population groups can differ from the national trends (Fleischer *et al.* 2008; Fernald 2007; Poterico *et al.* 2012). The complexity of these relationships has also been investigated by Monteiro and coworkers in a cross-sectional study including national data sets from surveys carried out between 1992 and 2000 in 37 developing countries. They argued that women's obesity is associated with higher SES – in this study defined by countries' quartiles of the women's years of schooling – in low income countries, whereas the increasing national GNP per capita, that is upper middle income countries and the women's SES appear to inversely modify the prevalence of obesity (Monteiro *et al.* 2004).

Table 4.12 Relationship between selected variables and anthropometric indicators*

	Model 1 (n = 143)			*Model 2* (n = 143)			*Model 3* (n = 118)			*Model 4* (n = 118)		
	B	Beta	p	B	Beta	p	B	Beta	p	B	Beta	p
BMI (kg/m²)												
Constant	14.741		< .001	13.511		< .001	12.453		< .001	12.477		< .001
Age	.103	.280	.001	.100	.272	.002	.112	.264	.006	.112	.265	.006
Women's education	2.534	.310	< .001	2.453	.300	.001	3.316	.413	< .001	3.361	.418	.001
SES				.106	.100	.214	.191	.170	.061	.190	.169	.064
Partner's education							-1.203	-.124	.292	-1.056	-.109	.581
Education of the HH's head										-.203	-.020	.924
R^2		.114			.124			.168			.168	
MUAC (cm)												
Constant		20.297	< .001		19.105	< .001		19.469	< .001		19.572	< .001
Age	.089	.306	< .001	.086	.296	.001	.080	.237	.014	.081	.242	.013
Women's education	1.965	.303	< .001	1.887	.291	.001	2.552	.400	.001	2.747	.430	.001
SES				.102	.122	.126	.155	.174	.059	.153	.171	.063
Partner's education							-1.161	-.150	.205	-.517	-.067	.736
Education of the HH's head										-.894	-.113	.600
R^2		.121			.136			.151			.153	
Weight (kg)												
Constant	36.593		< .001	31.125		< .001	29.547		< .001	29.674		< .001
Age	.209	.212	.015	.195	.198	.022	.190	.162	.094	.192	.163	.093
Women's education	6.179	.282	.001	5.817	.266	.002	7.568	.340	.004	7.809	.351	.008
SES				.469	.166	.042	.591	.190	.041	.588	.189	.043
Partner's education							-1.68	-.062	.602	-.885	-.033	.870
Education of the HH's head										-1.104	-.040	.855
R^2		.083			.110			.130			.130	

* Regression models with the nutritional status indicators as dependent and age, educational level, and SES as explanatory variables

According to the present results, the highest prevalence of overweight/obesity was found in the upper SES (41.0%). By contrast, 18.0% and 16.3% were found in the middle and low SES. Specifically for Peru, Monteiro's research team also found a direct association between SES and obesity. This would support the evidence explained in other studies about the overall increasing overweight in women from transitional economy countries. Although the reported national percentages of overweight and obesity among rural women in Peru are higher (28.6% and 8.3% respectively), the present results confirm that over- and no longer only under-nutrition seems to be an increasing public health problem even in more isolated rural communities such as the selected population. Recent studies worldwide (Mendez *et al.* 2005) and specifically in Latin America highlight the dietary and lifestyle changes of the last years and the resulting nutrition transition with increasing rates of obesity mainly in women, in urban areas, and even in indigenous populations (Uauy *et al.* 2001). Another study on nutritional status of an Andean population in Jujuy, Argentina detected stunting and obesity in children and adolescents beside the high obesity prevalence of the adults (Romaguera *et al.* 2007). In Peru, a coexistence of maternal obesity and stunting in children at family level in the Peruvian population has also been reported (Mispireta *et al.* 2007).

Anthropometry and seasonal changes

Though not noticeably distinctive, another finding was the statistically significant seasonal change of the used nutritional indicators over the year (s. Table 3.19). Thereafter, the lowest mean weight, BMI, and MUAC were found in the third study season which was carried out mainly in November and coincided with the beginning of the stated food scarcity in terms of staple food and the planting time of many subsistence crops, which required increased physical activity. The results are consistent with previous findings reported about rural populations of developing countries (Leonard 1991; Bentley *et al.* 1999; Ferro-Luzzi *et al.* 2001). According to them, seasonal stress in other subsistence populations of developing countries has been reported as an important predictor of nutritional status. Thus, changes in energy intake and physical activity might have influenced the nutritional outcome of the subjects.

Despite the seasonal changes in nutritional status, no associations could be found between the used food scores and the BMI or anthropometric measures at any survey period. On the one hand, the present study used the food groups proposed by FAO/FANTA which are meant to reflect a balanced diet. Hence, food groups such as sugar, frying oil, or beverages – which could be associated with high energy intake and therefore increasing body mass – were not considered and can be one reason for the missing relationship. On the other hand, given the evidence of seasonal energy stress without an apparent relationship to the dietary diversity, the lack of association may reflect a certain limitation of the food scores used, since food portion sizes are not taken into account. Nevertheless, even though DDS or FVS according to the BMI levels (underweight, normal, overweight/obese) did not show significant differences at any season, overweight/obese women had a slightly higher mean DDS than normal weight and underweight women in the post-harvest and the farming season, and a higher mean FVS in the farming period (Table 4.13).

Table 4.13 Mean (SD) DDS and FVS according to BMI levels* in each survey round

BMI levels	DDS Rain-S	DDS Post-S	DDS Farm-S	FVS Rain-S	FVS Post-S	FVS Farm-S
Underweight (BMI < 18.50 kg/m²)	6.7 (1.2)	6.7 (1.1)	6.8 (1.6)	10.1 (2.9)	11.2 (2.6)	10.3 (2.4)
Normal range (18.50 – 24.99 kg/m²)	6.9 (1.4)	6.8 (1.4)	6.9 (1.4)	10.6 (2.9)	11.7 (3.0)	10.7 (2.3)
Overweight (25 – 29.99 kg/m²)	6.6 (1.0)	7.0 (1.1)	7.2 (1.1)	10.1 (2.5)	11.9 (1.7)	11.1 (1.9)
Obese (BMI > = 30 kg/m²)	6.6 (1.5)	7.3 (2.6)	8.0 (0.0)	9.8 (2.6)	11.0 (3.2)	12.0 (1.4)

* BMI levels according to standard international references (WHO 1995)

Comparing recent studies to the present one, however, a similar lack of association was previously reported by other scholars, for instance Torheim and her research team. Thereby, the association between the dietary diversity defined through DDS and FVS and the nutrient adequacy and nutritional status indicators of an adult population in rural Mali was examined in a cross sectional study design. The research team found the food scores to be a useful indicator of nutrient adequacy and to be related to certain socio-demographic characteristics but not to BMI (Torheim *et al.* 2004). Furthermore, associations can also be missing depending on the season assessed, as reported by Savy and her team, who found a significant relationship between DDS and BMI before the cereal shortage than in the end of this period (Savy et al. 2006). Conversely, Savy et al. discussed in another research paper about the positive association between the qualitative food scores and nutritional indicators in the same rural setting, but the survey was conducted in a period far away from the food shortage (Savy *et al.* 2005). Not surprisingly, as reported by Kennedy and colleges in a study during the nineties, even more complex scores such as the healthy index, developed for evaluation of the dietary quality among American subjects, did not show a direct association with anthropometric indicators, since they were not direct measures of the person's diet and factors such as physical activity were unrelated to the eating patterns (Kennedy *et al.* 1995).

Finally, one additional point to be mentioned is that food groups used for calculating the scores also differed among studies, since there is no consensus about a standard number of food groups, and it can differ depending on the research aim of the studies (Hatløy *et al.* 2000). As previously described in section 2.2.2 and in light of future research with comparable methods, the present study defined DD according to the DDS score proposed by FANTA/FAO.

4.4.2 Anemia and iron status

Prevalence of anemia

In general, although the mean Hb (SD) values, corrected to sea level, were within the normal range in each season, 123.3 (14.4), 120.7 (12.8), and 121.1 (13.2) g/L respectively, the prevalence of anemia (Hb < 120 g/L) among women in each cross-sectional survey was high, with seasonal fluctuations between 35% in the rainy season, almost 50% after the harvest period, and about 45% during the planting or farming season. A similar pattern could be observed in the longitudinal sample with 30%, about 48%, and 43% of anemia among women, respectively. The reported share of women with anemia in rural Peru accounts for 32%. Moreover, it is more likely that children from anemic women are anemic as well (INEI *et al.* 2007). A study conducted in Bolivia investigated the impact of high altitude on body iron and found a similar pattern, whereby maternal iron status showed a strong correlation with that of their children (Cook 2005). Since a large share of the participants were mothers with children, attention paid to vulnerable groups such as the studied one can help identify households with children at risk of nutritional problems as well. Specifically for the region, Puno is one of the provinces in Peru with the highest prevalence of anemia among pregnant women, namely more than 40% (Campos 2007). According to international information sources such as the WHO's database on anemia, the prevalence among non-pregnant women aged 15-49 in the same region is 50.9% (World Health Organization 2006). Inadequate iron status before conception can lead to unavailable iron stores during pregnancy and possibly affect perinatal events (Kaufer *et al.* 1990; Viteri *et al.* 2005). Although national surveys have been conducted to identify the current prevalence of anemia in children, pregnant women, and non-pregnant women (INEI 1999; Centro Nacional de Alimentación y nutrición *et al.* 2006), the used indicator has been limited to the common measure of Hb as a proxy for iron deficiency. At the same time, large-scale studies in the population focusing on specific iron status indicators, for instance the soluble transferrin receptor, are scarce. Since the overall dietary iron intake among women in Peru is estimated to be inadequate according to recent national data, and iron deficiency is considered as the most important cause for anemia in Peru (Centro Nacional de Alimentación y nutrición *et al.* 2006), many interventions and programs on iron supplementation have been carried out targeting infants, school children, and pregnant women (Zavaleta *et al.* 2000; Davidsson *et al.* 2001; de Romaña *et al.* 2005). Most of the studies that used iron-specific indicators are intervention trials for iron supplementation.

Iron status and IDA

Higher sTfR concentrations indicate iron deficiency even before developing anemia and specifically reflect tissue iron deficiency. Thus, sTfR is a useful indicator in the diagnosis of IDA (Punnonen *et al.* 1997; Clark 2008; Skikne 2008). With respect to the results from the two cross-sectional surveys in which sTfR could be measured in addition to Hb, only a small share of the participants were anemic (Hb < 120 g/L) and had elevated sTfR concentrations (> 8.3 mg/L) at the same time, namely nine women (8.6%, n = 105) in the post-harvest and three (3.1%, n = 98) in the farming or planting season. At the first glance, this fact could suggest that IDA affects fewer women than expected. The median sTfR of 5.98 mg/L and 4.76 mg/L for each season showed normal values as well and were lower than the value of 8.25 mg/L reported by Cook *et al*. for Bolivian women living at a similar geographic altitude such as the Oruro province (3,753 masl.). When the evaluation of the iron status was made considering merely elevated sTfR concentrations as iron deficiency criterion, 12.4% and 4.1% of the participants were identified as positive cases, respectively. According to the observed sTfR concentrations, the share of women with elevated values are yet lower than expected if anemia in the region is supposed to be mainly related to iron. Cook and colleagues found a similar disparity between estimations of ID in the population based on hemoglobin measures and one based on specific body iron indicators (Cook 2005). As with the present results, the Hb concentrations in Cook's study were previously corrected for altitude by the corresponding adjustment factors. Thereafter, the reported prevalence of anemia in Bolivian women based on Hb concentrations was 26.6% (vs. 43% on average for the whole year in Peruvian women), while, based on the body iron assessment using serum ferritin and sTfR, only 5.7% of the Bolivian women had tissue iron deficiency enough to produce anemia. The markedly difference was explained by Cook and his colleagues as due to erroneous altitude corrections of the Hb concentrations, pitfalls in relating body iron measurements to anemia prevalence, or other anemia-influencing factors different than ID.

One limitation in the present study is the lack of ferritin measures for the calculation of the sTfR/ferritin ratio to differentiate IDA from ACD, or to identify the combination of both. Nevertheless, it is well established that sTfR begins to rise early in iron deficiency and continues to rise even prior to the development of anemia (Skikne 2008). Considering the defined cut-off value for sTfR used in this study, thirteen (12.4%) women in the post harvest and four (4.1%) in the farming season were iron deficient. These values are distinctively lower than the overall anemia prevalence of 49% and 45% respectively. The different pattern of association between sTfR and Hb in the second and third survey rounds, however, might suggest that, beyond iron deficiency, additional and possible season-specific factors influence the etiology of anemia over the year. In a study conducted in another rural area of Peru, anemia among pregnant women was not correlated to different intakes of total iron and heme iron but to environmental factors suggesting parasitic infection as key role in the anemia etiology (Gyorkos *et al.* 2004). The fact that the inflammation status, adjusted for all other dietary and biochemical variable used, significantly predicted the Hb concentrations during the farming season in the present study indicates that infections might be an additional agent of anemia. Since parasite infestation was not assessed in the region, the question remains whether infection causes were from parasitic nature, or due to common cold or other diseases.

The possible bias due to the relatively small sample size also has to be considered while interpreting results. Nevertheless, no statistically significant differences referring to the demographic and socio-economic background were identified between women who took part in the collection of blood samples and the total sample of participants in each cross-sectional survey, meaning that dropout was not systematic and that results are likely to reflect the nutritional and health status from the total study population.

Determinants of Hb concentrations

As detected in this and many other studies discussed above, anemia, regardless whether it is iron-related or not, still seems to be a public health problem among Andean populations. Based on the results from the multiple regression models it could be observed that different influencing factors played a role depending on the season (s. Table 3.23). Even when DDS and FVS were not directly related to anemia and iron status, some relationships between certain dietary aspects and Hb could be identified. For instance, the model run for the rainy season showed the impact of gathering herbs and edible plants on hemoglobin concentrations, while flesh meat negatively influenced the Hb concentrations. It is reasonable to expect that the lack of associations in the other two surveys are due to the fact that the greatest variety of fresh herbs was found during the rainy season and not in the cold dry period of the year, namely June-July, or later in October-November. In addition, it is culturally usual to gather a variety of herbs and let them be blessed during the Christian Easter feast that took place late in April 2007. As indicated by many women, these herbs are then consumed in the course of the year.

During the period of food abundance, animal source foods such as eggs, milk and dairy products, and organ meat, defined after the guidelines of FANTA/FAO as "animal-based vitamin A-rich food groups", played a key role in predicting hemoglobin levels together with sTfR. Furthermore, this model explained 20% of the variation of Hb. In contrast, during the other two seasons the models poorly explained this variation. Different than expected, flesh meat did not show a significant effect when checked for the selected predictors. Indeed, there was no statistically significant difference between the mean Hb of women who consumed flesh meat according to the 24h recalls and those who did not. Beyond the vitamin A contained in the three mentioned food groups, only organ meat is rich in heme iron, but it was consumed by a few women, while eggs and milk tend to limit the iron absorption from the whole meal consumed with them (Cook *et al.* 1976). Thereafter, results should be taken with caution. Based on observations from the research team itself during the surveys and on the literature, besides iron, other micronutrients are likely to be deficient in the study population. Thereafter, the following assumptions can be made:

- Since large amounts of fresh potatoes are commonly consumed in this time of the year, and this tuber is known to be an important source of vitamin C and iron in Andean populations, the combination with animal source foods might improve the bioavailability of iron from the whole meal.

- If anemia is not related to iron deficiency only, additional micronutrient contained in the animal source foods mentioned might improve Hb concentrations.

Finally, the age and the infection status significantly predicted hemoglobin concentrations during the farming season, while the influence of dietary factors did not play a major role in this case. Hence, when the women showed infection evidence (increase by one), the Hb concentration decreased by 13.8 g/L.

Though many well-described studies on dietary intakes and/or nutritional status have previously been conducted in other Andean regions (Mazess *et al.* 1964; Leonard *et al.* 1988; Leonard *et al.* 1993; Berti *et al.* 1998; Graham 2003; Macdonald *et al.* 2004; Graham 2004; Berti *et al.* 2010), comparable studies with a focus on qualitative dietary assessments such as food scores and hematologic parameters over more than two seasons are scarce.

Seasonal variation of the micronutrient status has been reported in other cultural settings, for instance among Chinese women of childbearing age (Ronnenberg *et al.* 2000). Interestingly, a high prevalence of anemia was identified, but only a small share of the women had elevated sTfR levels. Additionally, other nutrient deficiencies were found in this population different than iron alone, for instance folate and vitamin B6, and the authors argued that anemia was caused by all these micronutrient deficiencies rather than merely ID.

According to studies conducted in similar regions of the Andes, authors often agree with the statement that one major constraint of the diet is the limited intake of heme iron. In general, low levels of ASF, marginal vitamin A and riboflavin intakes, low fat, vitamin B12 and calcium, but high levels of total iron and vitamin C are frequently reported (Mazess *et al.* 1964; Berti *et al.* 1998; Graham 2004; Berti *et al.* 2010). This would support the findings from the present study and the suggestion that anemia in the region might be caused by multiple micronutrient deficiencies.

Seasonal changes in iron status

A novel finding in the present work is the significant decrease, though modest, of the sTfR levels in the period between June-July and October-November, that is, a slight amelioration of the iron status. At the same time, a similar pattern was observed in the prevalence of anemia among the same women (47.4% in post-S vs. 42.3% in farm-S). Surprisingly, it was unexpected finding an impaired iron status in the period of larger food abundance, where availability of local fresh crops is high and food exchange among villagers but also local markets offer access to additional food groups such as green leafy vegetables, fruits, and ASF. Moreover, the share of women who consumed iron sources from flesh and organ meat was the highest in this period.

On the one hand, findings from other authors about iron intake revealed that the habitual diet meets the dietary recommendations of this micronutrient (Mazess *et al.* 1964; Picón-Reátegui 1978; Berti *et al.* 2010). However, in these studies, additional measures of specific biochemical indicators among the populations were not undertaken. On the other hand, even when the native potato varieties are a good source of iron and also vitamin C, helping absorption of the former (Burgos *et al.* 2007), it is well known that iron absorption from non-heme food sources may be impaired due to phytic acid and polyphenols (Davidsson 2003; Brown 2008). Thus, describing the habitual Aymara diet as abundant in tubers, grain cereals, and legumes while rather poor in animal food sources, the bioavailability of iron appears to be limited and seems to be reflected by the iron status of the participants. In addition, amounts of meat in the usual meals of the Altiplano inhabitants are reported as small (Berti *et al.* 2010), and it is improbable that these portion sizes provide as much heme-iron as is needed. Similarly served meat portions were observed while eating with the villagers or after informal interviews with the participants.

In relation to the longitudinal sample in the present study, the majority of women with low DDS levels consumed the same food groups in each season, namely basically tubers, cereals, legumes, oil, and fats, while more than 50% of the women in the high DDS group additionally consumed green leafy vegetables, fruits, and flesh meat during the post-harvest season, thus contributing several micronutrients either involved in hemoglobin synthesis or known as enhancers of non-heme iron absorption. Though not statistically significant, women with a low DDS level also had a low mean Hb concentration compared to the medium and high DDS levels (s. appendix Table 9.18).

Secondary outcomes from this study were the significant influence of inflammation status, specifically of AGP on Hb (s. Table 3.23) and the lack of association between Hb and sTfR during October-November (s. Table 3.25) suggesting other influencing factors different than iron deficiency. It is generally recognized that sTfR is a useful and specific indicator of iron status even in the presence of inflammation (Punnonen *et al.* 1997; Wander *et al.* 2009). Hence, anemia due to iron deficiency can be distinguished from other anemia causes (Shell-Duncan *et al.* 2004). Results from this study suggest that the assessment of AGP in addition to CRP should be considered for the interpretation of sTfR and anemia-related parameters. Moreover, multiple micronutrient deficiencies seemed to play a role in anemia during June-July, while presumably inflammation status rather than dietary issues is an important cause of anemia at the end of the year in this cultural context. Comparisons with outcomes of the first survey during February-March were not possible because only Hb data were available, whereas sTfR and inflammation indicators were not performed. For future research on seasonal changes of anemic status and identification of risk factors, it could be of interest to assess the used hematologic parameters in different periods of the year.

Rather than determining correlates between isolated nutrients and health outcome, an important goal of the present study was to identify vulnerable groups at risk of nutritional problems based on their DD. Thus, even with qualitative dietary methods, associations between Hb and dietary patterns could be found. In addition, not only dietary issues but health outcomes played a role in the etiology of anemia according to the season.

One limitation in the present study was the missing biochemical data over the year due to reasons previously explained. Nevertheless, because of the similar dietary and health patterns found in other studies discussed in this and the previous sections of the chapter 4, it can be postulated that the current results reflect the anemic condition of many people in the study region.

4.4.3 Vitamin A status

<u>*Vitamin A status and seasonal changes*</u>

Different than in Asian or African settings with frequent clinical manifestation of VAD such as xerophthalmia, deficiency of this vitamin in Latin America and the Caribbean is mostly subclinical (Mora *et al.* 1998). The disorders in the immune function associated with VAD are well established (Semba 1998), and epidemiological surveys have also shown evidence of association between the prevalence of anemia and VAD (Bloem 1995). Worldwide, however, the main focus has been given to VAD prevalence among preschool-children, while the public health significance of maternal VAD as a nutritional problem historically remained unrecognized in the past (West Jr.

2002). Specifically for Peru, estimations of VAD prevalence are based on low retinol among children and rely on subnational rather than on national surveys, for instance accounting for 24% in shantytowns surrounding Lima and 14% in Puno (Mora *et al.* 1998). Considering that existing VAD manifests itself more clearly during pregnancy and perinatal periods, and resource-poor population groups may be at higher risk of deficiencies, data of women in childbearing age, monitoring, and checking up on this vulnerable group should be desirable. Hence, the assessed nutritional status in the present study also aimed to contribute to biochemical data on vitamin A status of indigenous population groups.

According to the present results, VAD (RBP < 0.7 µmol/L) is not a public health problem among the participants. However, a marginal VA status (RBP < 1.05 µmol/L) was found in 12% and 25% of the women in the corresponding seasons and two VAD (RBP < 0.70 µmol/L) cases in the third survey. Moreover, the overall decrease of the RBP concentrations was highly significant ($p < 0.001$) and could imply inadequate intake of vitamin A during the main planting season. When asking the participants for periods of the year with food shortages in the household, the statements coincided in the time between October and February, whereby around 17% and 32% of the women indicated October and November, respectively. The last survey took place during these two months. In this case, women with poor VA status in the period with greatest food abundance could be more vulnerable to deficiencies in the next months before the next harvest season, in which food is perceived as scarce (in terms of depletion of their own produced food crops), the dependence on local markets is stronger, and the lack of monetary resources may limit access to an adequate amount of and varied nutritious food. In light of the global food price crisis that begun 2006 and reached the highest peak around 2008, West and Mehra described the dynamic of vitamin A intake during economic stress periods in Indonesia and argued that food price crises such as the one in 2008 might have increased the prevalence of VAD, among other related disorders (West *et al.* 2009). Regardless of economic crisis periods, a general seasonal stress in micronutrient status among women is reported in other developing countries, for instance in rural Nepal (Jiang *et al.* 2005), China (Ronnenberg *et al.* 2000) and the Congo (Barclay *et al.* 2003). Based on the presented results, it remains uncertain whether the impaired VA status was due to seasonal changes only or tightened by the global rise in food prices that also affected Peru (Cuesta *et al.* 2010). However, in light of the beginning food scarcity in many households, this nutritional outcome might reflect the difficult food availability faced by the women during this period, and it could be assumed that such a disadvantageous nutritional pattern occurs regularly every year.

Diet factors related to the VA status

As far as found in the literature, the vitamin A intake in high-altitude Andean populations is reported as low and may also vary across the year in the same district (Picón-Reátegui 1978; Berti *et al.* 2010). In the present population, less than 50% of the women included animal products in their diet over the year (s. Table 3.10), suggesting that the frequency of consumption and intake of preformed vitamin A is low. In contrast, the intake of pro-vitamin A as carotenoids through the consumption of carrots, pumpkins and spinach was more common. Moreover, a significantly higher proportion of women who said they consumed pumpkins was observed in the post-harvest season, pointing at seasonal foods contributing to the VA intake. VA-rich fruits such as mango and papaya were only consumed by a few women. In general, such fruits are not cultivated in the study area but in warmer zones of the country and transported to the local markets. During interviews, informal conversations, and visits in the villages, the general statement from the participants and other household members was that fruits were mainly purchased for the children than for the adults (s. Box 2 p 110).

The low intake of animal products in a similar Andean population of South Peru has also been reported by Graham based on quantitative dietary assessments (Graham 2004). In addition, she pointed out the energy stress and nutritional consequences of the seasonal decline of local food in the same period as the one assessed in the present study. The worsening of the VA status found between both seasons might thus confirm one nutritional consequence of this seasonal stress.

Though no direct association was found between VA status and the individual food scores or the socio-economic characteristics at any time, attention should be given to the positive correlation between consumption of ASF, gathering practices, and VA status ($p < 0.01$) in the post-harvest period (s. Table 3.26). Beyond the number of consumed food groups, it is relevant to identify the diet composition in the specific seasons to determine the quality of the diet. Based on bivariate associations and using dietary data, regression models with RBP as a dependent variable were tested, but the statistical requirements for the validity of them were not fulfilled and variables poorly explained the RBP concentrations. One reason could be the small sample size for which data was available.

It is clear that a single dietary recall per season may not be sufficient to capture all consumed food items during the season. Nevertheless, it has been reported that one recall day for the calculation of DDS is sufficient to predict the women's nutritional status in Burkina Faso, while the DDS calculated from a three day period was affected by memory bias (Savy *et al.* 2006). Yet, the fact that all three 24h recalls were conducted in different seasons and showed similar consumption patterns within the subjects implies a steady dietary diversity in terms of food groups over the year. Instead, the seasonal variation in food items within single food groups, differences in consumed portion size of the corresponding food items, and the availability of wild plants might influence the VA status over the year.

As in many resource-poor populations in developing countries, animal products such as meat, eggs, and dairy products were less frequent in the diet of the study population. Even in the more highly situated village Arcunuma with more than 50% of the households herding sheep, cattle, llama, and fowl (s. Table 4.2) and with the highest livestock inventory, only meat, fresh or dried ("charqui"), was commonly consumed. Regarding descriptive data of each surveyed village, certain consumption patterns among the women according to the place of residence, i.e. agro-ecological zones, might give some evidence of marginal VA intake. In general, the main proportion of women who consumed flesh meat came from Aychuyo and Arcunuma. Moreover, Arcunuma showed high mean RBP concentrations in the post-harvest and farming season and a high proportion of women who consumed flesh meat in spite of a rather lower DDS over the year. By contrast, the diet in Perka, closely situated to the lake and at a lower altitude, though slightly more diversified than Arcunuma, was mostly plant-based with local tubers and roots, purchased refined cereals (wheat flour, pasta, and bread), pulses, and vegetables with poor vitamin A precursor contents. These dietary patterns are in line with findings from other authors who reported that meat products are eaten by a greater proportion of inhabitants of the higher ecological zones in contrast to lower altitudes (Mazess *et al.* 1964). Consistent with biochemical data, in both seasons the mean RBP concentrations were the lowest, and the two cases of VAD also came from Perka. It has to be noted that there was a highly significant difference between communities related to flesh meat and gather practices that remained similar in each season ($p < 0.001$). In order to exemplify these findings Table 4.14 summarizes the food patterns, gathering practice and VA status according to the villages. The gathering of herbs and wild plants was more frequent among women in Aychuyo and Arcunuma than in Perka and Ccota, and the group differences were significant as well ($p < 0.001$).

Table 4.14 Selected subpopulation* for VA status according to the villages, food patterns and gather practice

Variable	Aychuyo (3 850 m)	Arcunuma (4 100 m)	Ccota (3 828 m)	Perka (3 828 m)
Main food groups consumed**	• Tubers • Cereals • VA-rich vegetables • Other vegetables • Legumes • Oil/fats	• Tubers • Cereals • VA-rich vegetables • Other veg-etables • **Flesh meat** • Oil/fats	• Tubers • Cereals • VA-rich vegetables • Other veg-etables • Legumes • Oil/fats	• Tubers • Cereals • VA-rich vegetables • Other veg-etables • Legumes • Oil/fats
Gather practice	88.2% (post-S) 96.4% (farm-S)	82.4% (post-S) 100% (farm-S)	82.4% (post-S) 38.5% (farm-S)	**18.2% (post-S)** **25.0% (farm-S)**
Mean (SD) RBP (µmol/L) **Post-S**	1.49 (.27)	**1.52 (.32)**	1.32 (.27)	1.26 (.31)
Mean (SD) RBP (µmol/L) **Farm-S**	1.28 (.32)	1.23 (.34)	1.22 (.39)	**1.12 (.31)**

*Population based on following sample sizes for the post-harvest and farming season, respectively: 34 and 28 in Aychuyo, 17 and 11 in Arcunuma, 17 and 13 in Ccota, and 22 and 16 in Perka.
** Average from both the post-harvest and the farming season and consumed by more than 50% of the participants in each village.

The more favorable geographic situation of Aychuyo, Ccota, and Perka along with the easier access to market foods seems to influence certain food patterns e.g. consumption of milk, eggs and fish compared to Arcunuma, while meat remains infrequently consumed in the former villages, probably due to economic factors for instance the general limiting purchasing power of many households with obvious consequences on the individual VA status. Table 4.15 shows the most frequently consumed food groups including the VA-rich sources in each village referred to the women included in the assessment of VA status but also in comparison to the total population in the post-harvest and farming season.

Table 4.15 Frequency and prevalence of consumed food groups (%) according to villages and corresponding women included in the assessment of VA status*

Season	Food Group	Aychuyo (n = 34)	Arcunuma (n = 17)	Ccota (n = 17)	Perka (n = 22)	Total sample** (n = 90)	All participants*** (n = 161)
Post-harvest (June-July)	VA-rich vegetables	32 (94.1)	16 (94.1)	14 (82.4)	20 (90.9)	82 (91.1)	141 (87.6)
	Dark green leafy vegetables	15 (44.1)	3 (17.6)	2 (11.8)	7 (31.8)	27 (30.0)	47 (29.2)
	VA-rich fruits	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.6)
	Other vegetables	33 (97.1)	16 (94.1)	16 (94.1)	21 (95.5)	86 (95.6)	150 (93.2)
	Organ meat	1 (2.9)	0 (0)	0 (0)	0 (0)	1 (1.1)	2 (1.2)
	Flesh meat	16 (47.1)	16 (94.1)	8 (47.1)	1 (4.5)	41 (45.6)	77 (47.8)
	Eggs	10 (29.4)	0 (0)	5 (29.4)	1 (4.5)	16 (17.8)	28 (17.4)
	Fish	7 (20.6)	0 (0)	1 (5.9)	3 (13.6)	11 (12.2)	20 (12.4)
	Milk and dairy products	11 (32.4)	0 (0)	7 (41.2)	4 (18.2)	22 (24.4)	37 (23.0)
		Aychuyo (n = 28)	**Arcunuma (n = 11)**	**Ccota (n = 13)**	**Perka (n = 16)**	**Total sample** (n = 68)**	**All participants*** (n = 158)**
Farming (Oct.-Nov.)	VA-rich vegetables	26 (92.9)	11 (100.0)	7 (53.8)	13 (81.3)	57 (83.8)	140 (88.6)
	Dark green leafy vegetables	11 (39.3)	2 (18.2)	6 (46.2)	4 (25.0)	23 (33.8)	50 (31.6)
	VA-rich fruits	0 (0)	1 (9.1)	0 (0)	0 (0)	2 (1.3)	2 (1.3)
	Other vegetables	28 (100.0)	11 (100.0)	13 (100.0)	16 (100.0)	68 (100.0)	154 (97.5)
	Organ meat	0 (0)	0 (0)	0 (0)	0 (0)	2 (1.3)	2 (1.3)
	Flesh meat	11 (39.3)	9 (81.8)	7 (53.8)	2 (12.5)	29 (42.6)	72 (45.6)
	Eggs	13 (46.4)	1 (9.1)	1 (7.7)	1 (6.3)	16 (23.5)	37 (23.4)
	Fish	9 (32.1)	0 (0)	3 (23.1)	4 (25.0)	16 (23.5)	36 (22.8)
	Milk and dairy products	10 (35.7)	0 (0)	3 (23.1)	2 (12.5)	15 (22.1)	32 (20.3)

*The percentages are put in brackets and refer to the frequency of women who consumed the corresponding food group according to the 24h dietary recalls.
** Available data of VA status in the corresponding seasons.
***Considered sample according to the surveys in which VA status was assessed.

Even if quantitative dietary assessments could contribute with valuable estimations on micronutrient intake among the population, the present findings give evidence of dietary patterns assessed with qualitative methods influencing the VA status. It is questionable if absolute conclusions could be made based on the small sample size available for biochemical data. Nonetheless, given the similarity of food patterns in other highland communities of the region, it is likely to identify the same phenomenon among them as well. Additionally, relying on the identified seasonal changes of VA status and traditional food patterns, the VA intake among the population does not seem to be an availability issue but an educational one. Besides the dietary characteristics mentioned above, the infrequent use of oil and fat for cooking discussed in more detail in section 4.2 let one assume that some women and their corresponding household members including vulnerable groups such as children and the elderly could be at risk of low absorption of fat-soluble vitamins. Owed to the mostly plan-based diet, and thus the frequent intake of carotenoids rather than preformed vitamin A from animal foods, future nutrition programs should pay attention to the quality and amount of edible oils used in the region and supply adequate nutritional information that targets each population group.

Conclusions

An unexpected low prevalence of underweight but a considerable share of overweight/obese women instead suggests that even this subpopulation of Peru is currently undergoing a nutrition transition. This in turn may have serious health implications in the future due to degenerative chronic diseases (e.g. diabetes mellitus type 2).

Besides age, women’s education was positively associated with MUAC, weight, and BMI. In addition, increasing SES was associated with higher weight as well.

There was a high prevalence of anemia not only in the cross-sectional surveys but also in the cohort throughout the year. Though distinctive changes could not be found in the mean Hb throughout the year, the lowest prevalence of anemia was found during the first survey in February-March.

There was a positive relationship between the women’s Hb concentrations and the gathering of edible plants during the rainy season, suggesting that this traditional practice might be beneficial for an individual’s health status. Meanwhile, Hb was positively associated with the consumption of VA-rich animal foods and negatively related to sTfR concentrations during June-July (post-harvest), giving evidence of dietary issues influencing Hb concentrations. During the third survey, the Hb concentrations were inversely associated with the inflammation status, but no associations with the diet were found. Thus, influencing factors of Hb levels seem to be different in each season and are not only associated with dietary but also with health issues. Presumably, anemia is attributed to factors that are not only iron-related, e.g. multiple micronutrient deficiencies (folate, vitamin B12), or non dietary factors such as parasites and chronic infections.

Significant seasonal changes in the mean RBP and sTfR concentrations ($p < 0.001$) were found between June-July and October-November. Thereby, a decrease of both sTfR (amelioration of the iron status) and RBP (worsening of the VA status) were identified between the seasons.

The simple count of food scores or food items did not show direct associations with the nutritional status. Yet, certain consumption patterns identified through the qualitative assessment of the diet showed a relationship with indicators of iron and vitamin A status. This fact points out that attention should be paid to the specific food groups consumed by the individuals, and thus, even qualitative dietary methods are able to identify critical consumption patterns.

Overall conclusions and recommendations

The main conclusions given within each of the four discussion sections attempted to give answers to the objectives defined in Chapter 1. In order to give an overview, the major findings are summarized within each objective in a more concise way. Subsequently, possible approaches and recommendations to improve the present situation in the region are explained.

Due to the complexity of the topic, it is not possible to give overarching recommendations that can be applied in every cultural context but instead points to be considered for future research and development programs in the region and elsewhere.

Objective 1: Is agrobiodiversity potentially available as a resource for a diversified diet?

The subsistence agriculture identified in the region plays an important role for staple food production. There is an ample diversity of indigenous and exotic food crops among tubers, cereals, and legumes cultivated by the farmers, which varies, in part, depending on the agro-ecological zones where the villages are located. However, the majority of households do not produce fruits, dark green leafy, red or yellow fleshed vegetables, which may provide essential nutrients and further bioactive substances.

Though often used as savings via asset accumulation (Byron 2003), animal husbandry potentially offers access to animal source foods, for instance small domesticated animals (sheep, pig, fowl) in villages situated at lower altitudes and the more cold-resistant camelids at higher altitudes.

Home gardens for horticulture are not common among the households, and fishing is almost limited to areas nearby Lake Titicaca. In contrast, the traditional gathering of edible plants is still widespread and foremost a women's household duty. With the exception of a lack of vegetables and fruits, the existent food sources in the region potentially offer a diversified diet rich in macro- and micronutrients.

There was a positive relationship between crop variety and the food scores, and this confirms the assumption that agricultural biodiversity positively influence the dietary diversity of the individuals. Nevertheless, additional factors influencing this simple relationship could also be found in this study, for instance the dependency on markets, the length of the staple food scarcity, the educational level of the household's head, and the socio-economic status.

Objective 2: How diversified is the current diet of the population measured with the food scores? Does seasonality influence the dietary diversity (DD)?

According to the findings discussed in this section and comparisons with several studies in similar Andean regions, the food scores as qualitative methods turned out to be a good tool to characterize the overall diet in the population and to identify strengths and critical consumption patterns.

At this point it should be stressed that food variety does not imply that individuals consume nutrient-dense foods, but it matters when changes in the consumption of certain items within food groups have to be identified throughout the year. Contrary to that, the dietary diversity, at least in terms of a balanced diet, may reflect the consumption trends in a population and therefore a certain quality of the diet.

In general terms, the diet relied mostly on plant food sources. A minority of the population consumed animal source foods (flesh and organ meat, fish, eggs, milk and dairy products), dark green leafy vegetables, and fruits. Specifically, participants with low DDS showed a diet mainly based on indigenous tubers, non-traditional cereals and a few vegetables; whereas women with high DDS additionally consumed legumes, green leafy vegetables and animal source foods. Even if the consumed indigenous food can supply one with complex carbohydrates, protein, fat, dietary fiber as well as several vitamins and minerals such as vitamin C, E, pro Vitamin A, Mg, Fe and Ca, their bioavailability may be constrained due to inappropriate food combination or insufficient intake of such local foods. Additionally, the full utilization of these foods might be limited due to the high consumption prevalence of commercial foodstuffs with low nutrient density.

Seasonality could be identified in the food variety but not in the dietary diversity, indicating that at least in terms of diversity, food groups consumed are similar throughout the year, and consumption differences are expected to be related to quantity.

In most cases, regional and socio-economic rather than seasonal factors had an impact on dietary diversity and food variety. It can be said that environmental diversity in the form of crop farming, husbandry, and gathering in combination with cash are the current conditions ensuring food security in the region.

Objective 3: Which socio-economic and household-related factors influence individual DD?

The dietary diversity and food variety were sensitive to selected household characteristics of the women, which in turn are relevant nutrition security components. Thus, the used individual food scores appear to reflect the current conditions of food and nutrition security of the studied Andean households.

Regarding several predicting factors as determinants of DDS and FVS within a model, the complexity of the topic showed that the food scores can be explained through different factors depending on the surveyed season and the consideration of certain factors.

In pre-harvest periods (rainy season) supposed to be affected by the highest dietary stress due to staple food scarcity, the most important determinants of DDS and FVS were of a demographic and socio-economic nature regardless of the basic or more complex models constructed, while agricultural biodiversity, i.e. food resources coming from farming activities, did not seem to play a significant role.

During periods of more abundant food such as the post-harvest, DDS and FVS were basically influenced by agrobiodiversity and SES. In a more complex model adding the educational level of the household's head, the outcome revealed that this caring capacity factor had the main impact on the DDS, modifying it positively.

Finally, during the next main farming season, also the beginning of the staple food shortage, the crop variety of the households along with the sector of residence and in case of FVS, the length of food shortage and education of the head of household were significant influencing factors of the food scores.

Objective 4: Is there a relationship between the food scores and nutritional outcomes?

The simple count of food groups or food items did not show direct associations with the nutritional status. No significant relationships were found between the food scores and weight, MUAC, or BMI, suggesting that differences in body composition might be an issue of food quantity and/or consumption of further foods e.g. sugar and beverages not reflected in the applied DDS and FVS. Yet, certain consumption patterns identified through the qualitative assessment of the diet showed a relationship with indicators of iron and vitamin A status. In this case, the biochemical indicators were sensitive to some aspects of the diet reflected in the food groups consumed by the individuals. This points out that attention should be paid to the specific food groups consumed by the individuals, and thus, even qualitative dietary methods are able to identify critical consumption patterns.

In general terms, relying on the identified seasonal changes of iron and VA status and in light of the traditional food patterns found, the micronutrient intake in this Andean population does not seem to be an availability issue only but also to be influenced by the combination of foods. Thus, not only the food variety is relevant but the quality of the diet which may be improved by promoting nutrition education among the population.

Outlook and recommendations

Although the present findings are based on a small sample size, the strength of the study relies on the repeated measurements over three different seasons with relevant information on diet, farming activities, demography, socio-economy, and anthropometric, as well as biochemical data. Results obtained may have practical implications for either research or food-based program planning in the region. The outcomes might reflect the current nutritional and health conditions of many other Andean communities and underscore the importance of enhancing the use of local food and traditional activities such as gathering practices in order to improve the intake of nutrient-dense food and tackle micronutrient deficiencies.

The evaluation of the diet with the food scores was useful for identifying consumption patterns. Many of these characteristics are in line with findings from earlier studies carried out with dietary quantitative methods in similar regions of the Andes, suggesting that qualitative methods are able to capture valuable information about diet and consumption patterns where there is a limited timeframe or budget for data collection and qualified personnel.

In terms of food and nutrition security, the variety of local crops can potentially improve the diet if they are combined adequately. At higher altitudes, the value of indigenous crops and animals relies not only on its adaptation to the habitat and its resistance against the harsh geographic conditions but also on the nutritional aspects. There is no need to introduce additional crops, but the cultivation of minor indigenous crops and also horticulture using local plants could be increasingly encouraged. Thus, not only food-based approaches or rural-development programs but also agricultural intervention programs supporting the agrobiodiversity should integrate nutrition education and awareness of local food resources in order to ensure an optimal and full utilization of their own produced food resources and improve the quality of the diet. As shown in the general characteristics of the population, women are still responsible for most of the household tasks (e.g. gathering of edible plants, raising the children, food purchase, and home gardening). This target group therefore plays an important role in nutrition security for the household members. In addition, the education of the household's head was one of the main factors influencing the dietary diversity and food variety of the women. Since mostly men were the head of the households and they certainly play a role in earning and managing income, they should also be made aware of the value and importance of their local already available food resources and appropriate food choices for their families.

The prevalence of overweight/obesity among the women and the popular consumption of commercial foods with low nutrient density may become a serious problem in coming years. If appropriate health and nutritional interventions are not implemented early enough, these issues may contribute to an increasing prevalence of non-communicable disease as already identified in other Latin American regions (Bermudez *et al.* 2003) and even within indigenous populations (Uauy *et al.* 2001).

In a cultural rural setting with strong skeptical attitudes and taboos concerning participation in research trials, the collection of capillary blood samples for the DBS assay in this high altitude region was a good alternative to the withdrawal of venous blood. However, further investigation on biochemical indicators of VA and iron status using this less invasive method would be desirable in order to compare the present results with data of similar Andean regions.

Given the dietary characteristics of the population detected with the food scores, some deficiencies in dietary antioxidants, high-quality protein, vitamins (e.g. B12, folate, and A), and minerals (e.g. iron, calcium, Mg, Zn) are to be expected in the region. In order to countervail these deficiencies, feasible and sustainable strategies should be implemented. For instance, since ancestral practices such as gathering of plants are still usual, the promotion of indigenous knowledge across the generations with respect to the use of wild edible plants may be invaluable. The evidence of a positive impact on health through the consumption of local herbs and wild plants shown in this study should be considered for more comprehensive research.

One additional strategy for promoting vegetable and fruit consumption throughout the year could be the introduction of greenhouses. Even in more isolated and more highly located areas, this option may improve the availability of nutritious food and make the household independent of local markets and its fluctuating prices over the year. For instance, in a rural population of northwestern Patagonia it could be shown that traditional practices such as gathering plants and novel practices such as greenhouses complemented each other, suggesting resilient processes in the community (Eyssartier *et al.* 2011).

Aiming to improve the consumption of animal source foods, guinea pig for one's own meat production may be an option and also be an attractive low-input alternative for income generation (Lammers *et al.* 2009). In addition, the re-valuation of camelids such as llama and alpaca as an available and affordable nutritious meat resource may serve to improve the diet even in the poorest households.

Although quantitative dietary methods provide valuable information on the nutrient adequacy of an individual's diet, findings from this study contribute to research information on the usefulness of food scores applied in a different cultural setting such as the Latin American highlands. Moreover, not only do the levels of DDS or FVS seem to be relevant, but also the dietary composition and patterns identified through the consumed food groups and food items do as well.

General consensus should be met in how to manage food sources different than those coming typically from farming or market systems, for instance food from gathering practices and uncommon dietary sources such as edible clay identified in the diet of this Andean population. Exclusion of such information may result in a wrong assessment of nutrient intake as measured with usual quantitative or qualitative dietary methods.

5 Summary

It was postulated that populations living in an environment with a high degree of agrobiodiversity are also more likely to show a higher dietary diversity and therefore a better nutritional outcome. Thus, a serial cross-sectional study was conducted in four rural Aymara communities in the southeast region of Peru situated between 3,825 and 4,100 masl, a region with high agrobiodiversity.

The main objectives were the following: A) to examine whether agrobiodiversity is potentially available for a diversified diet, B) to assess the dietary diversity and food variety in different seasons of the year and identify possible seasonal influence, C) to identify influencing factors such as socio-economic and household-related characteristics on both the dietary diversity and food variety, and D) to examine whether a diversified diet is correlated with the nutritional outcomes.

The selected seasons were the rainy one (February-March), the post-harvest period (June-July), and the farming or sowing season (October-November) during 2007.
The target population was women aged 15-49. The surveys included two parts in each season: 1) standardized questionnaires with general household and socio-economic questions as well as a qualitative 24h dietary recall, and 2) anthropometric measures for the calculation of BMI, and MUAC, as well as capillary blood samples for measuring iron and vitamin A status. Cases with possible diseases or the intake of medicaments or nutritional supplements were excluded.
After data cleansing, a total sample size of 183 women in the first, 161 in the second, and 158 in the third survey were considered for further nutritional and socio-economic analysis, while anthropometric and biochemical data from 143, 105, and 98 women were included for the corresponding statistical tests, respectively. The DDS and FVS were calculated for each season based on the 24h recalls, using 14 food groups and 61 food items, respectively. A wealth and housing index was constructed to classify each participant into low, medium, or high socio-economic status.

The most cultivated food crops were potato (100%), barley (80.3%), broad beans (77.6%), *quinoa* (71.6%) and *oca* (57.9%). Animal husbandry was characterized by sheep (92.4%), cattle (76.5%), chickens (49.2%), and pigs (42.6%). In general, domestic animals such as cattle and pig were mainly kept for sale purposes, while sheep and chickens were used for household consumption. Home gardens for horticulture and fruits were not wide spread among the households (23%), while 82.5% of the women said they gathered plants.

Taking all three seasons into account (n = 147), a median (IQR) DDS of 6.7 (6.3 to 7.7) food groups out of 14 and FVS of 11.0 (9.7 to 12.3) food items out of 61 were obtained. Over the three surveyed seasons, the diet was characterized by potatoes (100%), cereals (97.3%) – mostly wheat products and rice, vegetables (95.3%) such as onions and tomatoes, vitamin A-rich vegetables (87.8%) such as carrots and pumpkins, and legumes (67%) – mainly broad beans. Overall, animal source foods were not frequently consumed (< 50%). Nevertheless, the consumption prevalence of flesh meat accounted for approx. 56% of the women within the highest DDS tercile. The dietary diversity was not significantly different among the three seasons, while the food variety was significantly higher in June-July than in February-March ($p < 0.001$) and in October-November ($p = 0.013$).

The median (IQR) number of utilized traditional food, 4.0 (3.0 to 5.0) did not differ significantly between seasons, villages, income sources or SES. In contrast, a slightly higher number of commercial foods were purchased by women from wealthier households, by those living closer to markets, and by those with income sources coming from regular wages or from a combination between agricultural and non-farm activities (all tests $p < 0.01$). A higher number of vegetables and fruits were purchased by the upper SES level ($p < 0.05$) and the village with the shortest distance to local markets ($p < 0.01$) during the first survey period.

When checked for factors related to agrobiodiversity, food security, and caring capacity, the dietary diversity and food variety were determined by different factors according to the surveyed seasons. In pre-harvest periods (rainy season), staple food scarcity, demographic and socio-economic factors influenced DDS and FVS the most, while agricultural biodiversity, i.e. food resources coming from farming activities, did not play a significant role. During the post-harvest season, DDS and FVS were basically influenced by agrobiodiversity and SES. After inclusion of the educational level of the household's head in the model, the outcome revealed that this caring capacity factor had the main impact on the DDS, modifying it positively.

Finally, during the farming season (the initial food shortage), the crop variety of the households along with the sector of residence, and in case of FVS, the length of food shortage and education of the head of household were also significant influencing factors on the food scores.

Less than 10% of the women were underweight, while more than 20% were overweight or even obese, suggesting processes of nutrition transition as observed in other middle and low income populations. Though not distinctive, a significant ($p < 0.05$) seasonal decrease in BMI, weight, and MUAC was found at the end of the year, which coincided with the initial local food shortage.

The prevalence of anemia was high in each season (35%, 49%, and 45%, respectively). Nevertheless, the share of anemic women during the rainy season was significantly lower than the one in the post-harvest ($p < 0.05$). Gathering ($p < 0.01$) during the rainy season and animal-based vitamin A-rich foods ($p < 0.05$) during the post-harvest influenced the Hb concentrations of the participants positively.

A seasonal amelioration of the iron status was found between the post-harvest and farming season, while the vitamin A status showed a worsening between the same periods (both $p < 0.001$). Because of the low percentage of women with abnormal sTfR concentrations but high anemia prevalence in each season, it is presumable that anemia in the study region is caused by other nutritional or health-related factors rather than iron-related only.

Though no significant relationships were found between the food scores and vitamin A or iron status, certain consumption patterns showed an association with Hb, sTfR, and RBP. In this case, the biochemical indicators were sensitive to some aspects of the diet reflected in the food groups consumed by the individuals. This fact points out that attention should be paid to the specific food groups consumed by the individuals, and thus, even qualitative dietary methods are able to identify critical consumption patterns.

6 Zusammenfassung

Es wurde postuliert, dass Bevölkerungen mit einer hohen agrobiologischen Vielfalt eine große Lebensmittelvielfalt und dadurch einen guten Ernährungsstatus aufweisen. Hierzu wurde eine serielle Querschnittstudie in vier Aymara Dörfern aus den südlichen Bergregionen Perus zwischen 3 825 und 4 100 m über N.N., einer geographischen Region hoher agrobiologischer Vielfalt.

Die Hauptziele der Studie waren folgende: A) Zu untersuchen, ob die agrobiologische Vielfalt in dieser Umgebung eine vielfältige Ernährung ermöglicht, B) Die Nahrungsmittelvielfalt in verschiedenen Jahreszeiten zu untersuchen und auf saisonale Unterschiede zu prüfen, C) Einflussfaktoren der Lebensmittelvielfalt wie z.B. sozioökonomische und andere haushaltsbezogene Faktoren zu identifizieren, und D) Zu-untersuchen, ob die Nahrungsmittelvielfalt, erhoben mit den DDS (Dietary Diversity Score) und FVS (Food Variety Score), einen Zusammenhang mit dem Ernährungsstatus aufweist.

Die ausgewählten Erhebungsperioden waren die Regenzeit (Februar-März), die Nachernte-Phase (Juni-Juli), und die Anbauphase (Oktober-November) im Jahr 2007.

Die Studienpopulation umfasste Frauen zwischen 15 und 49 Jahren. Die Erhebungen beinhalteten verschiedene Methoden in zwei Teilen: 1) Standardisierte Fragebögen mit allgemeinen, sozioökonomischen und haushaltsbezogenen Fragen sowie ein qualitatives 24-Stunden-Ernährungssprotokoll der am Tag zuvor aufgenommenen Nahrungsmittel, und 2) Anthropometrische Messungen für die Berechnung des BMI sowie kapillare Blutproben für die Bestimmung des Eisen- und Vitamin A-Status. Fälle mit möglichen Erkrankungen, der Einnahme von Medikamenten oder Nahrungsergänzungsmitteln wurden ausgeschlossen.

Nach der Datenbereinigung wurden 183 Frauen aus der ersten, 161 aus der zweiten, und 158 aus der dritten Erhebungsperiode für die ernährungs- und sozioökonomische Untersuchungen berücksichtigt. Nach Ausschluss von schwangeren Frauen wurden anthropometrische und biochemische Daten von jeweils 143, 105, und 98 Teilnehmerinnen für weitere statistische Tests genutzt. Die Berechnung der Vielfalt der Ernährungsgruppen (DDS) und Lebensmittel (FVS) basierte auf dem 24-Stunden-Ernährungsprotokoll mit jeweils 14 Lebensmittelgruppen und 61 einzelnen Lebensmitteln. Ein sozioökonomischer Index wurde gebildet, um Teilnehmerinnen in niedrigen, mittleren, oder hohen soziökonomischen Status zu klassifizieren.

Die am häufigsten angebauten Pflanzen waren Kartoffel (100%), Gerste (80,%), Dicke Bohnen (77,6%), Quinoa (71,6%) und Oca (57,9%). Die Tierhaltung war durch Schafe (92,4%), Rindvieh (76,5%), Hühner (49,2%) und Schweine (42,6%) gekennzeichnet. Tiere wie Rind und Schwein wurden generell zum Verkauf, Schaf und Huhn für den eigenen Haushaltskonsum gehalten. Hausgärten für den Anbau von Gemüse und Obst waren nicht üblich (23%), während 82,5% der Frauen Pflanzen für den Eigenkonsum sammelten.

In der Kohorte ($n = 147$) zeigte der DDS einen Median (IQR) von 6,7 (6,3 – 7,7) Lebensmittelgruppen und der FVS einen Median von 11,0 (9,7 – 12,3) Lebensmitteln auf. Im Laufe der drei Erhebungen beruhte die durchschnittliche Ernährung auf Kartoffeln (100%), Getreide (97,3%) – meistens Weizenprodukte und Reis – Gemüse (95,3%) wie Zwiebeln und Tomaten, Pro-Vitamin A reiches Gemüse (87,8%) wie Möhren und Kürbis, und Hülsenfrüchten (67%), zumeist dicken Bohnen. Im Allgemein wurde der Verzehr tierischer Produkte eher selten festgestellt (< 50%). Innerhalb der Gruppe mit hohen DDS verzehrten jedoch 56% der Frauen Fleisch. Es gab keine signifikanten Unterschiede im DDS zwischen den Saisons, während der FVS im Zeitraum Juni-Juli höher als im Februar-März ($p < 0.001$) und im Oktober-November ($p < 0.01$) war.

Die Anzahl der konsumierten lokalen Produkte hatte einen Median (IQR) von vier (3,0 – 5,0) Nahrungsmitteln, und es gab keine signifikanten Unterschiede zwischen Saisons, Dörfern, Einkommensquellen oder sozioökonomischen Status. Im Gegensatz dazu konnte eine leicht höhere Anzahl an industriellen oder verarbeiteten Produkten bei den wohlhabendsten Frauen, bei Frauen, die näher an Märkten lebten, oder bei solchen mit regelmäßigem Einkommen oder Einkommen von Landwirtschaft und Nebentätigkeiten festgestellt werden (alle Tests $p < 0.01$). Ebenso wurde eine höhere Anzahl an Obst und Gemüse bei Frauen im höchsten soziökonomischen Status ($p < 0.05$) und solchen, die leichten Zugang zu Märkten ($p < 0.01$) hatten, während der ersten Erhebungsperiode festgestellt.

Unter Berücksichtigung von Faktoren eines umfassenden Models wie agrobiologische Vielfalt, Nahrungssicherung und Fürsorgekapazität konnte festgestellt werden, dass DDS und FVS in jeder Erhebungsperiode von verschiedenen Faktoren beeinflusst wurden. In der Regenzeit –mit Nahrungsmittelknappheit assoziiert – übten demographische und sozioökonomische Faktoren Einfluss auf beide Indikatoren der Nahrungsmittelvielfalt, während die Vielfalt der angebauten Pflanzen keine Rolle spielte. In der Nacherntephase wurden DDS und FVS zunächst von Nahrungsressourcen der agrobiologischen Vielfalt und vom sozioökonomischen Status beeinflusst. Nach Einschluss von Schulbildung des Familienoberhaupts in das Model konnte ein positiver Zusammenhang zwischen diesem Faktor und dem DDS gezeigt werden. In der Anbauperiode (auch der Beginn der Nahrungsmittelknappheit) spielten die angebaute Pflanzenvielfalt und die Wohnsitzlage (d.h. die jeweiligen Dörfer) eine signifikante Rolle beim DDS; die Länge der Nahrungsmittelknappheit und die Schulbindung des Familienoberhauptes spielten zusätzlich eine signifikante Rolle beim FVS.

Weniger als zehn Prozent an Unterernährung und mehr als 20% Übergewicht und Adipositas konnten festgestellt werden. Dieses Phänomen kann ein Hinweis auf Veränderungen der traditionellen Ernährung und eine Anpassung des Lebensstils, kurzum „nutrition transition“ bedeuten, wie es bereits in anderen Ländern niedrigen und mittleren Einkommens festgestellt worden ist. Eine saisonale, wenn auch leichte Abnahme in BMI, Körpergewicht und MUAC konnte im Laufe des Jahres gezeigt werden. Diese stimmte mit dem Beginn der Nahrungsmittelknappheit überein.

Eine hohe Prävalenz an Anämie wurde in jeder Erhebung festgestellt (35% bzw. 49% und 45%). Der Anteil an Frauen mit Anämie war in der Regenzeit signifikant geringer als in der Nacherntepheriode ($p < 0.05$). Die Hb Konzentrationen hatten einen positiven Zusammenhang mit dem Sammeln von Pflanzen in der Regenzeit ($p < 0.01$) und mit dem Konsum von tierischen Vitamin A reichen Nahrungsquellen in der Nachherntephase.

Eine saisonale Verbesserung des Eisenstatus bei gleichzeitiger Verschlechterung des Vitamin A Status fanden zwischen Juni-Juli und Oktober-November statt (beides $p < 0.001$). Aufgrund des niedrigen Anteils an Frauen mit abnormalen sTfR Konzentrationen bei gleichzeitig hoher Anämie-Prävalenz scheint Anämie in dieser Region nicht ausschließlich auf Eisenmangel sondern auf weitere ernährungs- oder gesundheitsbezogene Faktoren zurückzuführen sein.

Trotz des nicht signifikanten Zusammenhangs zwischen DDS und FVS mit Vitamin A und Eisenstatus waren bestimmte Konsummerkmale mit Konzentrationen von Hb, sTfR und RBP assoziiert. In diesem Fall bestand ein Zusammenhang zwischen dem Ernährungsstatus und der Ernährung, wie sie durch den DDS wiedergegeben werden konnte. Dadurch konnte gezeigt werden, dass auch qualitative Ernährungserhebungsmethoden kritische Konsummuster aufdecken können.

7 Resumen

La hipótesis planteada para el presente estudio se basó en que poblaciones que se desarrollan en un ambiente de alta agrobiodiversidad muestran una diversidad de la dieta igualmente alta y por consecuencia presentan un mejor estado nutricional que poblaciones con condiciones contrarias.

Para ello, un estudio transversal repetido se llevó a cabo en cuatro comunidades rurales Aymara en la región sudeste de Peru situada entre 3,850 y 4,100 m sobre el nivel del mar, en una zona con alta agrobiodiversidad.

Los objetivos principales fueron: A) Examinar si la agrobiodiversidad existente es favorable para una dieta balanceada, B) Evaluar la diversidad de alimentos y grupos alimenticios consumidos en diferentes épocas del año e identificar la posible influencia de temporadas, C) Identificar factores socioeconómicos y características domésticas que influyan en la diversidad de la dieta (DDS) y la variedad de alimentos (FVS), y D) Investigar si existe relación entre la dieta de la población y los indicadores nutricionales.

Los períodos seleccionados fueron: la temporada de lluvias (Febrero-Marzo), la post-cosecha (Junio-Julio) y la campaña de siembra (Octubre-Noviembre) durante el 2007. La población de estudio estuvo compuesta por mujeres entre los 15 y 49 años de edad. En cada período se incluyeron: 1) Cuestionarios estandarizados con preguntas generales y socioeconómicas, asi como tambien un recordatorio de las 24 horas y 2) Circunferencia braquial, peso y talla para el cálculo del IMC, y muestras de sangre capilar para investigar el estado nutricional relacionado con el hierro y la vitamina A.

Posterior a la limpieza de datos se obtuvo una muestra compuesta por 183, 161 y 158 mujeres en cada período, respectivamente. Para la investigacion de indicadores nutricionales se obtuvo muestras de 143, 105 y 98 mujeres en cada período, respectivamente. La diversidad de la dieta (DDS) se basó en 14 grupos alimenticios, mientras que en la variedad de alimentos (FVS) se identificaron 61 diferentes alimentos. Basado en un índice de riqueza y vivienda se distinguieron tres niveles de hogares con bajo, medio y alto nivel socioeconómico.

Los productos agrícolas más cultivados fueron la papa (100%), la cebada (80.3%), las habas (77.6%), la quinoa (71.6%) y la oca (57.9). La ganadería estuvo caracterizada por la cría de ovejas (92.4%) y gallinas (49.2%) para el propio consumo, y vacuno (76.5%), y cerdos (42.6%) mayormente para venta. Huertos para

el cultivo de vegetales y frutas sólo se identificaron en el 23% de los hogares, mientras que el 82.5% de las participantes indicó recolectar plantas silvestres. Considerando las mismas mujeres en los tres períodos (n = 147), la mediana (rango intercuartil IQR) de DDS fue de 6.7 (6.3 a 7.7) grupos alimenticios, y la de FVS fue de 11.0 (9.7 a 12.3) alimentos. La dieta estuvo caracterizada por papa (100%), cereales (97.3%) – mayormente arroz y productos a base de trigo, vegetales (95.3%) como la cebolla y el tomate, vegetales con pro-vitamina A (87.8%) tales como la zanahoria y el zapallo, y leguminosas (67%) mayormente habas. En general la prevalencia de consumo de alimentos de origen animal fue baja (< 50%). Sin embargo, la prevalencia de consumo de carne fue de cerca del 56% en las participantes del tercil superior de DDS. No hubo diferencias significantes en el DDS a lo largo de los tres períodos, mientras que el FVS entre Junio y Julio fue mas alto que el correspondiente entre Febrero y Marzo (p < 0.001) así como entre Octubre y Noviembre (p = 0.013).

La mediana (IQR) de número de alimentos tradicionales consumidos, 4.0 (3.0 a 5.0) no varió significantemente entre temporadas, comunidades, fuente de ingresos o nivel socioeconómico. Por el contrario, un mayor número de alimentos comerciales consumidos fue identificado en mujeres del tercil superior de nivel socioeconómico, de aquellas viviendo cerca mercados locales, de aquellas con ingresos mensuales, o bien con ingresos provenientes de la agricultura y de actividades adicionales (p < 0.01). Un mayor número de verduras y frutas se identificó en participantes del tercio superior de nivel socioeconómico (p < 0.05) y aquellas viviendo cerca a mercados locales (p < 0.01) durante la primera temporada.

Bajo la influencia de factores relacionados con la agrobiodiversidad, seguridad alimentaria y nivel de educación, el DDS y el FVS fueron determinados por diferentes factores dependiendo la temporada del año. En la temporada de pre-cosecha (época de lluvias) el DDS y el FVS fueron determinados por la escasez de alimentos y factores demográficos y socioeconómicos, pero no por la variedad de cultivos. Durante el tiempo post-cosecha, DDS y FVS fueron influenciados por la variedad de cultivos y el nivel socioeconómico. Al incluir en dicho período el nivel de educación del jefe del hogar, se observó un impacto positivo en el DDS.

Finalmente, en la época de siembra coincidente con el inicio de la escasez de alimentos, la variedad de cultivos existentes en el hogar y el lugar de residencia de las mujeres tuvieron impacto en el DDS, mientras que la duración del período de escasez de alimentos, el lugar de residencia y el nivel de educación influyeron en el FVS.

Menos del 10% de las mujeres tuvieron peso bajo, mientras que más del 20% presentaron sobrepeso o incluso obesidad, indicando procesos de transición nutricional en esta población. Por otro lado, si bien no muy marcado, se observó una significativa disminución de peso, BMI y circunferencia braquial ($p < 0.05$) hacia la última fase del estudio, coincidiendo con el inicio del período de escasez de alimentos.

La prevalencia de anemia fue alta en las tres temporadas (35%, 49% y 45%, respectivamente). Sin embargo, en la época de lluvias la prevalencia fue significativamente menor que en la post-cosecha ($p < 0.05$). La recolección de plantas silvestres en la primera temporada y el consumo de alimentos de origen animal ricos en vitamina A en la post-cosecha estuvieron significativamente relacionadas con mayores concentraciones de hemoglobina ($p< 0.01$ y $p < 0.05$, respectivamente).

Una significativa mejora en el estado del hierro se observó entre la temporada post-cosecha y de siembra, mientras en el mismo período el estado de la vitamina A empeoró ($p < 0.001$ en ambos indicadores). Debido a la alta prevalencia de anemia pero bajo porcentaje de mujeres con concentraciones suboptimales de sTfR es probable que la anemia en la población se deba no exclusivamente a la deficiencia de hierro sino también de otros nutrientes o factores de salud.

A pesar de que no hubo asociación significativa entre el DDS, el FVS y los indicadores nutricionales de vitamina A y hierro, los patrones de consumo mostraron tendencias asociadas con Hb, sTfR y RBP. En tal caso, los indicadores bioquímicos fueron sensibles a aspectos nutricionales reflejados en los alimentos consumidos por las participantes. De esta manera es importante investigar qué grupos alimenticios son consumidos por el individuo y queda demostrado que también métodos cualitativos pueden identificar patrones de consumo que pueden ser críticos.

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10 Appendix

Table 10.1 Most commonly gathered plants in the studied region

Vernacular name	English translation	Scientific name	usage
Amayzapato	--	*Calceolaria buchtieniana*	Cystitis, kidney and vesicular ailment, pains after childbirth, protate disorders
Anuch'api, amorseco	--	*Xanthium spinosum*	Blood depurative, fever
Berro/ocoruro	Watercress	*Nasturtium officinale*	Bronchitis, cough, cold, depurative, diuretic
Cedrón	Lemon verbena	*Aloysia triphylla*	Stomach ache, enteritis, high blood pressure, sedative
Chachacoma	--	*Senecio graveolens*	Stomach ache,
Chijchipa	--	*Tagetes multiflora*	Pains after childbirth, stomach ache
Chinchircoma, chinchirkuma	--	*Mutisia acuminata*	Headache, kidney ailments
Chiri chiri, chili chili	--	*Grindelia boliviana*	Contusions, luxations
Diente de Leon /auj auj cora	Dandelion	*Taraxacum officinale*	Depurative, bile and vesicular disorders, liver pain, kidney pain, stomach ulcer
Eucalipto	eucalyptus	*Eucaliptus globulus*	Cough, flu
Hierba Buena	Mint	*Mentha spicata*	Intestinal parasites
Kanapakho, Janapakho	--	*Sonchus oleraceus*	Bile and vesicular disorders, liver pain
Kencha mali, mali mali	--	*Quinchamalium procumbens*	Kidney ailment, lungs ailment
Llanten	--	*Plantago major*	Antibacterial, anti-inflammatory, kidney swelling, liver swelling
Llayta	--	*Nostoc commune*	Against Osteoporosis and anemia
Manzanilla	Chamomile	*Matricaria recutita*	Anti-inflammatory, colds, cough, stomach ache
Misico	--	*Bidens andicola*	Rheumatism, internal hemorrhage
Mostaza, nabo silvestre	--	*Brassica rapa subsp. campestris*	Fever, headache
Muña (qoa o qowa)	Andean mint	*Minthostachys spp.*	Digestive, fever, enteritis, teeth ache, stomach ache, cold.
Muni muni	--	--	--
Muni qoa	--	--	--
Nina sanku	--	--	--
Oraqtula	--	--	--
Ortiga		*Urtica urens*	Depurative, diuretic, rheumatism, protate disorders
Paico	Wormseed	*Chenopodium ambrosioides*	Bile and vesicular disorders, stomach pain
Pampa limon	--	--	--
Pata qoa	--	--	--
Patamuña	--	--	Stomach ache
Phuskalla	--	*Maihueniopsis cumulopuntia*	--
Pinku pinku	--	*Equisetum bogotense*	Diuretic

Continued

Ruda	--	*Ruta graveolens, Ruta chalepensis*	Digestive, headache, stomach pain
Salvia	Sage	*Salvia oppositiflora*	Cold, cough
Sanc ayu, sanqui	--	*Corryocactus brevistylus*	Liver ailments
Saya saya	--	--	--
Siki	--	--	--
Sillu sillu	--	*Lachemilla pinnata*	Kidney swelling, liver swelling, urine disorders
Verbena	Verbena	*Verbena litoralis*	Bile and vesicular disorders, stomach pain
Wira wira	--	*Gnaphalium cheiranthifolium*	Cough

Source: (Macía *et al.* 2005; Vidaurre *et al.* 2006; Yetman 2007).

Table 10.2 Used conversion factors for calculation of the animal index based on the livestock inventory*

Conversion factor for each animal type	
Cattle	7
Llama	6
Pig	5
Alpaca	4
Donkey	4
Sheep	3
Poultry and similar	2
Guinea pig	1

*The number of each animal type was multiplied by its conversion factor, and then the total amount for each animal kept by the household was added for the final animal index.

Table 10.3 Used subdivision of the animal index and corresponding score for the construction of the housing and wealth index

Values according animal index*	Corresponding score included in the housing and wealth index (after percentiles)
0 – 28	1
29 – 43	2
44 – 59	3
60 – 85	4
86 – 524	5

*Values refer to the livestock inventory.

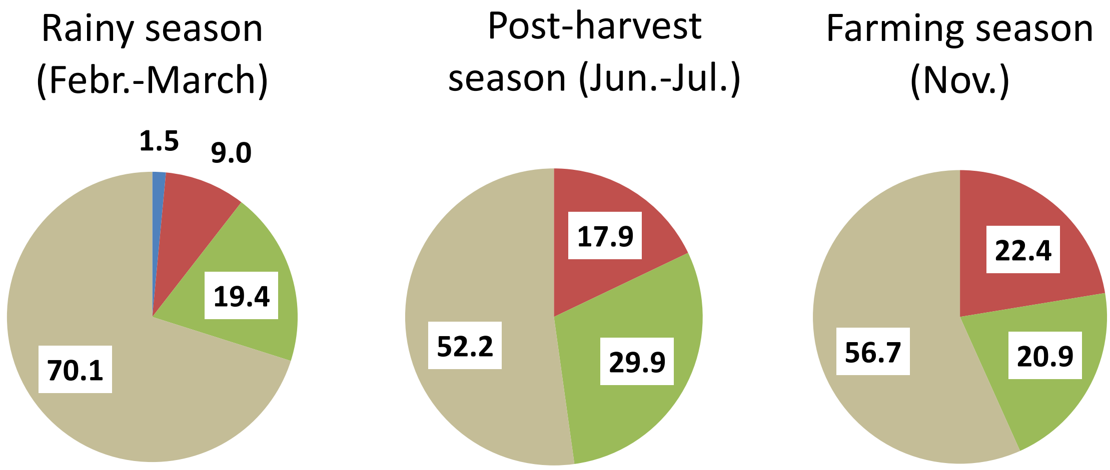

Figure 10.1 Percentages (%) of the cohort (n = 67) with normal Hb and different levels of anemia according to the WHO classification in each season (grey = non-anemia, green = mild anemia, red = moderate anemia, blue = severe anemia)

Table 10.4 Frequency of gathering practices and percentages related to the sample size in each village during the three cross-sectional surveys*

Village	Aychuyo	Arcunuma	Ccota	Perka	Pearson X^2
Rain-S	45 (84.9)	51 (96.2)	35 (100.0)	20 (47.6)	49.978**
Post-S	43 (84.3)	39 (97.5)	30 (100.0)	19 (47.5)	44.289**
Farm-S	43 (84.3)	31 (100.0)	34 (100.0)	20 (47.6)	46.044**

* Differences between villages according to Pearson chi square.

**Significance at the 0.001 level.

Table 10.5 Descriptive statistics of the number of purchased and consumed commercial foodstuffs according to certain socio-economic factors

Variable	Rain-S		Post-S		Farm-S	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Village						
Aychuyo	4.1 (1.2)	4.0 (3.0 to 5.0)	4.0 (1.3)	4.0 (3.0 to 5.0)	4.3 (1.4)	4.0 (4.0 to 5.0)
Arcunuma	2.8 (1.1)	3.0 (2.0 to 3.0)	2.4 (1.2)	2.0 (1.3 to 3.0)	2.3 (1.3)	2.0 (2.0 to 3.0)
Ccota	3.5 (1.0)	3.0 (3.0 to 4.0)	4.0 (1.3)	4.0 (3.0 to 5.0)	3.4 (1.2)	3.0 (2.8 to 4.3)
Perka	3.0 (0.9)	3.0 (3.0 to 4.0)	2.8 (1.0)	3.0 (2.0 to 3.0)	3.1 (0.9)	3.0 (3.0 to 4.0)
SES						
Low	3.3 (1.2)	3.0 (2.0 to 4.0)	3.1 (1.4)	3.0 (2.0 to 4.0)	3.1 (1.3)	3.0 (2.0 to 4.0)
Medium	3.2 (1.1)	3.0 (3.0 to 4.0)	3.2 (1.3)	3.0 (2.0 to 4.0)	3.2 (1.2)	3.0 (2.5 to 4.0)
High	4.1(1.2)	4.0 (3.0 to 5.0)	4.0 (1.3)	4.0 (3.0 to 5.0)	4.1 (1.6)	4.0 (3.0 to 5.0)
Income source						
Seasonal /unskilled activities	3.2 (0.9)	3.0 (3.0 to 4.0)	3.4 (1.3)	3.0 (3.0 to 4.0)	3.1 (1.2)	3.0 (2.0 to 4.0)
Agricultural act.	3.2 (1.4)	3.0 (2.0 to 4.0)	3.1 (1.6)	3.0 (2.0 to 4.0)	3.0 (1.5)	3.0 (2.0 to 4.0)
Agricultural and additional act.	3.7 (1.1)	4.0 (3.0 to 4.0)	3.5 (1.5)	3.5 (2.0 to 5.0)	4.2 (1.4)	4.0 (3.0 to 5.0)
Regular wage/salary	4.4 (1.2)	4.5 (4.0 to 5.0)	3.9 (1.1)	4.0 (3.0 to 5.0)	4.1 (0.8)	4.0 (3.5 to 5.0)

Table 10.6 Descriptive statistic of the number of consumed local foods according to certain socio-economic factors

Variable	Rain-S		Post-S		Farm-S	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Village						
Aychuyo	4.2 (1.4)	4.0 (3.0 to 5.0)	4.3 (1.2)	4.0 (3.5 to 5.0)	3.7 (1.0)	4.0 (3.0 to 4.0)
Arcunuma	3.9 (1.2)	4.0 (3.0 to 5.0)	3.9 (1.1)	4.0 (3.0 to 4.0)	4.1 (1.0)	4.0 (4.0 to 5.0)
Ccota	4.2 (0.9)	4.0 (3.8 to 5.0)	4.3 (1.1)	4.0 (4.0 to 5.0)	4.2 (1.3)	4.0 (3.0 to 5.0)
Perka	3.8 (1.2)	4.0 (3.0 to 5.0)	4.0 (1.1)	4.0 (3.0 to 5.0)	3.9 (0.9)	4.0 (3.0 to 4.3)
SES						
Low	4.2 (1.2)	4.0 (4.0 to 5.0)	4.1 (1.1)	4.0 (3.0 to 5.0)	4.1 (1.1)	4.0 (3.0 to 5.0)
Medium	3.9 (1.1)	4.0 (3.0 to 5.0)	4.3 (1.4)	4.0 (4.0 to 5.0)	3.8 (0.9)	4.0 (3.0 to 4.0)
High	4.1 (1.3)	4.0 (3.0 to 5.0)	3.9 (0.9)	4.0 (3.0 to 4.0)	3.9 (1.1)	4.0 (3.0 to 5.0)
Income source						
Seasonal /unskilled activities	3.9 (1.3)	4.0 (3.0 to 5.0)	4.3 (1.2)	4.0 (3.0 to 5.0)	4.1 (0.9)	4.0 (4.0 to 5.0)
Agricultural act.	4.1 (1.2)	4.0 (4.0 to 5.0)	3.9 (0.9)	4.0 (3.0 to 4.0)	3.9 (1.0)	4.0 (3.0 to 5.0)
Agricultural and additional act.	4.2 (0.9)	4.0 (3.8 to 5.0)	3.8 (0.9)	4.0 (3.0 to 4.3)	3.8 (1.2)	4.0 (3.0 to 5.0)
Regular wage/salary	4.3 (1.4)	4.0 (3.0 to 5.0)	4.7 (1.2)	4.0 (4.0 to 6.0)	3.6 (1.0)	3.0 (3.0 to 4.0)

Table 10.7 Descriptive statistic of the number of purchased and consumed vegetables and fruits according to certain socio-economic factors

Variable	Rain-S		Post-S		Farm-S	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Village						
Aychuyo	4.8 (1.6)	5.0 (3.5 to 6.0)	4.9 (2.0)	5.0 (3.5 to 6.0)	4.4 (1.4)	5.0 (3.0 to 5.0)
Arcunuma	3.4 (1.7)	3.0 (2.0 to 4.0)	4.1 (1.7)	4.0 (3.0 to 5.0)	3.9 (1.2)	4.0 (3.0 to 5.0)
Ccota	2.9 (1.4)	3.0 (2.0 to 4.0)	4.6 (2.0)	5.0 (4.0 to 6.0)	3.7 (1.6)	3.0 (2.8 to 5.3)
Perka	4.3 (1.5)	4.0 (3.0 to 5.0)	4.9 (1.9)	5.0 (4.0 to 6.0)	4.5 (1.6)	5.0 (3.0 to 6.0)
SES						
Low	3.5 (1.8)	3.0 (2.0 to 4.0)	4.6 (1.9)	5.0 (3.0 to 6.0)	3.9 (1.5)	4.0 (3.0 to 5.0)
Medium	4.0 (1.6)	4.0 (3.0 to 5.0)	4.7 (1.9)	5.0 (4.0 to 6.0)	4.3 (1.4)	4.0 (3.0 to 5.0)
High	4.5 (1.7)	4.0 (3.0 to 6.0)	5.0 (2.1)	5.0 (4.0 to 6.0)	4.4 (1.5)	5.0 (3.0 to 5.0)
Income source						
Seasonal /unskilled activities	3.2 (0.9)	3.0 (3.0 to 4.0)	4.7 (1.9)	5.0 (4.0 to 6.0)	4.2 (1.5)	4.0 (3.0 to 5.0)
Agricultural act.	4.3 (1.6)	4.0 (3.0 to 5.0)	4.6 (1.7)	5.0 (4.0 to 6.0)	3.9 (1.5)	4.0 (3.0 to 5.0)
Agricultural and additional act.	3.9 (1.7)	4.0 (3.0 to 5.0)	4.6 (1.7)	5.0 (4.0 to 6.0)	4.7 (1.3)	5.0 (3.8 to 6.0)
Regular wage/salary	4.7 (1.4)	4.0 (3.3 to 6.0)	5.6 (2.7)	6.0 (3.0 to 8.0)	3.5 (1.5)	3.0 (2.0 to 4.5)

Table 10.8 Marginal means from predictors and parameter estimates from covariates using DDS as dependent variable in the GLM analysis during the rainy season

Predictor variable	Model 1 "With agrobiodiversity"			Model 2 "Adding demography and cash"			Model 3 "Adding caring capacity"		
	Mean	**SE**	**p***	**Mean**	**SE**	**p***	**Mean**	**SE**	**p***
Crop variety									
Low	6.51	0.24		6.86	0.25		6.93	0.28	
Medium	6.73	0.15	n.s.	6.87	0.16	n.s.	6.89	0.18	n.s.
High	6.52	0.23		6.49	0.23		6.63	0.25	
Residence									
Aychuyo (A)				7.46	0.21		7.49	0.23	
Arcunuma (Ar)				6.11	0.24	A – Ar < 0.001,	6.21	0.27	A – Ar 0.001
Ccota (C)				6.83	0.27	A – P 0.027	6.88	0.29	
Perka (P)				6.58	0.23		6.68	0.26	
Income source									
Seasonal labor				6.28	0.17		6.41	0.21	
Agricultural labor				6.75	0.19		6.89	0.22	
Agric. and additional labor				6.92	0.24	n.s.	7.10	0.27	n.s.
Monthly wage/salary				7.04	0.32		6.87	0.34	
Education of the HH's head									
<3y primary school							6.55	0.33	
Completed primary school							6.56	0.23	
Completed secondary school							6.78	0.19	n.s.
Higher degree							7.38	0.34	
Covariates	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	0.001	0.011	0.956	-0.007	0.010	0.508	-0.008	0.013	0.514
Household size	0.133	0.053	**0.013**	0.114	0.050	**0.025**	0.103	0.055	0.064
SES	0.110	0.033	**0.001**	0.066	0.032	**0.040**	0.045	0.035	0.197
Food shortage (length)	-0.251	0.087	**0.004**	-0.089	0.089	0.317	-0.115	0.095	0.227

*p values refer to the pairwise comparisons with adjustment (according to Bonferroni).

Table 10.9 Marginal means from predictors and parameter estimates from covariates using FVS as dependent variable in the GLM analysis during the rainy season

Predictor variable	Model 1 "With agrobiodiversity"			Model 2 "Adding demography and cash"			Model 3 "Adding caring capacity"		
	Mean	**SE**	**p***	**Mean**	**SE**	**p***	**Mean**	**SE**	**p***
Crop variety									
Low	10.52	0.48		11.01	0.50		10.95	0.56	
Medium	10.44	0.30	n.s.	10.49	0.33	n.s.	10.40	0.37	n.s.
High	10.12	0.46		9.70	0.46		9.77	0.49	
Residence									
Aychuyo(A)				11.85	0.43	A-Ar and A-C < 0.001, C-P 0.035	11.77	0.45	A-Ar and A-C 0.001, C-P 0.041
Arcunuma(Ar)				9.41	0.48		9.39	0.53	
Ccota(C)				9.24	0.55		9.20	0.59	
Perka(P)				11.11	0.47		11.13	0.51	
Income source									
Seasonal labor				9.57	0.35		9.58	0.42	
Agric.labor				10.10	0.39	n.s.	10.22	0.44	n.s.
Agric. and additional labor				10.69	0.47		10.73	0.54	
Monthly wage/salary				11.25	0.64		10.97	0.68	
Education of the HH's head									
<3y primary school							9.41	0.66	
Completed primary school							10.49	0.47	n.s.
Completed secondary school							10.60	0.37	
Higher degree							10.99	0.68	
Covariates	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	0.019	0.021	0.383	-0.004	0.020	0.836	0.004	0.025	0.888
Household size	0.238	0.108	**0.029**	0.277	0.102	**0.007**	0.190	0.111	0.089
SES	0.190	0.067	**0.005**	0.122	0.065	0.061	0.106	0.070	0.133
Food shortage (length)	-0.697	0.177	**<0.001**	-0.359	0.179	**0.046**	-0.394	0.190	**0.040**

*p values refer to the pairwise comparisons with adjustment (according to Bonferroni).

Table 10.10 Marginal means from predictors and parameter estimates from covariates using DDS as dependent variable in the GLM analysis during the post-harvest season

Predictor variable	Model 1 "With agrobiodiversity"			Model 2 "Adding demography and cash"			Model 3 "Adding caring capacity"		
	Mean	**SE**	**p***	**Mean**	**SE**	**p***	**Mean**	**SE**	**p***
Crop variety									
Low(l)	6.08	0.25		6.41	0.28		6.23	0.32	
Medium(m)	6.95	0.14	*l – m* 0.007	6.97	0.17	n.s.	7.04	0.18	n.s.
High(h)	6.61	0.23		6.61	0.24		6.77	0.25	
Residence									
Aychuyo (A)				6.84	0.24		6.84	0.25	
Arcunuma (Ar)				6.06	0.27	*C-Ar* 0.015	6.09	0.31	n.s.
Ccota (C)				7.19	0.27		7.09	0.29	
Perka (P)				6.58	0.27		6.72	0.29	
Income source									
Seasonal labor				6.59	0.16		6.72	0.19	
Agricultural labor				6.59	0.22	n.s.	6.89	0.24	n.s.
Agric. and additional labor				6.45	0.25		6.49	0.28	
Monthly wage/salary				7.02	0.36		6.61	0.38	
Education oft he HH's head									
<3y primary school (a)							6.01	0.38	
Completed primary school (b)							6.57	0.24	*a – d* 0.009, *b – d* 0.045, *c – d* 0.005
Completed secondary school (c)							6.38	0.18	
Higher degree(d)							7.77	0.35	
Covariates	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	-0.003	0.011	0.798	-0.002	0.011	0.827	0.006	0.014	0.664
Household size	0.030	0.058	0.522	0.005	0.058	0.928	0.014	0.062	0.821
SES	0.097	0.036	**0.008**	0.068	0.037	0.066	0.032	0.039	0.822
Food shortage (length)	-0.132	0.102	0.197	-0.066	0.114	0.566	-0.035	0.121	0.772

*p values refer to the pairwise comparisons with adjustment (after Bonferroni).

Table 10.11 Marginal means from predictors and parameter estimates from covariates using FVS as dependent variable in the GLM analysis during the post-harvest season

Predictor variable	Model 1 "With agrobiodiversity"			Model 2 "Adding demography and cash"			Model 3 "Adding caring capacity"		
	Mean	**SE**	**p***	**Mean**	**SE**	**p***	**Mean**	**SE**	**p***
Crop variety									
Low(l)	9.79	0.52		10.69	0.58		10.39	0.67	
Medium(m)	11.57	0.30	*l – m* 0.009	11.58	0.35	n.s.	11.53	0.39	n.s.
High(h)	11.34	0.48		11.10	0.49		11.14	0.53	
Residence									
Aychuyo				11.87	0.50		11.80	0.54	
Arcunuma				9.64	0.57	n.s.	9.64	0.65	n.s.
Ccota				11.32	0.56		10.96	0.63	
Perka				11.66	0.57		11.68	0.61	
Income source									
Seasonal labor				10.98	0.34		11.05	0.40	
Agricultural labor				10.58	0.45	n.s.	10.79	0.52	n.s.
Agric. and additional labor				10.57	0.51		10.44	0.59	
Monthly wage/salary				12.35	0.75		11.82	0.82	
Education oft he HH's head									
<3y primary school (a)							10.32	0.80	
Completed primary school (b)							10.74	0.52	n.s.
Completed secondary school (c)							10.85	0.38	
Higher degree (d)							12.18	0.75	
Covariates	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	-0.029	0.024	0.231	-0.036	0.024	0.129	-0.022	0.031	0.478
Household size	0.045	0.122	0.716	0.037	0.120	0.758	0.039	0.132	0.296
SES	0.183	0.076	**0.017**	0.098	0.076	0.201	0.057	0.084	0.501
Food shortage (length)	-0.098	0.215	0.650	0.126	0.238	0.597	0.160	0.257	0.533

*p values refer to the pairwise comparisons with adjustment (according to Bonferroni).

Table 10.12 Marginal means from predictors and parameter estimates from covariates using DDS as dependent variable in the GLM analysis during the farming season

Predictor variable	Model 1 "With agrobiodiversity"			Model 2 "Adding demography and cash"			Model 3 "Adding caring capacity"		
	Mean	**SE**	**p***	**Mean**	**SE**	**p***	**Mean**	**SE**	**p***
Crop variety									
Low (l)	6.19	0.26	*l – m* 0.002, *l – h* 0.045	6.45	0.27	n.s.	6.34	0.32	n.s.
Medium (m)	7.21	0.14		7.18	0.17		7.16	0.18	
High (h)	7.10	0.22		6.84	0.24		6.89	0.25	
Residence									
Aychuyo (A)				7.58	0.25	A – Ar 0.012, A – P 0.041	7.63	0.26	A – Ar 0.006
Arcunuma (Ar)				6.42	0.31		6.28	0.35	
Ccota (C)				6.84	0.24		6.77	0.27	
Perka (P)				6.45	0.27		6.51	0.29	
Income source									
Seasonal labor				6.84	0.16	n.s.	6.92	0.19	n.s.
Agric.labor				6.65	0.22		6.75	0.24	
Agric. and additional labor				7.16	0.21		7.05	0.27	
Monthly wage/salary				6.64	0.35		6.47	0.36	
Education of the HH's head									
<3y primary school (a)							6.52	0.35	n.s.
Completed primary school (b)							6.65	0.24	
Completed secondary school (c)							6.65	0.18	
Higher degree (d)							7.35	0.33	
Covariates	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	-0.008	0.012	0.488	-0.011	0.012	0.384	-0.006	0.015	0.706
Household size	-0.017	0.056	0.765	-0.019	0.057	0.739	0.001	0.060	0.988
SES	0.060	0.036	0.101	0.028	0.035	0.436	0.009	0.038	0.805
Food shortage (length)	-0.108	0.095	0.261	0.019	0.103	0.857	0.103	0.111	0.357

*p values refer to the pairwise comparisons with adjustment (according to Bonferroni).

Table 10.13 Marginal means from predictors and parameter estimates from covariates using FVS as dependent variable in the GLM analysis during the farming season

Predictor variable	Model 1 "With agrobiodiversity"			Model 2 "Adding demography and cash"			Model 3 "Adding caring capacity"		
	Mean	**SE**	**p***	**Mean**	**SE**	**p***	**Mean**	**SE**	**p***
Crop variety									
Low (l)	9.87	0.45		10.28	0.46		9.76	0.54	
Medium (m)	11.01	0.23	n.s.	10.78	0.28	n.s.	10.63	0.30	n.s.
High (h)	11.06	0.38		10.43	0.41		10.45	0.42	
Residence									
Aychuyo (A)				11.87	0.42	*A – Ar*	11.71	0.44	
Arcunuma (Ar)				9.63	0.53	0.003,	9.38	0.59	*A – Ar* 0.005,
Ccota (C)				10.16	0.42	*A – C*	9.72	0.46	*A – C* 0.009
Perka (P)				10.34	0.47	0.029	10.32	0.49	
Income source									
Seasonal labor				10.66	0.28		10.58	0.33	
Agricultural labor				10.43	0.37	n.s.	10.55	0.39	n.s.
Agric. and additional labor				11.15	0.36		10.72	0.45	
Monthly wage/salary				9.75	0.59		9.28	0.61	
Education of the HH's head									
<3y primary school (a)							9.16	0.59	
Completed primary school (b)							10.06	0.41	*a – d* 0.036
Completed secondary school (c)							10.41	0.31	
Higher degree (d)							11.49	0.55	
Covariates	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	-0.008	0.021	0.693	-0.017	0.021	0.411	0.005	0.026	0.859
Household size	-0.123	0.096	0.203	-0.075	0.098	0.441	-0.081	0.101	0.422
SES	0.136	0.062	**0.030**	0.079	0.060	0.195	0.022	0.064	0.728
Food shortage (length)	-0.114	0.164	0.488	0.338	0.175	0.055	0.420	0.187	**0.026**

*p values refer to the pairwise comparisons with adjustment (according to Bonferroni).

Table 10.14 Relationship between DDS and women's demographic and socio-economic characteristics†

	Rain-S (February-March)			Post-S (June-July)			Farm-S (Oct.-Nov.)			Factor* season
Selected factors	n	DDS	p**	n	DDS	p**	n	DDS	p**	p
Age										
15-19	20	5.8 (1.3)	**0.005**	17	6.4 (1.3)	0.732	11	7.2 (1.2)	0.553	0.923
20-29	44	6.9 (1.3)		35	6.7 (1.7)		39	6.8 (1.4)		
30-39	66	6.9 (1.3)		59	6.8 (1.3)		60	7.1 (1.3)		
40-49	53	6.7 (1.3)		50	6.8 (1.1)		48	7.0 (1.3)		
Household size										
Small (2-3)	50	6.3 (1.5)	**0.034**	43	6.3 (1.2)	0.853	43	6.9 (1.4)	0.776	0.112
Medium (4-5)	65	6.8 (1.2)		56	7.0 (1.1)		57	7.0 (1.2)		
Large (>5)	65	6.9 (1.3)		59	7.0 (1.3)		56	7.1 (1.3)		
Crop diversity										
Low (1-4)	44	6.2 (1.3)	**0.020**	35	6.0 (1.3)	**0.001**	31	6.2 (1.3)	**< .001**	0.519
Medium (5-7)	96	6.8 (1.2)		85	7.0 (1.3)		89	7.2 (1.3)		
High (>7)	43	7.0 (1.5)		41	6.9 (1.4)		38	7.2 (1.2)		
Home garden										
Yes	42	6.9 (1.3)	0.222	19	7.2 (1.3)	0.156	15	7.8 (1.2)	**0.012**	0.522
No	141	6.6 (1.4)		140	6.7 (1.4)		142	6.9 (1.3)		
Gathering										
Yes	151	6.8 (1.4)	0.346	105	6.9 (1.3)	0.056	99	7.0 (1.4)	0.836	0.354
No	32	6.5 (1.0)		55	6.5 (1.3)		58	7.0 (1.2)		
Place of residence										
Aychuyo	53	7.6 (1.2)	**<.001**	51	7.2 (1.3)	**<.001**	51	7.6 (1.3)	**<.001**	0.119
Arcunuma	53	5.9 (1.5)		40	5.9 (1.2)		31	6.1 (1.2)		
Ccota	35	6.9 (1.1)		30	7.3 (1.4)		34	7.1 (1.2)		
Perka	42	6.4 (0.9)		10	6.6 (1.1)		42	1.0 (1.0)		
SES level										
Low	59	6.3 (1.5)	**0.001**	51	6.5 (1.4)	**0.003**	44	6.7 (1.4)	0.091	0.551
Medium	80	6.6 (1.1)		69	6.6 (1.3)		72	7.0 (1.2)		
high	44	7.3 (1.3)		41	7.3 (1.2)		42	7.3 (1.3)		
Source of income										
Seasonal/unskilled activities	69	6.4 (1.3)	**0.001**	69	6.8 (1.1)	**0.035**	64	6.9 (1.1)	**0.008**	0.074
Farming activities	59	6.6 (1.3)		45	6.4 (1.2)		37	6.6 (1.5)		
Farming and additional activity	37	7.0 (1.4)		31	6.7 (1.4)		41	7.5 (1.2)		
Regular wages	17	7.7 (1.2)		15	7.6 (1.8)		14	7.2 (1.3)		
Education of the head of HH										
< 3y schooling years	19	6.4 (1.1)	**0.009**	18	6.3 (0.9)	**0.001**	17	6.8 (1.4)	0.104	0.906
Primary school	41	6.7 (1.4)		39	6.8 (1.2)		39	7.0 (1.3)		
Secondary school	90	6.7 (1.3)		74	6.6 (1.4)		74	6.9 (1.2)		
Higher education	17	7.8 (1.4)		15	8.1 (1.4)		16	7.8 (1.3)		
Food shortage										
No food shortage	16	6.9 (0.3)	**0.048**	14	6.9 (1.0)	0.665	12	7.2 (1.1)	0.362	0.833
1-3 months	145	6.7 (0.1)		133	6.7 (1.4)		129	7.0 (1.3)		
> 3 months	22	6.1 (0.3)		14	6.4 (1.1)		17	6.6 (1.4)		

†Values as mean (SD).
**p values according to group comparisons.

Table 10.15 Relationship between FVS and women's demographic and socio-economic characteristics†

	Rain-S (February-March)			Post-S (June-July)			Farm-S (Oct.-Nov.)			Factor* season
Selected factors	n	FVS	p**	n	FVS	p**	n	FVS	p**	p
Age										
15-19	20	9.4 (2.7)	0.354	17	11.1 (3.2)	0.982	11	11.7 (1.8)	0.283	0.258
20-29	44	10.2 (2.3)		35	11.4 (3.3)		39	10.4 (2.2)		
30-39	66	10.5 (2.7)		59	11.3 (2.5)		60	10.9 (2.9)		
40-49	53	10.6 (3.0)		50	11.2 (2.9)		48	11.0 (2.0)		
Household size										
Small (2-3)	50	9.9 (2.9)	0.292	43	11.2 (3.0)	0.861	43	11.1 (2.4)	0.308	0.055
Medium (4-5)	65	10.3 (2.3)		56	11.2 (2.8)		57	10.5 (1.8)		
Large (>5)	65	10.7 (3.0)		59	11.4 (2.9)		56	10.9 (2.3)		
Crop diversity										
Low (1-4)	44	9.6 (2.7)	0.067	35	9.8 (2.8)	**0.002**	31	10.0 (1.9)	**0.048**	0.263
Medium (5-7)	96	10.4 (2.5)		85	11.7 (2.7)		89	11.0 (2.3)		
High (>7)	43	11.0 (3.1)		41	11.8 (2.8)		38	11.1 (2.0)		
Home garden										
Yes	42	11.1 (2.8)	0.056	19	11.8 (2.4)	0.156	15	12.1 (2.4)	**0.022**	0.907
No	141	10.1 (2.7)		140	11.2 (2.9)		142	10.7 (2.1)		
Gathering										
Yes	151	10.3 (2.7)	0.056	105	11.6 (2.8)	**0.028**	99	10.8 (2.3)	0.732	0.087
No	32	10.6 (2.7)		55	10.6 (2.9)		58	10.9 (2.3)		
Place of residence										
Aychuyo	53	12.2 (2.6)	**<.001**	51	12.4 (3.0)	**<.001**	51	11.6 (2.1)	**<.001**	**0.002**
Arcunuma	53	9.2 (2.6)		40	9.5 (2.3)		31	9.6 (1.8)		
Ccota	35	9.2 (1.9)		30	11.9 (2.5)		34	10.6 (2.3)		
Perka	42	10.5 (2.3)		10	11.2 (2.5)		42	11.0 (1.9)		
SES level										
Low	59	9.7 (2.8)	**0.002**	51	10.8 (2.9)	**0.041**	44	10.5 (2.1)	0.060	0.619
Medium	80	10.2 (2.4)		69	11.1 (2.6)		72	10.7 (2.1)		
high	44	11.6 (2.7)		41	12.2 (3.0)		42	11.5 (2.1)		
Source of income										
Seasonal/unskilled activities	69	9.6 (2.6)	**0.001**	69	11.5 (2.3)	**0.002**	64	10.8 (2.0)	**0.018**	**0.001**
Farming activities	59	10.2 (2.6)		45	10.3 (2.8)		37	10.4 (2.3)		
Farming and additional activity	37	11.0 (2.5)		31	11.2 (2.9)		41	11.8 (2.1)		
Regular wages	17	12.4 (2.7)		15	13.5 (3.9)		14	10.4 (1.7)		
Education of the head of HH										
< 3y schooling years	19	9.4 (2.4)	**0.035**	18	10.6 (2.4)	0.067	17	9.9 (1.7)	0.074	0.858
Primary school	41	10.9 (3.0)		39	11.1 (2.9)		39	10.9 (2.3)		
Secondary school	90	10.2 (2.5)		74	11.2 (2.8)		74	10.8 (2.1)		
Higher education	17	11.8 (3.2)		15	13.1 (3.1)		16	11.9 (2.2)		
Food shortage										
No food shortage	16	11.1 (2.4)	0.082	14	11.2 (2.0)	0.993	12	10.3 (2.5)	0.566	0.150
1-3 months	145	10.4 (2.7)		133	11.3 (3.0)		129	10.9 (2.1)		
> 3 months	22	9.2 (2.9)		14	11.2 (1.9)		17	10.7 (2.6)		

†Values as mean (SD).

**p values according to group comparisons.

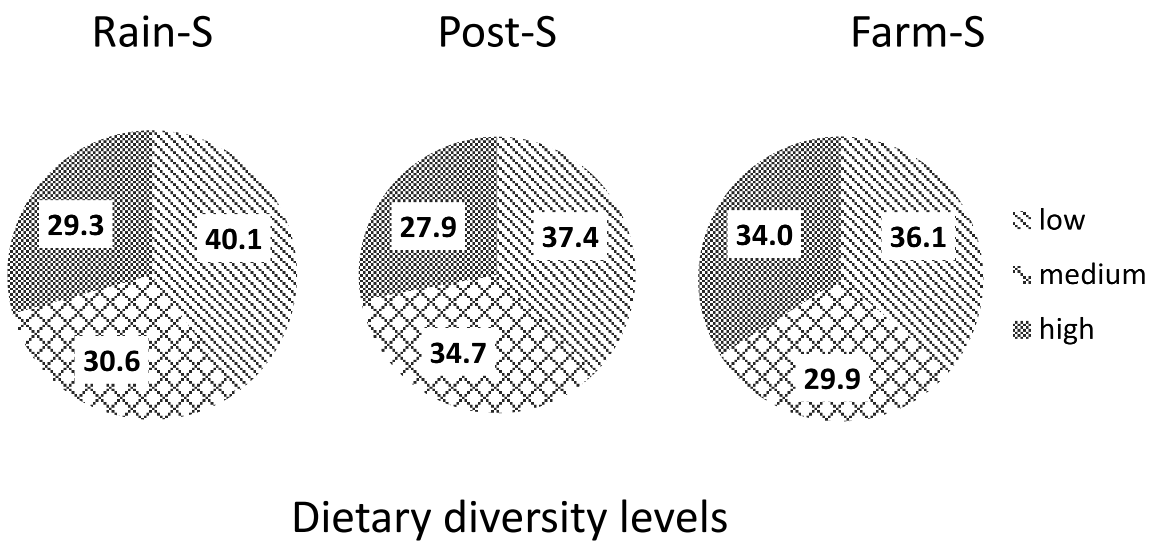

Figure 10.2 Share of participants of the cohort with low, medium, and high DDS throughout the year (n = 147)

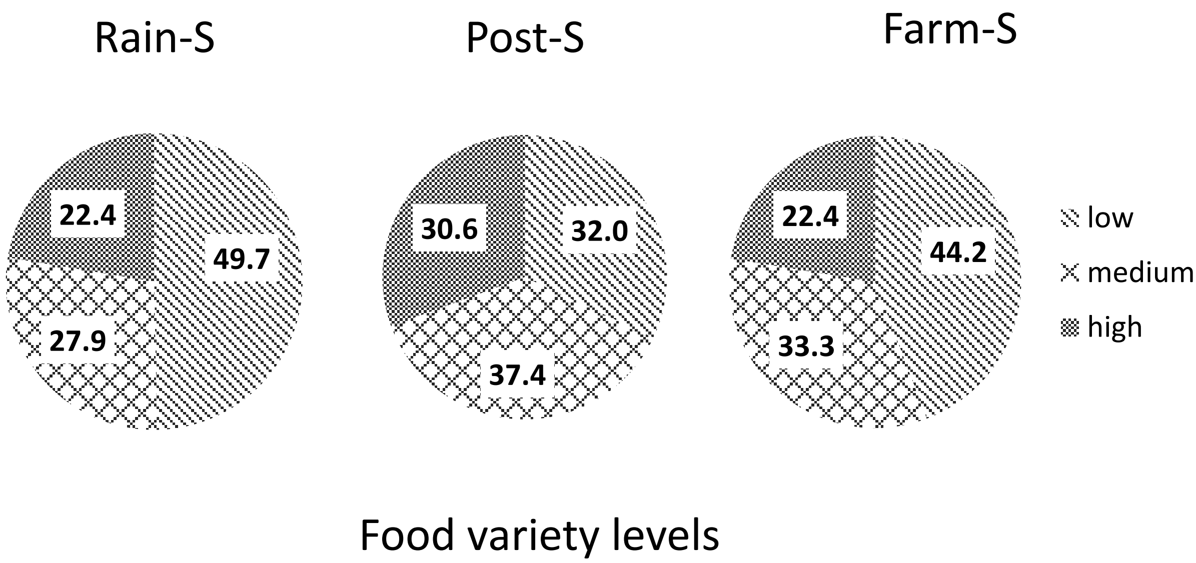

Figure 10.3 Share of participants of the cohort with low, medium, and high FVS throughout the year (n = 147)

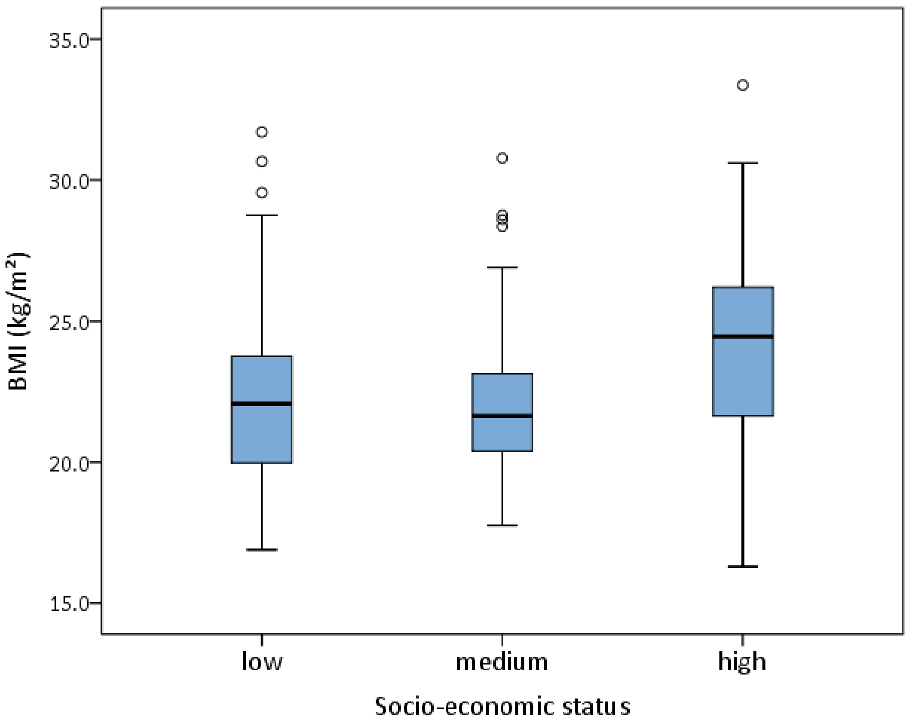

Figure 10.4 BMI according to low, medium, and high SES in the first survey (n = 147)

Table 10.16 Relationship* between selected socio-economic and demographic characteristics and the anthropometric measurements of the second cross sectional survey (n = 105)

Variable	Height		Weight		MUAC		BMI	
Age	-0.113	n.s.	0.042,	n.s.	0.074,	n.s.	0.091,	n.s.
Wealth and housing index	0.188,	p = 0.026	0.171,	n.s.	0.213,	p = 0.029	0.148,	n.s.
Education level of the HH**	0.184,	p = 0.037	0.139,	n.s.	0.153,	n.s.	0.163,	n.s.
Educational level of the partner***	0.236,	p = 0.011	0.188,	n.s.	0.214,	p = 0.045	0.200,	n.s.
Education level of the participant	0.155,	n.s.	0.213,	p = 0.029	0.210,	p = 0.031	0.213,	p = 0.029

* Spearman's coefficient rho of the bivariate correlations
**According to the available data, n = 97.
***Only referred to those participants who stated being married or living together with the partner, n = 88.

Table 10.17 Spearman's coefficient rho of the bivariate correlations between selected socio-economic and demographic characteristics and the anthropometric measurements of the third cross sectional survey (n = 98)

Variable	Height		Weight		MUAC		BMI	
Age	-0.113,	n.s.	-0.027,	n.s.	0.016,	n.s.	0.036,	n.s.
Wealth and housing index	0.201,	p = 0.017	0.133,	n.s.	0.131,	n.s.	0.072,	n.s.
Education level of the HH**	0.158,	n.s.	0.171,	n.s.	0.156,	n.s.	0.189,	n.s.
Educational level of the partner***	0.216,	p = 0.018	0.238,	p = 0.027	0.213,	p = 0.047	0.233,	p = 0.030
Education level of the participant	0.114,	n.s.	0.271,	p = 0.007	0.280,	p = 0.006	0.266,	p = 0.009

* Spearman's coefficient rho of the bivariate correlations
**According to the available data, n = 95.
***Only referred to those participants who stated being married or living together with the partner, n = 87.

Table 10.18 Hb concentrations according to the DDS levels in each season

			Hemoglobin (g/L)	
	DDS levels	n	Mean (SD)	Min - Max
Rain-S	*Low*	58	120.2 (14.4)	83.9 – 147.9
	Medium	46	127.4 (11.3)	95.6 – 147.6
	High	39	123.1 (16.6)	63.9 – 149.9
Post-S	*Low*	41	117.6 (9.8)	98.9 – 134.6
	Medium	34	122.8 (14.8)	79.9 – 151.6
	High	30	122.5 (13.5)	85.9 – 154.6
Farm-S	*Low*	36	119.8 (13.9)	92.1 – 155.1
	Medium	28	120.3 (12.7)	99.9 – 151.6
	High	34	123.0 (12.9)	92.1 – 140.9
Cohort Rain-S	*Low*	43	122.4 (14.9)	83.9 – 147.9
	Medium	43	127.4 (11.7)	95.6 – 149.9
	High	36	124.1 (16.9)	63.9 – 149.9
Cohort Post-S	*Low*	33	118.4 (9.7)	98.9 – 134.6
	Medium	34	122.8 (14.8)	79.9 – 151.6
	High	30	122.5 (13.5)	85.9 – 154.6
Cohort Farm-S	*Low*	34	119.1 (13.6)	92.1 – 155.1
	Medium	28	120.3 (12.7)	99.9 – 151.6
	High	33	123.4 (12.9)	92.1 – 140.9

Table 10.19 Hb concentrations according to the FVS levels in each season

			Hemoglobin (g/L)	
	FVS levels	n	Mean (SD)	Min - Max
Rain-S	*Low*	76	122.4 (14.9)	79.9 – 149.9
	Medium	36	122.5 (16.7)	63.9 – 148.9
	High	31	126.2 (9.5)	107.1 – 148.6
Post-S	*Low*	35	121.1 (12.5)	98.9 – 142.1
	Medium	34	120.3 (13.8)	79.9 – 151.6
	High	36	120.6 (12.3)	85.9 – 154.6
Farm-S	*Low*	44	119.7 (14.6)	92.1 – 155.1
	Medium	33	124.2 (12.6)	101.6 – 151.6
	High	21	118.9 (10.5)	98.6 – 138.6
Cohort Rain-S	*Low*	59	124.1 (15.4)	79.9 – 149.9
	Medium	33	123.6 (17.1)	63.9 – 148.9
	High	30	123.9 (8.9)	110.9 – 148.5
Cohort Post-S	*Low*	28	122.8 (12.4)	98.9 – 142.1
	Medium	33	120.6 (13.9)	79.9 – 151.6
	High	36	120.6 (12.5)	85.6 – 154.6
Cohort Farm-S	*Low*	42	119.1 (14.3)	92.1 – 155.1
	Medium	33	124.2 (12.6)	101.6 – 151.6
	High	20	119.4 (10.5)	98.6 – 138.6

10.20 Questionnaire used for the surveys (English version)

Encuesta: Biodiversity & nutrition in the Peruvian Andes, code: ______
Ursula Chavez Zander, Justus Liebig University Giessen, Germany
E-mail: Ursula.Chavez-Zander@ernaehrung.uni-giessen.de 1

Questionnaire

Date of survey (day/month/year)		
Interviewer		
Name of respondent		
Village	1= Perka 3= Aychullo 2= Ccota 4= Arcunuma	

General questions

1	Name of the respondent			NAMEFA
2	Name of the partner			NAMEMO
3	Birthdate of respondent			BIRTHDA
4	What is your marital status?	1= Single 4= Widowed 2= Married 5= Divorced 3= Living together 6= Separated		MARSTA
5	Who is the head of the family?	1= respondent 77:other 2= partner 3= both of them		HOUSEH
6	How many people live in this household?	<5 years : 5-15 years : 15-49 years : > 50 years :		HMEMNO
7	Is this village your original place of living or from which part of the country did you come?	1= In this community 2= In a neighboring community 3= From another city within Puno 4= From another Peruvian city: 5= From another country: 77= Ohter: 99= No answer		PLACELIV
8	What was the reason for moving to this town?	1= Marriage 2= Economic reasons 3= Available cultivable land 77= Other: 88= Don't know 99= No answer		RFMOVE
9	Which ethnic group do you belong to?	1= Quechua 2= Aymara 77= Other:		ETHGR
10	Which religion do you belong to?	1= catholic 2= protestant 3= any religion 77= otro:		RELIG
11	Which languages do you speak?	1= Aymara 2= Aymara and Spanisch 3= Aymara, Quechua, Spanisch 77= Other:		SLANGMO
12	Which languages does your partner speak?	1= Aymara 2= Aymara and Spanisch 3= Aymara, quechua, Spanisch 77= other:		SLANGFA
13	What schooling degree do you have?	1= < 3 years 2= 3 - finishing primary school 3= secondary school education 4= university or other higher education		EDUCMO
14	What schooling degree does your partner have?	1= < 3 years 2= 3 - finished primary school 3= Secondary school education 4= University or other higher education		EDUCFA
15	Can you read and write?	1= Yes, both of them 2= Reading, difficulty in writing 3= None of them 99= No answer		LITMO

16	Can your partner read and write?	1= Yes, both of them 2= Reading, difficulty in writing 3= None of them 99= No answer		LITFA
17	What is your main occupation? (max. two options)	1= Crop farmer 2=Livestock farmer 3= Daily labourer 4= Artisan 5= Small business 6= Domestic servant 77= Other:		JOBMO
18	What is the main occupation of your partner? (max. two options)	1= Crop farmer 2= Livestock farmer 3= Fisher 4= Daily labourer 5= Small business 6= Artisan 77= Other:		JOBFA
19	Who earned money in the last month?	1= Respondent 2= Partner 3= Both of them 77= Other :		INCHH
20	What has been and is your main income source **in the last month**? (Don't read the answers, mark with crosses what is mentioned by the respondent)	Crop farming		INCSOURC
		Fishing		
		Livestock farming		
		Animal products (milk, eggs, curd, meat, etc.)		
		Artisan activities/handicrafts		
		Wild fruits/honey		
		Hunting		
		Unskilled daily labour		
		Employment with monthly salary		
		Small scale vendor		
		Other (specify) :		

Living conditions

21	**Observation** : What material was used to build the house?	1= Mud 2= Red brick / cement block 3= Stone 77= Other :		HOUMAT
22	**Observación** :Material de construcción del techo de la vivienda	1= Calamine 2= Straw 3= Cat-tail 77= Other :		HOUROOF
23	What do you use for cooking?	1= Shrub (gathered) 2= Manure: 3= Kerosene 4= Gas 5= Firewood 77= Other:		COOK
24	**Observation**: Does the house have electricity?	1= Yes 2= No		ELECTR
25	Do you have following assets :	1= Yes 2= No		
		Radio		HOURAD
		Bicycle		HOUBIKE
		Mobile phone		HOUMOB
		77= Other:		
26	From where do you obtain drinking water? During the dry season? During the rainy season?	1= Own public water supply 2= Public supply outside 3= Water traders 4= Rain water 5= Well/spring 6= River/canal 77= Other: 99=No answer		WATDRY WATWET
27	Do you boil the water before drinking?	1= Yes, always 2= No		WATBOIL

		3= Sometimes					
28	Are there critical months when water is scare?	1= Yes 2= No					WATSUPP
29	In which months is there water shortage?	January	February	March	April		WATSHOR
		May	June	July	August		
		September	October	November	December		

Household/Food situation

30	Who is mainly responsible for bringing up the children?	1= Respondent 2= Partner 3= Both of them 4= Brother/sister 5= Other relative 77= Other (non relative) 99= No answer					KIDCARE
31	Do you have a home garden where you grow vegetables/fruits?	1= Yes 2= No					HOMEGARD
32	Who is mainly responsible for the home garden?	1= Respondent 2= Partner 3= Both of them 77= Other: 99= No answer					GARDCARE
33	Who is mainly responsible for gathering wild foods?	1= Respondent 2= Partner 3= Both of them 77= Other: 99= No answer					FOODGATH
34	Who is mainly responsible for processing food? (chuño, herbs drying etc.)	1= Respondent 2= Partner 3= Both of them 77= Other: 99= No answer					FOODPROC
35	Are there especially critical months for food supply?	1= Yes 2= No					FOAVAIL
36	In which months is there food shortage?	January	Ferbruary	March	Abril		FOSHORT
		Mai	June	July	August		
		Sept.	Oct.	Nov.	Dec.		
37	What do you do to overcome food shortage? (max. two options)	1= Reducing number of meals 2= Use stored food from last harvest 3= Depend on food aid 4= Purchase food at the market 5= Barter trade 77= Other:					FSOVERC1 FSOVERC2
38	Did the household receive supplementary food through a food program **in the last month**?	1= Yes 2= No 88= Don't know 99= No answer					FOODAID
39	(If the answer is "yes", then continue with this question, if not, then continue with 38) Which foods did you receive?	Rice				FOAIDITEMS	
		Pasta					
		Milk (evaporated, powder)					
		Vegetable oil					
		Animal fat					
		Sugar					
		Pulses					
		Wheat flour					
		Grains					
		Cereals					
		Vegetables, specify :					
		Fruits, specify:					
		Cookies or similar					
		Other (=77), specify:					

40	Has one or more of the children participated in a school feeding program **during the last four weeks?**	1= Yes 2= No 88= Don't know 99= No answer		FEEDPRO
41	Are you beneficiary of any food or agricultural extension project **at present**? If yes, which is the name of the intitution?	1= Yes 2= No Specify :		DEVELPRO

Agricultural activities

42	How many land plots do you have?		LANDNUM	
43	How large is your farming operation?		FARMAREA	
44	What is the ownership status of the land?	1= Own land 2= Leased land 3= Own and leased land 4= Shared land 88= Don't know 99= No answer		LANDTEN
45	What do you produce **in this farming season** on your land and for which purpose?	1= Mainly for own consumption 2= Mainly for sale 3= Both (in approx. equal amounts)		
		Potato (variety):		
		Quinoa (variety):		
		Broad beans (variety)		
		Barley		
		Oca		
		Tarwi		
		Kañihua		
		Peas		
		Oat		
		Olluco		
		Corn		
		Izaño		
		Fruits (specify)		
		Vegetables (specify)		
		Other (specify):		
46	Are you currently harvesting some crops?	Potato(variety):		POTATO
		Quinua (variety):		QUINOA
		Broad beans		BR BEAN
		Barley		BARLEY
		Oca		OCA
		Tarwi		TARWI
		Kañihua		KANIHUA

		Peas		
		Oat		OAT
		Olluco		ULLUCU
		Corn		MAIZE
		Izaño		MASHUA
		Fruits:		FRUITS
		Vegetables:		VEGETAB
		Other:		
47	If husbandry occurs **in this season:** Which animals and which purpose of each?	1= Mainly for own consumption 2= Mainly for sale 3= Both (in approx. equal amounts)		
		Livestock		
		Pig		PIG
		Chicken		CHICKEN
		Other fowl		
		Fish (Pisciculture)		FISH
		Llamas		LLAMA
		Alpacas		ALPACA
		Guinea pig		GUINPIG
		Sheep		SHEEP
		Other:		
48	If you have a home garden, how large is it (m^2)?		GARDAREA	
49	What do you produce **at present** in your own garden? (plants and use)	1= Mainly for own consumption 2= Mainly for sale 3= Both (in approx. equal amounts)		GARDPROD
50	Which local wild food do you gather **at present** for your own consumption? (Specify)		WILDPLANTS	
51	Which wild animals do you hunt **at present**? (which animals and for what purpose)	1= Mainly for own consumption 2= mainly for sale 3= both (in approx. equal amounts)		HUNTER
		Andean partridge		
		Andean deer		
		Quair		
		Other:		
52	If you fish, which kind of and what is done with the fish?	1= Mainly for own consumption 2= Mainly for sale 3= Both (in approx. equal amounts) specify:		FISHING

Compras/Adquisiciones

53	If you need other foodstuffs, how do you get them?	1= We only consume what we produce 2= barter with neighbors 3= at the market (in which locality) : 77= Other:		PURCHASE
54	Which foods do you purchase?	Vegetable oils		FOODPUR
		Animal fat (butter, etc.)		
		Salt (1= iodized ; 2= normal)		
		Sugar		
		Rice		
		Bread		
		Pasta		
		Meat (specify):		
		Fish (specify):		
		Soft drinks		
		Complementary food (babies)		
		Canned food		
		Eggs		
		Fruits:		
		Vegetables:		
		Alcohol		
		Vitamin supplements		
		Other:		
55	Who is mainly responsible for food purchase?	1= Respondent 2= Partner 3= Both of them 77= Other: 99= No answer		RESPPUR
56	How often do you commonly go buy food ?	1= daily 2= once a week 3= once a month 4= 2-3 times a month 88= Don't know 99= No answer		FRECPUR
57	How much money do you spend for food purchases monthly (NuevosSoles)?	1= < 25 Nuevos Soles 2= 25-50 Nuevos Soles 3= 50-100 Nuevos Soles 4= > 100 Nuevos Soles 88 = Don't know 99 = No answer		EXPFOOD

10.21 Questionnaire used for the health surveys (English version)

Proyecto ANDINU – Clinical parameters Code:________

« Agrobiodiversity and nutrition in Aymara regions of Puno »

Name of respondent: ______________________________ Age: __________

District: ____

1. Have you taken vitamin A supplements during the last 3 months? Yes = 1 No = 2
2. Have you taken iron supplements during the last 3 months? Yes = 1 No = 2
3. Have you taken any vitamin or mineral supplements during the last three months? Yes = 1 No = 2
4. Do you breastfeed currently? Yes = 1 No = 2
5. Are you pregnant? If yes, which trimester? Yes = 1 No = 2
   1er trimester____ 2do trimester____ 3er trimester____
6. Do you have visual problems during the day? Yes = 1 No = 2
7. Do you have visual problems during the night? Yes = 1 No = 2
8. Dou you feel chronically tired? Yes = 1 No = 2
9. Do you currently suffer from any disease? If yes, which one? Yes = 1 No = 2
   ____
10. Do you currently have any ailments? Yes = 1 No = 2
    ____
11. Have you taken any medicine during the last 3 months? Yes = 1 No = 2
    If yes, which one? ____________________
12. **Height** (cm):________________________
13. **Weight** (kg) :________________________
14. **MUAC** (cm): ________________________
15. **Hemoglobin** (g/dl):________________________
16. **Visible signs of iodine deficiency** Yes = 1 No = 2

10.22 24 h dietary recall

Biodiversidad y nutrición en zonas aymaras de Puno
Ursula Chávez Zander, Justus Liebig University Giessen, Germany
E-mail: Ursula.Chavez-Zander@ernaehrung.uni-giessen.de

code: _______

24 h dietary recall

Date of interview (d/m/a)	
Interviewer	
Respondent's name	
District	

- Select one day of the week between Tuesday and Saturday for the interviews
- Note only what the respondent consumed **yesterday**
- List the single components when a dish is mentioned
- Underline the main component of the dish
- Don't forget to ask for beverages (amounts in cups or glasses)
- Begin the recall with following question:
  Did you have a normal day yesterday, or was there an important event (birthday's celebration, wedding, baptism, funeral, etc.) for you?
  ____

What did you eat and drink yesterday *before breakfast*?

Food /beverages	**Source** 1 = purchased 2 = own production 3 = gathered/hunted 4 = gift 5 = other (specify)	**Type of preparation** (raw, dried, steamed, boiled, fried, grilled)

88= Don't know 99= No answer

Biodiversidad y nutrición en zonas aymaras de Puno
Ursula Chávez Zander, Justus Liebig University Giessen, Germany
E-mail: Ursula.Chavez-Zander@ernaehrung.uni-giessen.de

code: ______

What did you eat and drink yesterday *for breakfast*?

Food /beverages	**Source** 1 = purchased 2 = own production 3 = gathered/hunted 4 = gift 5 = other (specify)	**Type of preparation** (raw, dried, steamed, boiled, fried, grilled)

88= Don't know 99= No answer

What did you eat and drink yesterday *between breakfast and lunch*?

Food /beverages	**Source** 1 = purchased 2 = own production 3 = gathered/hunted 4 = gift 5 = other (specify)	**Type of preparation** (raw, dried, steamed, boiled, fried, grilled)

88= Don't know 99= No answer

Biodiversidad y nutrición en zonas aymaras de Puno
Ursula Chávez Zander, Justus Liebig University Giessen, Germany
E-mail: Ursula.Chavez-Zander@ernaehrung.uni-giessen.de

code: ______

What did you eat and drink yesterday *for lunch*?

Food /beverages	**Source** 1 = purchased 2 = own production 3 = gathered/hunted 4 = gift 5 = other (specify)	**Type of preparation** (raw, dried, steamed, boiled, fried, grilled)

88= Don't know 99= No answer

What did you eat and drink yesterday *between lunch and supper*?

Food /beverages	**Source** 1 = purchased 2 = own production 3 = gathered/hunted 4 = gift 5 = other (specify)	**Type of preparation** (raw, dried, steamed, boiled, fried, grilled)

88= Don't know 99= No answer

Ursula Chávez Zander, Justus Liebig University Giessen, Germany
E-mail: Ursula.Chavez-Zander@ernaehrung.uni-giessen.de

code: ______

What did you eat and drink yesterday *for supper*?

Food /beverages	**Source** 1 = purchased 2 = own production 3 = gathered/hunted 4 = gift 5 = other (specify)	**Type of preparation** (raw, dried, steamed, boiled, fried, grilled)

88= Don't know 99= No answer

What did you eat and drink yesterday *after supper and before going to bed*?

Food /beverages	**Source** 1 = purchased 2 = own production 3 = gathered/hunted 4 = gift 5 = other (specify)	**Type of preparation** (raw, dried, steamed, boiled, fried, grilled)

88= Don't know 99= No answer

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