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Alternative Sources of Plant Protein in Tropical and Subtropical Regions

Bc. Thesis

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"I hereby declare that this thesis entitled Alternative Sources of Plant Protein in Tropical and Subtropical Regions is my own work and all the sources have been quoted and acknowledged by means of complete references."

In Prague 04/18/2017

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Linda Vlčková

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Abstract

Purpose of this work was to investigate alternative sources of plant protein, particularly in Peru. Current issue is the restriction of animal products due to environmental pollution, and to increase the food security in developing countries. First part of the thesis examined how could vegetable protein substitute animal protein via the search alternative sources of protein in plants. It was found 36 plants which could serve as a good source of protein, while some of them seems to be even better than protein of animal origin. From these 36 plants were chosen ten of the most potential ones and useful plants, namely: (*Bertholletia excelsa* Bonpl., *Cucurbita argyrosperma*,*Chenopodium pallidicaule, Lepidium meyenii, Lupinus mutabilis, Moringa oleifera, Phaseolus lunatus, Plukenetia volubilis* L., *Scenedesmus acutus,* and *Sesbania bispinosa*.) Plants were described as follows: botanical name, common name, habitat, botanical and nutritional description and use. Furthermore it was mentioned what effect has animal protein on human health and the impact of animal production on the environment.

Key words: protein, plant, amino acids, Peru, underutilized, crop, chemical, nutritional, composition.

Abstrakt

Cílem této práce bylo zkoumání alternativních zdrojů bílkovin rostlinného původu, zejména v Peru. Aktuální otázkou je omezení živočišných produktů s ohledem na životní prostředí a zvýšení potravinové bezpečnosti v rozvojových zemích. První část práce se zabývá tím, zda mohou rostlinné bílkoviny zastoupit bílkoviny živočišného původu, a to prostřednictvím vyhledávání zdrojů bílkovin v rostlinné stravě. Bylo nalezeno 36 rostlin, které mohou být dobrým zdrojem bílkovin, přičemž některé z nich se zdají být lepším zdrojem bílkovin než bílkoviny živočišného původu. Z 36 rostlin bylo vybráno deset nejvíce potencionálních a nejužitečnějších rostlin, jmenovitě: (*Bertholletia excelsa* Bonpl., *Cucurbita argyrosperma*,*Chenopodium pallidicaule*, *Lepidium meyenii*, *Lupinus mutabilis*, *Moringa oleifera*, *Phaseolus lunatus*, *Plukenetia volubilis* L., *Scenedesmus acutus* a *Sesbania bispinosa*.) Rostliny byly popsány následovně: botanický název, obecný název, lokalita výskytu, nutriční a botanický popis a jejich využití. Dále bylo uvedeno, jaký vliv mají živočišné bílkoviny na zdraví a dopad jejich produkce na životní prostředí.

Klíčová slova: bílkovina, rostlina, aminokyseliny, Peru, podvyužívané, plodina, chemický, výživný, složení.

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List of the abbreviations

Am. - Amazonia

An. - Andes

Hu. – Humid area

Ri. - Rivers

SA – Semi-arid area

Wa. - Water

TA – Temperate area

1. Introduction

With population growth and environemntal pollution raises questions how to maintain food security while preventing excessive pollution. One of the step could be limitation of livestock production. But the question is, how to ensure an adequate supply of nutrients especially proteins.

The research shows that daily intake of protein should be 10%, but the average American consumes 15-16% protein. Furthermore, the studies show that excess of protein increases the risk of cancer for example liver cancer or type 1 diabetes, the worst is casein, one of the milk protein. On the other hand, in the experiment the plant protein has contrary effect, nutrients from plants sources hold down risk of cancer. It means, plant-based diet could be healthier than meat based diet (Campbell, 2014). There are a lot of reasons why to survey it. Irrespective of it, meat-based diet has very extensive environmental impact and 80% of agriculture land is used for livestock (Peters, 2016).

Another reason is population growth and demands on sustenance for whole world is growing too. There are many researches that meat-based diet cannot maintain future population, but another researches shows that plant-based diet could help provide enough food sources for population (Steinfeld, 2006; Campbell, 2014; Tilman, 2014; Peters, 2016). The most important for human nutrition is protein. This thesis is based on the research wheter there are sufficient sources of protein in plant foods. Peru was chosen for the rich diversity of plants.

2. Aim of the thesis

The main goal of the thesis was the investigation of available literature and electronic information databases to analyse plants as an alternative sources of proteins in the tropics and subtropics, particularly in Peru. Specific objective was the evaluation of both new and forgotten underutilized crops as a source of proteins, description of their postharvest processing and traditional use.

3. Methods

Data and information were collected by searching in database such as ScineceDirect (www.sciencedirect.com), Web of Knowledge (www.webofknowledge.com), Google Scholar (www.scholar.google.com) and in the literature available in the library such as Czech University of Life Sciences, Prague and Municipal Library of Prague. This thesis was focused on plants with a protein content of more than 10%. The most used key words for searching in the databases were:

protein, plant, amino acids, Peru, underutilized, crop, chemical, nutritional, composition

4. Literature Review

4.1 Proteins

Proteins, with sugars and fats are the most important elements in every living organism. All of energy of human body comes from them. The word protein comes from word *proteinos*, which means “of prime importance” and it is the main cornerstone of living matter (Campbell, 2012). “They carry information in the form of linear sequence of symbols, in the same way as a human message written in an alphabetic script.” (Alberts, 2015).

4.1.1 Protein structure

Proteins are macromolecules composed of polymeric chains of houndreds to thousands L-α- amino acids linked together on a sequence that is unique for each protein and they are part of all organims cells (Hammond, 2008). Amino acids are also linked together by peptide bond and they can be simple or composite in our organism (Holeček, 2006).

They are composed of six elements: hydrogen, carbon, nitrogen, oxygen, sulphur, and phosphorus. Each protein performing a specific function according to its own specified sequence of amino acids. One of their function is import and export of small molecules across the plasma membrane that forms the cell's boundary. The next specific function depends on its amino acids sequence, which is specified by the nucleotide sequence of a corresponding segment of the DNA (Alberts, 2015). According to OpenStax (2013), there are 4 types of protein chains that we called primary, secondary, tertiary and quaternary protein structure.

- Primary protein structure – the sequence of amino acids in polypeptide chain. Each chain has own set of amino acids.

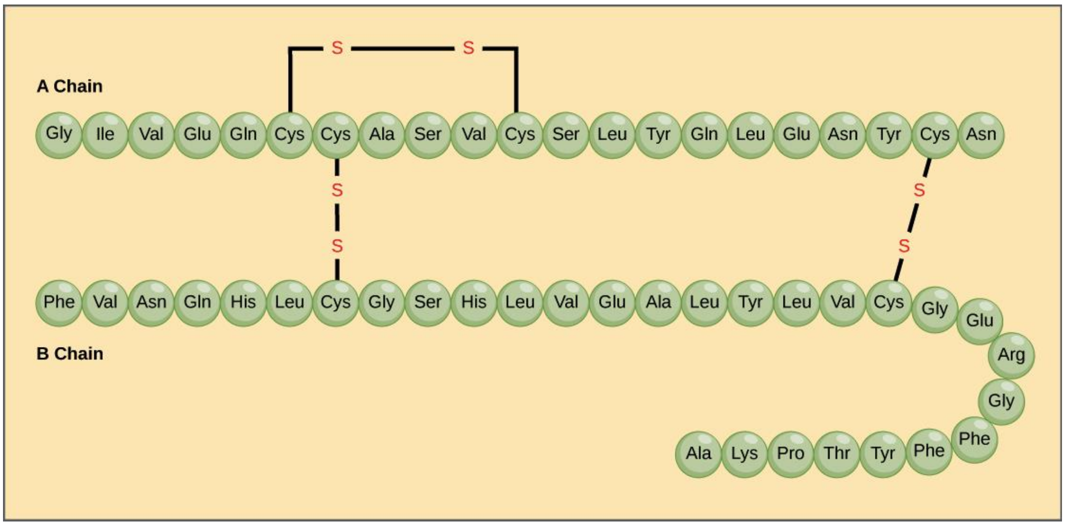


Figure 1. Primary protein structure (OpenStax, 2013)

➢ Secondary structure – refers to local folded structure that form within a polypeptide due to interactions between atoms and the backbone. The most common types of secondary structure are the α-helix and the β pleated sheet.

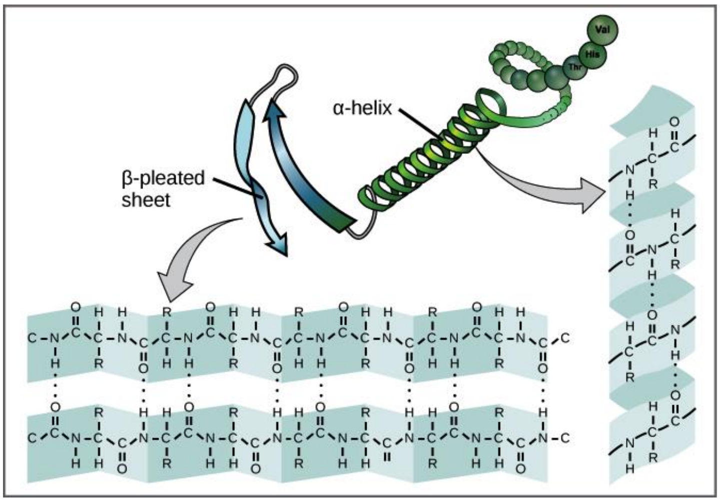


Figure 2. Secondary protein structure (OpenStax, 2013)

➢ Tertiary structure – is three-dimensional structure of a polypeptide. It is interaction between the R groups of the amino acids that make up the protein.

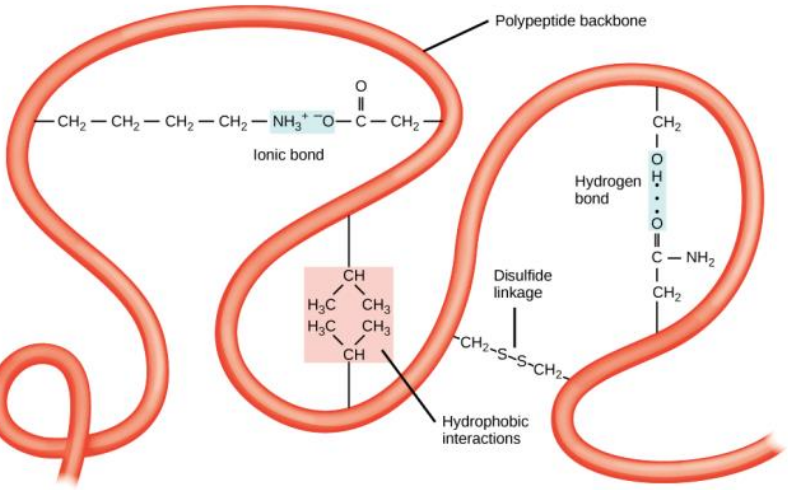


Figure 3. Terciary protein structure (OpenStax, 2013)

- Quaternary structure – many proteins have only three levels of structure. Some protein are made up of multiple polypeptide chains.

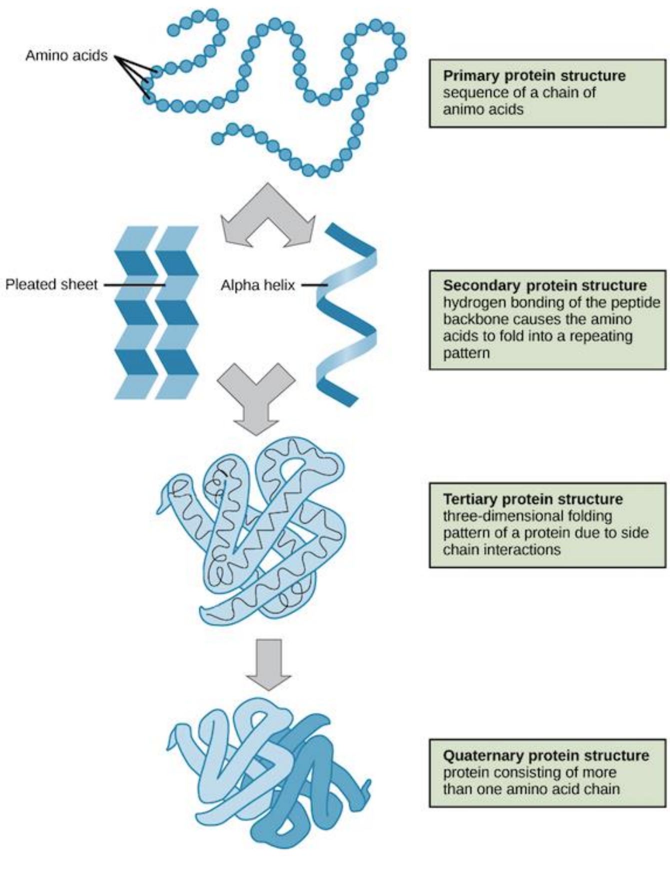


Figure 4. Types of proteins structures (OpenStax, 2013)

Approximately, 50% of protein in gastrointestinal tract come from food, 25% from digestive juice and 25% from flaked cells of the intestinal mucosa. Protein digestion starts by pepsin in stomach and they are hydrolysed after 3-5 hours after food intake. Released amino acids, dipeptides, tripeptides are resorpted in small intestine and they migrate throughout the body (Holeček, 2006).

The total amount of proteins in organism is determined by the ratio between their synthesis on first side and degradation and their loss in the form glandular secretions, skin epithelium, nails and hair on the other side. This is called “protein balance” (Holeček, 2006).

4.1.1.1 Amino acids

Amino acids are organic compounds. There are 22 proteinogenic amino acids, of which 20 are commonly found in human body. These 20 amino acids; lyzin, metionin, trenonin, izoleucin, leucin, valin, fenylalanin, tryptofan, histidin, arginin, alanin, aspartic acid, glutamic acid, asparagin, glutamin, cystein, glycin, serin, prolin and tyrozin, are use for synthesis proteins in living cells. They are elementary basic building blocks for peptides and proteins in every living organism (Börjesson, 2014).

In 1951 W. C. Rose defined on the basis of the nitrogen balance of the two amino groups essential and nonessential (Holeček, 2006).

Indispensable or essential amino acids

Human can produce 10 of the 20 aminoacids. The others must be supplied in the food. These 10 essential amino we cannot produce are arginine, histidine, isoleucine, leucine, lysine, methionine, valine, phenylalanine, tryptophan and threonine (Baldwin, 2003).

- Arginine – plays important role in nitrogen metabolism, urea cycle and in maintaining the overal charge balance of a protein. It stimulates growth hormone secretion, prolactin and insulin. It has positive effect for spermatogenesis and sexual function (Holeček, 2006).
- Histidine – helps in stabilizing the folded structures of protein. It has stimulative effect on gastric juice and important role in allergic reactions. It has vasodilate function (Li, 2007).
- Isoleucine – helps heal muscle tissue and the primary function is to boost up energy levels and to assist the body in recovering from strenuous physical

activity. Isoleucine can help in maintaining normal blood glucose levels (Baldwin, 2003).

- Leucine – is hydrophobic and generally buried in folded proteins (Baldwin, 2003).
- Lysine – is necessary for production of carnitine and its decarboxylation arises biogenic amine cadaverine (Strbáček, 2007).
- Methionine – “Methionine as the free amino acid plays several important roles in metabolism. It can react to form S-Adenosyl-L-Methionine (SAM) which servers at a methyl donor in reactions.” (Baldwin, 2003).
- Valine – is vital to muscle function. Valine provides glucose to working or active muscles to ensure that those muscle’s fibers do not break down. It is also important in improvement of insomnia, nervousness, and boosts the immune system and the most important function of valine is recover of long, strenuous activity (Brekke, 2017).
- Phenylalanine – is important in protein structure. It is not soluble in water (Baldwin, 2003).
- Tryptophan – is the largest of the amino acids, absorbs ultraviolet part of the spectrum. This essential amino acid is neccessary for protein synthesis (Baldwin, 2003).
- Threonine – contains a polar hydroxyl group which enables participation in hydrogen bonding, an important factor in protein structure and amino acid transporters are associated with membrane rafts (Ryu, 2011).

Dispensable or nonessential amino acids

These amino acids can be produced by human body are synthesized in sufficient quantities. These types of amino acids are alanine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, serine, proline, tyrosine (Holeček, 2006). Functions of most important amino acids are:

- Alanine – pyruvate from transamination of alanine is used as energetic substrate or glucose synthesis. Alanine is primary commlink between metabolism amino acids and carbohydrates. It had key role in maintaining glycemic (Holeček, 2006).

- Asparagine – “The amide is rather easily hydrolyzed, converting asparagine to aspartic acid. This process is thought to be one of the factors related to the molecular basis of aging. Asparagine is a common site for attachment of carbohydrates in glycoproteins.” (Baldwin, 2003).
- Aspartic acid – “Aspartic acid and glutamic acid play important roles as general acids in enzyme active centers, as well as in maintaining the solubility and ionic character of proteins.” (Baldwin, 2003).
- Cysteine - plays a key role in stabilizing extracellular proteins and it can react with itself to form an oxidized dimer by formation of a disulfide bond. “The environment within a cell is too strongly reducing for disulfides to form, but in the extracellular environment, disulfides can form and play a key role in stabilizing many such proteins, such as the digestive enzymes of the small intestine.” (Baldwin, 2003).
- Glutamic acid – connects amino acids metabolism with citric acid cycle and it enables transfer of amino groups into the reaction ornithine cycle (Holeček, 2006).
- Glutamine – is important substrate for cells of intestinal mucosa, immune system and formation of ammonia in the kidneys. Glutamin affects cytokine production and more substances that modulate the course of an inflammatory reactions (Coeffier, 2005). Kidneys, lymphocytes, monocytes, nerve tissue, livers and intestine use glutamin as energy and nitrogen source (Holeček, 2006).
- Glycine – is extremely adaptable and the preferred candidate for an interior position in proteins. Glycine is a decisive building block in many proteins, it is a component of the tripeptide glutathione and of the bile acid glycocholic acid. In addition, glycine is an essential substrate for the synthesis of a variety of biomolecules such as creatine, porphyrins and purine nucleotides. Last but not least, glycine represents the major inhibitor neurotransmitter in the adult CNS (Petrat, 2012).
- Serine – plays a central role in cellular proliferation, but it is also necessary for specific functions in the central nervous system (De Koning et al., 2003).

- Proline - “Proline is often found at the end of α helix or in turns or loops. Unlike other amino acids which exist almost exclusively in the *trans-* form in polypeptides, proline can exist in the *cis*-configuration in peptides. The *cis* and *trans* forms are nearly isoenergetic. The *cis/trans* isomerization can play an important role in the folding of protein.” (Baldwin, 2003).
- Thyrosine - absorbs ultraviolet radiation and contributes to the absorbance spectra of proteins (Baldwin, 2003).

4.1.2 Protein function in human body

There are more than 250,000 proteins in the human body that have biological functions. According to Hammond (2008) these functions are:

- Structural: it provides the scaffold, collagen, cells, and subcellular organelles (e.g. skin, muscle, bone, tendons, blood vessels).
- Regulatory: it creates hormones that carry messages from on part of the body to the other to help maintain homeostasis. (e.g. insulin, thyrotropin, somatotropin).
- Osmotic: proteins help regulate osmotic and pH balance.
- Metabolism: protein enzymes catalyse chemical reactions within cells.
- Transport: proteins transport substances (vitamins, oxygen etc.).
- Defence: they are primary element in immune system (immunoglobulins).
- Proteins with coagulation function.
- Motor function: proteins forces cells to move, contract, or change shape and permit muscle contraction.

4.1.3 Protein deficiency and sufficiency

Minimum daily intake of protein for human is 0.6 g per kg, but optimal intake is 1 – 1.5 g per kg. It is 13 – 14.5% of daily energetic intake. Lactating woman could intake daily about 2 g per kg (Klímová, 2007).

4.1.3.1 Protein deficiency

In development countries, there is not chance to get protein deficiency. Exceptions are people, who have alternative diets for example vegetarians and vegans, there could be possibility they do not have enough information about a nutrition diet.

Children and athletic adolescent are endargered. High amounts of protein can damage our tissues, organs, and cells, contributing to faster aging (Klímová, 2007).

The symptoms of protein deficiency:

- Weakend immunity, it means bad wound healing and the occurrence of infections are more frequent
- Mental disorders
- Decrease liver detoxification abilities
- Decrease vitality
- Degeneration muscles
- Declaration physical and psychic development
- Impair our kidneys; leach calcium, zinc, vitamin B, iron, and magnesium from our bodies
- Cause osteoporosis, heart disease, cancer, obesity (Klímová, 2007).

4.1.3.2 Protein sufficiency

Protein sufficiency leads to:

- Impair our kidneys; leach calcium, zinc, vitamin B, iron, and magnesium from our bodies and bones
- High pressure
- Cause osteoporosis, heart disease, cancer, obesity
- Higher production of amoniac and urea (Klímová, 2007).

4.1.4 Protein sources

There are two sources of protein – animals and plants. The main and the simplest source is from animals, for example eggs, meat, milk etc. Main sources of plants proteins are cereals (pasta, rice), leguminous (lentils, beans, peas) and oilseeds (nuts, seeds, poppy). Approximately half of needs should be covered of animal based protein (meat, milk, eggs), that is ensure adequate intake of all essential amino acids. Second half should be covered of plants based protein whose benefits are vitamins, low manufacturing cost and low cholesterol (Klímová, 2007).

Table 1. Protein sources Source: (FAO, 1983)

Feedstuff	Arg	His	Leu	Lys	Cys/Meth	Phe	Thr	Try	Val	Protein score
Fish meal (Peru)	85	85	88	110	71	78	74	58	61	79
Meat meal	77	96	100	86	36	72	60	68	75	66
Milk, skimmed	53	92	110	104	69	91	80	73	75	89
Milk, whole	60	100	136	106	83	92	83	84	78	91
Groundnut oil cake	164	92	72	53	24	91	51	-	45	54
Coconut oil cake	164	78	71	37	34	76	54	-	57	53
Soyabean meal	110	89	92	90	54	102	69	68	63	77
Palm kernel cake	207	92	75	54	83	66	64	147	69	66
Cottonseed cake	164	96	69	60	51	100	58	58	55	63
Sunflower oil cake	112	59	62	32	22	61	47	79	46	44
Sesame oil cake	191	107	88	42	94	79	58	73	60	69
Mung bean	100	78	84	107	31	109	62	-	62	76
Red bean	112	130	49	128	27	107	83	42	72	76
Chlorella vulgaris	77	55	90	44	47	92	100	68	72	68
Spirulina maxima	97	66	94	59	33	92	83	73	79	75
Scenedesmus obliquus	83	55	109	84	40	85	94	73	88	78
Torula yeast	77	81	94	111	51	81	91	63	66	78
Brewers spent grains	68	66	109	48	22	87	58	68	66	66

*Average essential amino acid score based on composite of: lysine, the sulphur-amino acids methionine and cystine; the branch chain amino acids leucine, isoleucine and valine, and phenylalanine

4.1.4.1 Proteins of animal origin

Meat is an important source of iron, vitamins A, B12 and more micronutrients. Vitamins A and B12 cannot be produced by human body or plants, it entails that meat is the perfect source of this micronutrients. For example iron, the best source of iron is meat, especially eggs and liver. The availability from vegetable exist, but you have to combine vegetable rich of iron with vitamin C, but still is not enough, especially for pregnant women. The everage protein content is 12.3% (duck meat) to 34.5% (chicken breast). “In addition to its richness, meat protein distinguishes itself because of its richness in all the essential amino acids with no limiting amino acids. Vegetarians have to combine cereal and legumes to get all the essential amino acids.” (Cordoso Pereira, 2013).

Table 2. Nutritional composition of several meat cuts Source: (Cordoso Pereira, 2013)

Meat cut	Energy Value (kcal)	Protein (g)	Fat (g)	Saturated fat (g)	Vitamin B12 (mcg)	Na (mg)	P (mg)	Fe (mg)	Zn (mg)
Chicken breast, skinless, raw	108	24.1	1.2	0.3	0.37	60	220	0.5	0.8
Chicken breast, raw	176	24.1	8.9	2.1	0.37	72	200	1	0.8
Chicken, average, raw	110	22.9	2	0.5	0.72	77	204	0.9	1
Beef, steak cuts, raw	122	20.9	4.3	1.8	2	60	169	1.4	3.6
Beef, loin, raw	114	21	3.3	1.4	2	60	145	1.5	3.6
Beef, calf, loin, raw	148	19.9	7.6	3.2	1.2	24	195	0.9	3
Pork, loin, raw	131	22.2	4.7	1.6	1	53	221	0.6	1.6
Pork, chop, raw	355	17.3	31.8	10.9	1	61	189	1.3	1.7
Pork, leg, raw	152	21	7.5	2.6	1	86	167	0.7	2.7
Turkey, breast, skinless, raw	105	23.4	1.3	0.3	1	63	210	0.7	0.6
Turkey, average, skinless, raw	137	20.5	6.1	2	2	49	210	2	1.6
Duck meat, average, skinless, raw	133	19.3	6.2	1.6	3	92	202	2.4	1.9
Mutton, chop or meat, raw	124	19.7	2.2	2.2	2	64	220	1.7	3.8

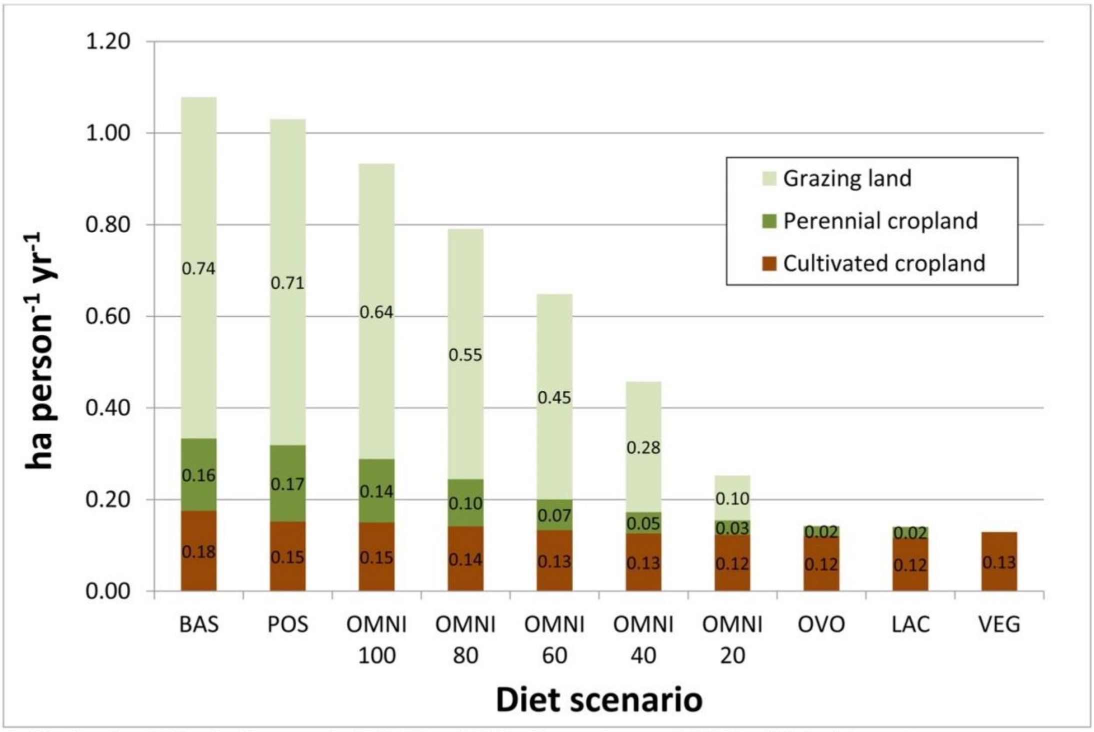
4.1.4.2 Plant-based protein

"There is a mountain of compelling research showing that "low-quality" plant protein, which allows for slow but steady synthesis of new proteins, is the healthiest type of protein. Slow but steady wins the race. We now know that through enormously complex metabolic systems, the human body can derive all the essential amino acids from the natural variety of plant proteins. It doesn't require eating higher quantities of plant protein or meticulously planning every meal." (Campbell, 2014). Cambell's study shows solving another problem, iron. The food rich in fiber (leguminous, greens and cereals) support reabsorption of iron. For example wheat and corn are rich in fiber, what more, they are rich of iron too. Another studies suggest, the more animal protein source we consume, the higher the risk of heart disease is, because of high cholesterol. Otherwise, plant protein source has opossite effect (Altschul, 1985).

4.1.5 Protein origin in the human diet and the environment

With the increasing growth of population the demands of agriculture production are rising too. A lot of countries prefer livestock production, but this type of production has a major impact on the environment such as land, water, air etc. According to De Vries (2010), the world's livestock is responsible for 18% of the global emission of greenhouse gases.

"Strategies for environmental sustainability and global food security must account for dietary change. Using a biophysical simulation model we calculated human carrying capacity under ten diet scenarios. The scenarios included two reference diets based on actual consumption and eight "Healthy Diet" scenarios that complied with nutritional recommendations but varied in the level of meat content. We considered the U.S. agricultural land base and accounted for losses, processing conversions, livestock feed needs, suitability of land for crops or grazing, and land productivity. The scenarios focused solely on differences in food consumption patterns; parameters for food losses and waste, processing conversions, livestock feed needs, crop yields, land availability, and land suitability were held constant." (Peters, 2016).



BAS = Baseline, POS = Positive control, OMNI 100 = 100% healthy omnivorous, OMNI 80 = 80% healthy omnivorous, OMNI 60 = 60% healthy omnivorous, OMNI 40 = 40% healthy omnivorous, OMNI 20 = 20% healthy omnivorous, OVO = Ovolacto vegetarian, LAC = Lacto vegetarian, VEG = Vegan

Figure 5. Annual per capita requirements for productive agricultural land by diet scenario and category of land use in U.S. (Peters, 2016)

The Baseline diet means, that food intake equals loss-adjisted food availability for individual food commodities. The Positive control is the same as the Baseline diet, except intake of fats and sweeteners is reduced to make diet energy-balanced. The 100% healthy omnivorous is 100% of person-meals follow an omnivorou healthy diet pattern. Next 4 diets are ratio between omnivorous healthy diet and ovo-lacto vegetarian healthy diet. Whereas the percentage (80, 60, 40, 20) was representation of omnivorou healthy diet. The Ovolacto vegeterian includes both eggs and dairy products, meanwhile the

Lacto vegeterian includes just diary products, not eggs and the Vegan exludes all livestock products. The conclusion of this research shows that under range of land use conditions, diets with low to modest amounts of meat outperfom a vegan diet, and vegetarian diets including dairy products performed best overal (Peters, 2016).

"Health problems such as hypertension, gall-stone formation which are related to animal protein consumption have raised great social and public health attention recently. Thus, plant protein of which legumes form a great majority has been found to play an important role in several favorable physiological responses, such as reducing heart and kidney diseases, lowering the sugar indices of diabetic patients, increasing in satiety, and reducing the occurrence of cancer." (Yellavila, 2015).

4.2 Overview of study area

Latin America is the cradle of the powerful civilization, which lives in latin countries. Peru is the cradle of Incas, Andean civilizations.

It is amazing place because of its biodiversity. Peru is among the ten most biodiverse countries on the planet. There is extreme climate and topography differences: mountains, beaches, rainforests, deserts are possible to find out there. These characteristics are favourably for agronomy (Worldmark Encyclopedia of Nations, c2007).

4.2.1 Location, area and geography

The official name of Peru is Republic of Peru or in spanish República del Perú. Total area is 1,285,220 sq km and Peru is bordered by five countries: Ecuador and Colombia in the north, Brazil in the east, Bolivia in the southeast and Chile in the south. Peru's capitl city, Lima, is located on the Pacific coast. Its official language is Spanish, but in the zones where they predominant, Quechua, Aymara also have official status. The currency is Sol and one USD = 3,2561 PEN (Sol Perú). In the 2016 GDP was 192.1 ml. USD (MZV, 2016).

Peru is the third largest country in South America. It is located on western coast of central South America. It is bounded on the north with Ecuador and Colombia, on the east by Brazil and Bolivia, on the south by Chile, and on the west by Pacific Ocean (Vránová, 2008). Typical land redistribution:

- La Costa - It is coastal trip along the all coast of Pacific ocean. It include near islands Islas La Ballestas and Chincha. Desert character is spasmodic of oasis that are irrigation from Andean rivers (Vránová, 2008). It ranges in altitude from sea level to 500 meters above sea level and in width from 65 km to160 km across (Queiroz, 2014).

- La Sierra – The Andes Mountains run the entire length of Peru, covering approximately 28 percent of its land area. This range encompasses mountain valleys, deeply-incised canyons, and glaciated landscapes with snow-covered peaks, cirque lakes, and glacial moraines. The Andes' diverse geomorphology, altitudinal range and climate variability give rise to a suite of unique ecosystems (Queiroz, 2014).

- La Selva – Sixty percent of Peru's territory is comprised by the Amazon Basin and is the largest physiogeographical region in the country. Thirteen percent of Peru's total population resides here, of which approximately twenty-seven percent resides in nine predominant urban centers populated by 20,000 or more (Queiroz, 2014).

4.2.2 Climate

According to Queiroz (2014) from the 32 types of climates on earth defined by Thornthwaite's Climate Classification, 27 are found in Peru. Temperatures and rainfall vary greatly throughout the country. The coastal region is dry, with an average annual temperature of 21.5°C and annual rainfall of 74.2 millimeters. This minimal rainfall, the dry coastal regions get enough moisture from fog to sustain some plant growth and animal life. In the Andes, the average annual temperature is 12.4°C. Seasonal temperature is limited, but daily temperature variations are extreme. In the higher altitudes, temperatures drop well below 0°C. The average annual precipitation ranges from 668 mm to 834 mm. The Amazon Basin has a warm and humid tropical climate averaging 22.8°C. This region experiences rainfall throughout the year, with an average annual precipitation of 1,571 mm and some areas receive over 4,000 mm annually.

4.2.3 Vegetation

According to Quieroz (2014) and Worldmark Encyclopedia of Nations (c2007) there are three main climate-based distribution zones:

1) Arid and Semiarid Zone – "Coastal desert vegetation covers approximately 10 percent of Peru's land area. This sparse vegetation cover consists primarily of slow-growing, drought-resistant scrub species interspersed with a mosaic of alluvial soils on the flood plains that house most of Peru's irrigated agriculture." The coastal desert is not barren of life. There are sparse xerophytic shrub, cactus, and algarroba, and a few palm oases. Perennial shrubs, candelabra cacti, and intermontane pepper trees account for much of the western slope vegetation in the higher altitudes and forests of eucalyptus have been planted.

2) Sub-humid Zone – "Vegetation classes typical of these areas include dry montane forests and sub-humid scrub. Of the sub-humid high altitude zones, "Puna" grasslands cover the largest total surface area, accounting for 15.34 percent of Peru's total vegetation cover." On the eastern slopes, mountain tall grass and sparse sierra cactus and low shrub give way at 900 m to rain forests and subtropical vegetation.

3) Humid Zone – "The humid zones, comprised by the Amazon and Yungas regions, cover the largest area of the country and encompass the greatest vegetation diversity due to abundant rainfall, landscape variations, warm temperatures, and pronounced ecosystem dynamics such as seasonal floods. The humid forests in the Amazon's lower altitudes account for approximately 22 percent of Peru's total vegetation cover, while the montane humid forests typical of Yungas region account for approximately 14 percent of the national territory." Native plants as sarsaparilla, barbasco, cinchona, coca, ipecac, vanilla, leche caspi, and curare have become commercially important, as well as the wild rubber tree, mahogany, and other tropical woods.

4.2.4 Flora of Peru

Flora of Peru is equally divers. The river valleys, mountains and Amazon Rainforest contain an unique plant life. In Peru, there is rich variety of plant species, some of them are rare and endemic, because the government has estabilished protected areas to conserve and preserve the Peruvian biodiversity. It is possible to find there moss, large representation family of Orchideaceae, cactuses, bromeliads, canopy plants, grass and palm trees. There is also “Puyas Raimondii” which is a 10 meters high plant that looks like a cactus (Sawe, 2016).

4.3 Plants as source of protein

In this work was analysed 36 plants from Peru, see Table 3 with summarized data on these plants. Nineteen out of a total 36 plants were from Andean area, eight of them from Amazonian area, two of them from humid area and one from semi-arid area. One plant was cultivated in water, when one was planted along the river. One plant was from temperate area, and three were from nonspecific areas. The highest content of protein was observed in seeds, follows leaves and fruits, but another parts of plant could contain protein to, for example tubers, flowers, roots.Whereas, most of the used parts had to be dried, for higher protein content. The family of Fabaceae was the most represented.

Table 3. Selected plants

	Botanical name	Local/Quechua	English name	Family	App.	Protein content	Use	Manufactured	Interest	Ref.
1)	*Amarathus caudatus*	Kiwicha	Amaranth	Amaranthaceae	An.	13-18.4 %	seeds grain	powder boiled	high level of lysine and other amino acids that is usually deficient in plant protein, high calcium, iron,	*1, 17*
2)	*Bertholletia excelsa* Bonpl.	Brazil nut	Brazil nut	Lecythidaceae	Am.	12-20 %	nuts bark wood	fresh powder oil	selenium, antioxidants, methionin, dried - 46 % protein	2
3)	*Canavalia Ensiformis*		Jack bean	Fabaceae	Hu.	24.2 ± 2.2 %	seeds	powder	stock feed, canavalin for pharmaceutical	*11*
4)	*Canna edulis*	Achira	Achira	Cannaceae	An.	10-14 %	roots tubers shoots	fresh boiled dried roasted	carbohydrates, ,,save net,, shelter for other crops	*1*
5)	*Cannabis sativa L.*	Maconha	Hemp	Cannabinaceae	Am.	30.8 %	seeds leaves stems	fresh powder oil	medicine, furnishing fiber, narcotic	22, 23
6)	*Carya illinoensis*	Pecan	Pecan	Juglandaceae	Riv.	10 %	nuts leaves bark	fresh oil milk tea	lysine, leucine, tryptophan, pharmaceutical use	*24, 25*
7)	*Cicer arietinum L.*	Garbazo	Chickpea	Fabaceae	SA	20.9-28.9 %	seeds leaves stems	fresh powder boiled	animal feed, textile industry, carbohydrates	12
8)	*Cucurbita argyrosperma*	Calabaza	Cushaw	Cucurbitaceae	An.	44 %	seeds fruits flowers stems	roasted oil		13
9)	*Cucurbita maxima*	Zapallo	Squash	Cucurbitaceae	An.	33.92 %	seeds fruit	boiled oil		3
10)	*Cucurbita moschata*	Zapallo	Butternut	Cucurbitaceae	An.	30 %	seeds fruit	boiled oil	antioxidants, vitamin A, tryptophan	13
11)	*Erythrina edulis*	Pajuro	Basul	Fabaceae	An.	20 %	seeds leaves wood	boiled dried	it grows in areas where seasonal food deficits occur often, methionin, tryptophan, phosphorus	*1*
12)	*Helianthus annuus*	Sunflower	Sunflower	Asteraceae		24 %	seeds	oil dried		14

(continued)

Table 3. Selected plants (continued)

Botanical name	Local/Quechua	English name	Family	App.	Protein content	Use	Manufactured	Interest	Ref.
13) *Hymenaea courbaril* L.	Jatobá	Courbaril	Fabaceae	Am.	10 %	seeds fruit bark sap	fresh powder dried	for cold, prostate cancer, fuel	2
14) *Chenopodium pallidicaule*	Kañiwa	Kaniwa	Amaranthaceae	An.	13-18 %	seeds leaves	powder	leaves are high in calcium, amino acids balance, lysine, isoleucine, tryptophan, livestok feed, dried - 30 % protein	*1, 4, 17*
15) *Chenopodium quinoa*	Chisiya mama	Quinoa	Amaranthaceae	An.	16-23 %	leaves grain	powder boiled fermented	it often takes the place of meat in the diet, aimal feed	*1, 17*
16) *Lepidium meyenii*	Maca	Maca	Cruciferae	An.	13-16 %	roots leaves	boiled dried roasted	dried can be stored years (7 y. old-10%), iron, iodine	*1*
17) *Lupinus mutabilis*	Tarwi	Tarwi	Fabaceae	An.	41 - 51 % dried	seeds	boiled oil	seeds contains almost 20 % oil as much than soybeans and othe oilseed crops, lysine and amino acids balance	*1,6*
18) *Mauritia flexuosa* L.f.	Buriti	Moriche palm	Arecaceae	Am.	11 %	seeds leaves pulp	fresh oil	carotene 20x more than carrots	2
19) *Mirabilis expansa*	Mauka	Mauka	Nyctaginaceae	An.	7-17 %	tubers leaves stems	boiled pickled	carbohydrates	*1*
20) *Moringa oleifera*	Moringa	Moringa	Moringaceae	An.	35.97 ± 0.19 %	all parts	powder boiled dried	10 times the vitamin A than carrot, 15 times the potassium of bananas, antioxidants etc.	26
21) *Mucuna pruriens*	Mucuna	Velvet bean	Fabaceae	Am.	25.7 ± 1.4 %	all parts	powder	anti-microbial and antioxidants activities	11, 15
22) *Oenocarpus bataua* Mart.	Patauá	Wine fruit	Arecaceae	Am.	7.4 %	fruit hearts	fresh oil	protein compareable to milk	2,5
23) *Oxalis tuberosa*	O'qa, okka	Oca	Oxalidaceae	An.	9 %	tubers	boiled roasted	stock feed, balance of aminoacids	*1*

(continued)

Table 3. Selected plants (continued)

	Botanical name	Local/Quechua	English name	Family	App.	Protein content	Use	Manufactured	Interest	Ref.
24)	*Pachyrhizus ahipa*	Ajipa	Ahipa	Fabaceae	An.	25.2-31.4 %	seeds roots	fresh boiled dried	pottasium, vitamin C, asparagine, arginine	*1,7*
25)	*Persea americana*	Avocado	Avocado	Lauraceae	Wa.	23.54 ± 0.09 %	seeds flowers	fresh boiled soaked		21
26)	*Phaselous vulgaris* Linnaeus	Ñuñas	Popping beans	Fabaceae	An.	22 %	seeds	boiled roasted	its like a popcorn	*1*
27)	*Phaseolus lunatus*	Lima	Butter/Lima bean	Fabaceae	An.	20.69 - 23.08 %	seeds	powder boiled	potassium, sodium, phosphorous and iron	29
28)	*Pisum sativum*	Pea	Pea	Fabaceae	TA	20-30 %	seeds	fresh boiled	potassium, manganese, phosporus	27, 28
29)	*Plukenetia volubilis* L.	Sacha Inchi	Inca peanut	Euphorbiaceae	Am.	27 %	seeds	dried pressed-cake	high quality and quantity of oil, high proportion of unsaturated fatty acids, omega-3 fatty acids, pressed-cake - 56 % protien	8, 10
30)	*Polymnia sonchifolia*	Yacón, llakuma	Yacon	Asteraceae	An.	11-17 %	tubers leaves	fresh boiled dried	swe Scenedesmus Scenedesmus	*1*
31)	*Scenedesmus acutus*	Scenedesmus	Scenedesmus	Scenedesmaceae	Wa.	47.4 - 66.6 %	all parts	fresh boiled dried		18
32)	*Sesbania bispinosa*	Canicha	Danchi	Fabaceae		32.9 %	seeds flowers pods	fresh boiled	lysine and threonine	20
33)	*Theobroma grandiflorum*	Cupuacu	Cacao	Malvaceae	Am.	11.9 %	fruit	powder jelly juice		9
34)	*Tropaeolum tuberosum*	Mashua	Mashua	Tropaeolaceae	An.	16 %	tubers leaves flowers	boiled roasted	medicine	*1*
35)	*Ullucus tuberosus*	Ullucu	Ulluco, melloco	Basellaceae	An.	15 %	leaves	boiled mashed grated	carbohydrates, vitamin C	*1*
36)	*Zea mays L.*	Corn	Maize	Poaceae		10 - 12 %	seeds	fresh powder boiled		16, 19

1 - (King, 1989), 2- (Shanley, 2011), 3 - (Rezig, 2011), 4- (Repo-Carrasco-Valencia, 2010), 5 - (Darnet, 2011), 6 - (Gross, 1987), 7 - (Leidi, 2003), 8 - (Rawdkuen, 2016), 9 - (Rogez, 2004), 10 - (Hamaker, 1992), 11 - (Agbede, 2005), 12 - (Duke, 1997), 13 - (Duke, 1994), 14 - (Ingale, 2011), 15 - (Lampariello, 2012), 16 - (Ndukwe, 2015), 17 - (Nadathur, 2016), 18 - (Gross, 1986), 19 - (Duke, 1983), 20 - (Duke, 1983), 21 - (Talabi, 2016), 22 - (Duke, 1983), 23 - (Dell'Acqua, 1989), 24 - (Venkatachalam, 2008), 25 - (Koch, 2012), 26 - (Gopalakrishnan, 2016), 27 - (Wang, 2004), 28 - (Frame, 1985), 29 - (Yellavila, 2015).

Ten plants were selected, based on high protein content. These ten plants were described as follow.

4.3.1 Bertholletia excelsa Bonpl.

Figure 6. Fruit of Brazil nut (Armstrong, 2005)

Figure 7. Tree and fruits of Brazil nut (Tricks-Collections Theme)

Botanical name: *Bertholletia excelsa* Bonpl.

Local name: Brazil nut

English name: Brazil nut

Family: Lecythidaceae

Habitat: A widely occurring emergent of the Amazonian forest (ARW, 1998).

Description: It belong to a pantropical family of trees. The fruits and seeds are unique. There is considerable variation in fruit size, weigh (0.5–2.5 kg), shape and number of seed per fruit (10-25 seeds). At maturity the large, woody fruits fall to the grount with the seeds inside (Mori, 1992).

Nutrition: Complete protein content is from 12%-18% with all essential amino acids. **The flour from nuts is approximately 46 % protein**, with no fat. Brazil nut contain minerals, such as phosphorous, vitamin B, potassium, furthermore iron, calcium and zinc (Shanley, 2011).

Brazil nut with *Hevea brasiliensis* are often cited as the most important products of Amazonia. Nuts are collected during the wet season and rubber is tapped during the dry season, the combination of these products provides year-round income for those living by extractivism (Mori, 1992).

Products from this tree are nuts, oil, fruit, bark and wood. Nuts are usually eaten fresh, but they also can be made a sweet spread, ground into flour, or used as “milk”. Oil appears in soap, creams and shampoo. Fruit is used to make crafts, toys and a bowl for collecting latex. The bark can be made into tea for diarrhoea. Wood is used for fence posts and construction (Shanley, 2011).

4.3.2 Cucurbita argyrosperma

Figure 8. Fruit of cucurbita (Huber, 2012)

Figure 9. Plant of cucurbita (MABA, 2011)

Botanical name: *Cucurbita argyrosperma*

Local Name: Calabaza

English name: Cushaw

Family: Cucurbitaceae

Habitat: Broad sandy arroyo and floodplain (MABA, 2011).

Description: It is climbing monoecious plant, ranging from villous to pubescent and which may be hirsute, with short, rigid and rather enlarged and sharp trichomes. Leaves are ovate-cordate with whote spots. The flowers are campanulate calyx. The fruit is short or long and piriform, straight or curved in the thinnest part and 11 to 50 cm long. It has a hard rind which is smooth to slightly ribbed, and is white with longitudinal green reticulate stripes or completely white. The flesh is white, yellow or orange, the seeds elliptical and slightly inflated, measuring 15 to 30 x 8 to 16 mm, with a white, smooth and even testa (Duke, 1994).

Nutrition: The seeds are the most important product, chiefly because of their oil (39 percent) and protein content (44 percent) (Duke, 1994).

The flowers, young stems, fruit and ripe fruit are eaten as vegetables. The riper fruit is used to prepare sweets and it is used as feed for livestock and poultry. The seeds are eaten whole, roasted or ground and are the main ingredients for sauces use to prepare various stews (Duke, 1994).

4.3.3 Chenopodium pallidicaule

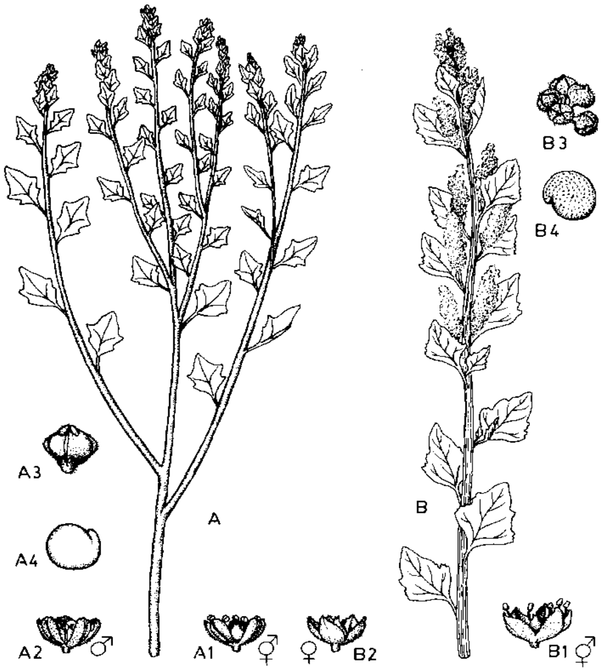


Figure 10. Botanical description of Chenopodium (Hernández Bermejo, 1994)

Figure 11. Chenopodium (Průša, 2013)

Botanical name: *Chenopodium pallidicaule*

Local name: Kañiwa

English name: Canihua, Kaniwa

Family: Chenopodiaceae

Habitat: The high plateau region

Description: It is an annual plant of 25 to 70 cm. Two tapes are differentated: Saigua, of erect growth and with few secondary branches, and Lasta, which is very branched. The flowers are small, without petals. The seeds is from 0.5 to 1.5 mm in diameter, is brown or black.

Nutrition: The seed adds high-quality protein (15-19%) to meat-sarce diets. It has an exceptional amino-acid balance, rich in lysine, izoleucine and tryptohan. The leaves have protein contents as high as 30 percent (Popenoe et al., 1989).

The traditional method of consumption is in the form of lightly roasted, ground grains which produce a flour called cañihuaco. This flour also has medicinal uses: it counteracts sickness and fights dysentery while the ashes of its stem can be used as a repellent against insect and spider bites (Hernández Bermejo, 1994).

4.3.4 Lepidium meyenii

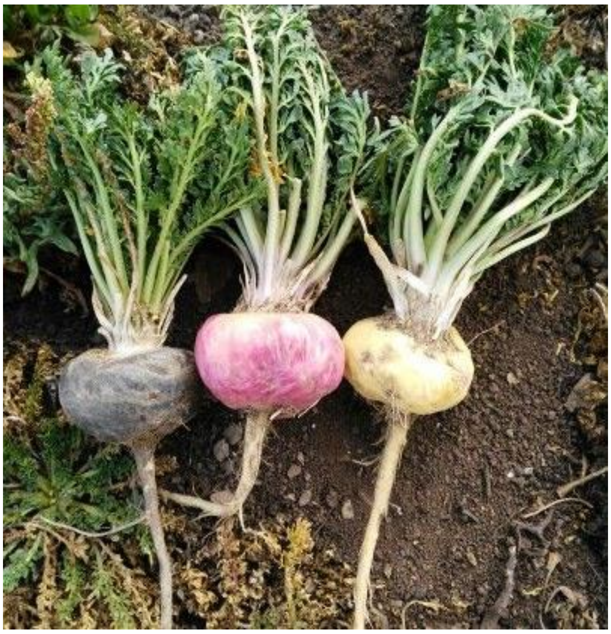


Figure 12. Fruit of Maca (Galvez, 2016)

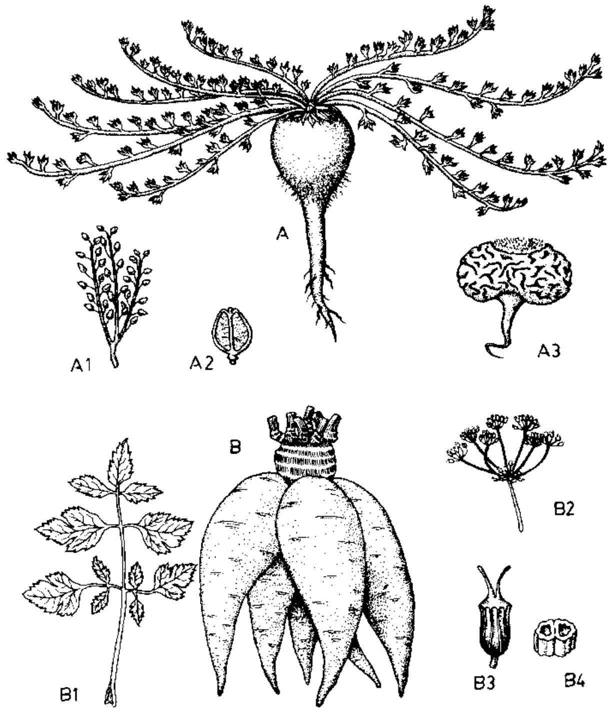


Figure 13. Botanical description of Maca (Hernández Bermejo, 1994)

Botanical name: *Lepidium meyenii*

Local name: Maca

English name: Peruvian ginseng

Family: Cruciferae/Brassicaceae

Habitat: The area is an environment of intense sunlight, violent winds, and bone-chilling cold, higher than any other crop in the world (Popenoe et al., 1989).

Description: It is a herbaceous plant growing 12-20 cm. Its has succulent roots and short, decumbent stems. Its leaves are renwed from the centre of the rosette. The roots are between 2 and 5 cm in size and may be white, yellow, reddish and white, white and yellow, while and purple, grey (Hernández Bermejo, 1994).

Nutrition: The tuberous are rich in sugars, starches, protein, and essential minerals-particularly iron and iodine. The dried roots are approximately 13-16% protein, and are rich in essential amino acids (Popenoe et al., 1989).

Dried roots can be stored for years. It is reported that flavor remains strong for two years, and often for much longer. Seven-year-old roots retain a high level of calories as well as 9-10 percent protein. The root of maca boiled in water is sweeter than cocoa. The leaves are eaten too (Popenoe et al., 1989).

4.3.5 Lupinus mutabilis

Figure 14. Plant of Tarwi (Sweet, 2005)

Figure 15. Seeds of Tarwi (USDA, 2017)

Botanical name: *Lupinus mutabilis*

Local name: Tarwi

English name: Tarwi/Andean Lupin

Family: Fabaceae

Habitat: Highlands and the temperate zones

Description: It is an erect annual, growing 1-2.5 m tall, with a hollow, highly branched stem and short taproot. The flowers are colored purple to blue and are held high above the digitate leaves. The hairy, 5-10 cm long pods are flattened, and contain 2-6 ovoid seeds.

Nutrition: Protein and oil make up more than half their wight. The seeds contain from 41-51 percent of protein (Popenoe et al., 1989), whereas the dry weight contain over 50% and oil content over 16% (Gross, 1987).

The seeds contain more than 40% protein (rich in lysine), the world's premier protein crops and 20 percent oil. The cooked seeds are popular in soups, stews, and salads, or are eaten as snacks, like peanuts or popcorn. It is suitable for processed high-protein meal for food and feed, and margarine (Popenoe et al., 1989).

4.3.6 Moringa oleifera

Figure 16. Botanical description of Moringa (BotanyNV, 2010)

Botanical name: *Moringa oleifera*

Local name: Moringa

English name: Moringa

Family: Moringaceae

Habitat: Moringa can be grown in tropical and subtropical regions with a temperature around 25-35 °C.

Description: It is a small, deciduous tree with sparse foliage, but can grow to 8 m high. Bark smooth, dark grey. Old leaves soon falling off. Flowers are in loose axillary panicles up to 15 cm long. Fruit is large and distictive, up to 90 cm long (Orwa et al., 2009).

Nutrition: The leaves are rich in minerals like calcium, potassium, zinc, magnesium, iron and copper. Furthermore, leaves are rich in vitamins like beta-carotene, vitamin B, C, D, E, pyridoxine and nicotinic acid. The pods are valuable to treat digestive problems and thwart colon cancer. The pods contain around 46.78% fiber and around 20.66% protein content. Moringa leaf powder has 28 mg of iron (beef has 2 mg) and around 35% protein content (Gopalakrishnan, 2016).

Moringa is said to provide 7 more vitamin C than oranges, 10 times more vitamin A than carrots, 17 times more calcium than milk, 9 times more protein than yoghurt, 15 times more potassium than bananas and 25 times more iron than spinach. The pods are valuable to treat digestive problems and thwart colon cancer.8 ounces of milk can provide 300-400 mg of calcium, moringa leaves can provide 1,000 mg and powder can provide more than 4,000mg (Gopalakrishnan, 2016).

4.3.7 Phaseolus lunatus

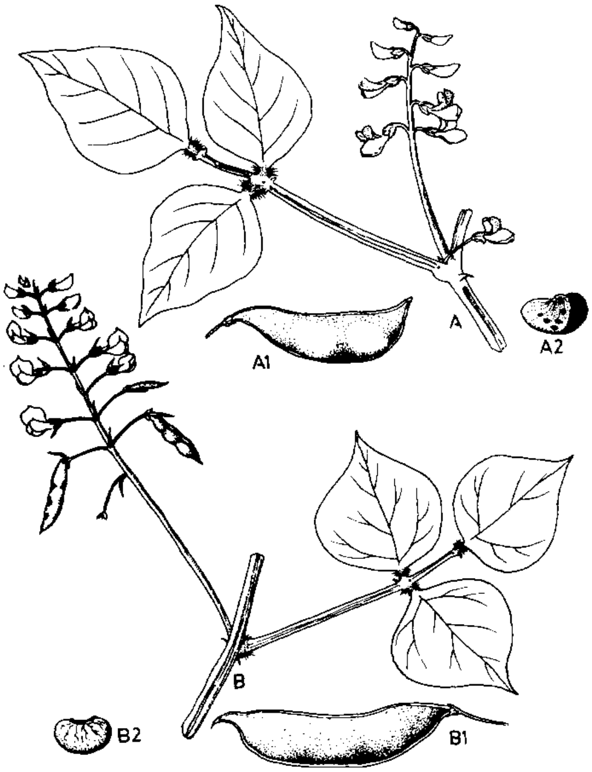


Figure 17. Botanical description of Lima bean (Hernández Bermejo, 1994)

Figure 18. Lima bean (Rodríguez, 1845)

Botanical name: *Phaseolus lunatus*

Local name: Lima

English name: Butter or Lima bean

Family: Fabaceae

Habitat: Desert zones or areas with a long dry period and high altitude (Hernández Bermejo, 1994).

Description: The varietal seeds differeces exist in size and colour, ranging from green to creamy white and a phenomenal starchy flavor (Yellavila, 2015). It is perennial plant, and have erect bush forms, which grow to around 1 m tall. Leaves are trifoliate compound with oval leaflets. Flowers could be white to yellow (Courteau, 2012).

Nutrition: Lima beans include antinutrients that interfere with absorption and utilization of important minerals such as calcium, iron, zinc and magnesium. The crude protein ranged from 20.69 to 23.08%. The fiber ranged between 4-7%. The Lima bean contain fairly good amounts of minerals such as potassium, sodium, phosporous and iron (Yellavila, 2015) .

Lima beans have appreciable functional propertie that could be exploited in food formulations such as koose, sauces and stews. The flours from the Lima bean could be also used, but protein and fiber are low. "Therefore, increased efforts should be made to encourage the cultivation of lima beans as well as its consuption/utilization in order to help curb food security." (Yellavila, 2015).

4.3.8 Plukenetia volubilis L.

Figure 19. Cultivation of Sacha Inchi (Rattasaritt, c2017)

Figure 20. Fruit of Sacha Inchi (Phloysungwarn, c2017)

Botanical name: *Plukenetia volubilis* L.

Local name: Sacha Inchi

English name: Inca peanut

Family: Euphorbiaceae

Habitat: It grows in the tropical jungles at altitudes between 200 and 1500 m

Description: It is a wild, climbing, semiwood, perennial oleaginous plant. The plant provides seeds of a lenticular shape and contain heat-labile substances with a bitter taste (Krivankova, 2012).

Nutrition: Seeds are good source of mineral content such as potassium, phosporus, calcium, and magnesium. The pressed-cake from sacha inchi contained 62.07% protein. The main essential amino acids are lysine, leucine, histidine, and phenylalanine (Rawdkuen, 2016).

This plant has long been a staple in the diet of various native tribal groups in Peru. The seeds are of great interest because they contain a high quantity and quality of edible oil with a very high propotion of saturated fatty acids. The protein content i salso relatively high, around 33%, with the main component being 3S storage protein, a water soluble albumin, which potentially could have promising applications in the food and pharmaceutical industries. Oilseed cake is a by-product of traditional oil processing. The seeds are mechanically pressed in a proces called “cold pressing”. Oils form this proces are the highest quality vegetable oils when compared with expeller-pressed seeds (Rawdkuen, 2016).

4.3.9 Scenedesmus acutus

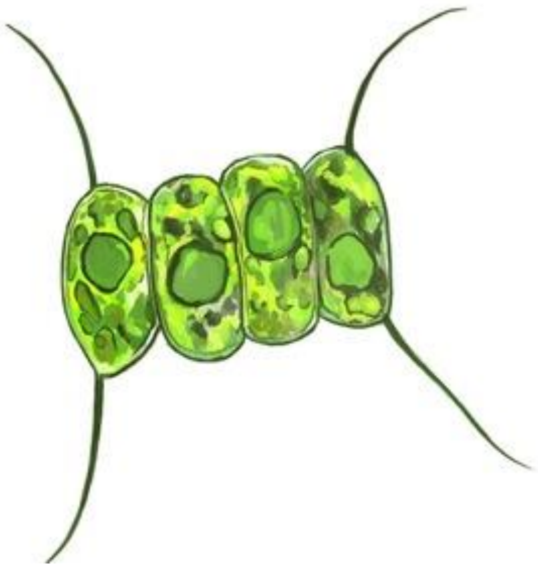


Figure 21. Scenedesmus acutus (Frey, 2015)

Botanical name: *Scenedesmus acutus*

Local name: Scenedesmus

English name: Scenedesmus

Family: Scenedesmaceae

Habitat: This is freshwater species (Guiry, 2017). It could raised in open tanks with clean water (Mahadevaswamy, 1981)

Description: It a type of algae

Nutrition: The protein content varies between 47.4-66.6% (Gross, 1986).

Algae are good source of biomass protein for use in animal feeds and foods. Scenedesmus is dried and use as powder (Mahadevaswamy, 1981). “The major constituent of the alga is protein, which contributes to about 50% of dry weight. The essential amino acid content of the protein is comparable to the human requirement pattern. The supplementary effect of alga to cereal based diets like rice, ragi and wheat is significant. Alga is a concentrated source of protein of good nutritional quality.” (Venkataraman, 1977).

4.3.10 Sesbania bispinosa

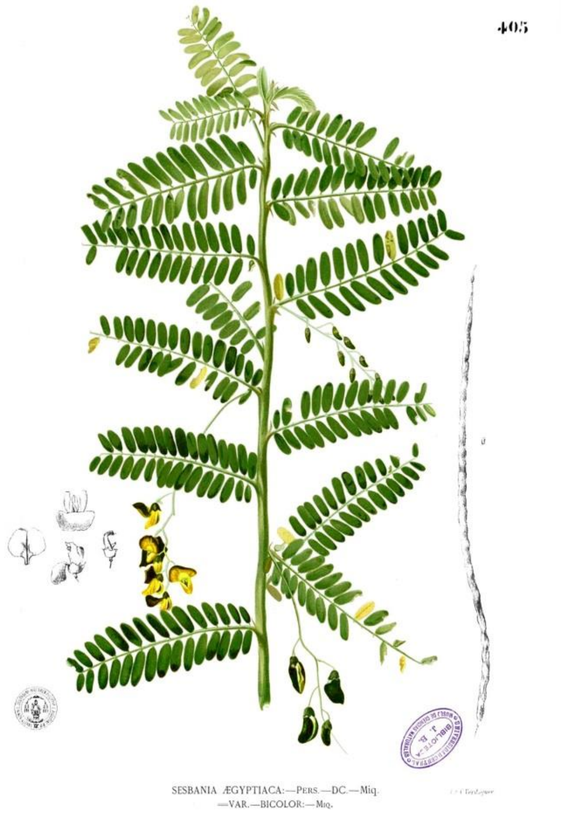


Figure 22. Canchi plant (Rodríguez, 1845)

Botanical name: *Sesbania bispinosa*

Local name: Canchi

English name: Danchi

Family: Fabaceae

Habitat: It is not confined to wetlands but often found in swamps, marshy wastelands, water-logged places, banks of pond and rivers and seasonally inudated areas (Mani, 2011).

Description: It is a small annual shrub with thick stems, up to 7 m tall. Leaves are up to 38 cm long, leaflets 18-55 pairs; flowers are yellow and purple-spotted; pods up to 25 cm long with many seeds (Duke, 1983).

Nutrition: Seed contain 6.2% of a fixed oil and 32.9% crude protein (Duke, 1983).

The stems provide a strong durable fiber, which is used in paper industry. It is grown as a green manure (adding 150 kg N/ha), leaves used for forage and for poultry feed in South Africa. Seed flour is used in the treatment of ringworm, skin diseases and wounds. The mature seeds of this species are known to be cooked and eaten by the Indian tribals, Katkharis and Ghonds (Mani, 2011). This plant is used for erosion control, hedges, intercropping “moter plants“, nitrogen fixation, and windbreaks (Duke, 1983).

5. Conclusion

Electronic information databasis and available literature sources to analyze plants as an alternative sources of proteins in Peru was investigated in this study. Data and information were collected by searching in database such as ScineceDirect (www.sciencedirect.com), Web of Knowledge (www.webofknowledge.com), Google Scholar (www.scholar.google.com) and in the literature available in the library such as Czech University of Life Sciences, Prague and Municipal Library of Prague. The most used key words for searching in the databases were: protein, plant, amino acids, Peru, underutilized, crop, chemical, nutritional, composition.

In this work were analysed 36 plants from Peru, which could serve as a source of protein, summarized in complex Table 3. From these 36 plants were chosen ten of the most potential ones and useful plants, namely: *Bertholletia excelsa* Bonpl., *Cucurbita argyrosperma*,*Chenopodium pallidicaule, Lepidium meyenii, Lupinus mutabilis, Moringa oleifera, Phaseolus lunatus, Plukenetia volubilis* L., *Scenedesmus acutus,* and *Sesbania bispinosa* and were described more in detail.

The meat will always be an important source of minerals, which are under-represented in plant sources, such as iron, but partly reducing of animal foods could help to reduce the incidence of civilizations diseases, such as certain cancers, high blood pressure, high cholesterol and diabetes. Increasing intake of plant food could help supplement essential vitamins and minerals that are lacking in animal sources. Reducing meat production also helps to improve the environment and may arise areas for underutilized plants rich of protein, which could contribute food security in developing countries. This thesis dealed with plants that are very adaptable and are used to conditions that are unacceptable to many plants, for example mountains, high or low temperature areas, barren soils and other factors. Although reducing the consumption of animal products will not solve all the problems that have been caused by the various factors, but it is just one step that can be easily taken and could have a positive effect for people and environment. This work brings a complete overview of plants which could be used as an alternative sources of proteins in Peru. Collected data in this thesis could serve as a basic literature review for the writing of diploma thesis and for future research.

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