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Pulses Protein Quality Control at Different Storage Conditions for Further Protein Extraction – A Review

Milena O. Dutra, Carlos E.S. Soares, Bárbara C.F. Ferreira, Cristiano W.R. Ribeiro, Vildes M. Scussel*

Mycotoxicology and Food Contaminants Laboratory, Food Science & Technology Department, Center of Agricultural Sciences, Federal University of Santa Catarina, Florianopolis, SC, Brazil
*Corresponding author: vildescussel_2000@yahoo.co.uk
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Abstract

The storage conditions are of extreme importance with regards to grains (cereal & pulses) components (carbohydrates, lipids, proteins) preservation and quality for industry (that may interfere to whole process and quality of the final product). In addition, the vegetarian consumers' interest of protein supplement (capsules) from pulses such as beans (*Phaseolus vulgaris* L.), chickpeas (*Cicer arietinum L.*), lentils (*Lens culinaris* L.), peas (*Pisum sativum* L.), peanuts (*Arachis hypogaea* L.), also soybeans (*Glycine max* L.) has grown considerably, mainly due to their non-lactose&non-animal-based ingredients and also non-transgenic in some of the pulses. Therefore, there is a need of information regarding pulses storage conditions on their components' quality/quantity and so for safety of the raw material utilized for protein extract purposes. In addition, to get safe pulses raw materials for protein extraction aimed for vegetarian supplements, one needs to take into account (a) quite controlled storage conditions, apart from (b) pesticide residues and mycotoxins contamination control. Therefore, the present reviewgathers and compiles the characterization of six different pulses by evaluating amino acids profile as indicators of protein quality, and compares them with different varieties for further protein extraction.

Key words: pulses, beans, peas, lentils, storage, protein, denaturation, fungi, mycotoxins.

1. Introduction

1.1 Pulses consumption and proteins

Pulses, are dry seeds from Fabaceae or Leguminosae family, which are cultivated throughout the world due to its easy adaptation to different climates. They are highly nutritious and play an important role on human diet (Aykroyd et al, 1982; Ofuya, 2005). They include beans (*Phaseolus vulgaris* L.), chickpeas (*Cicer arietinum L.*), lentils (*Lens culinaris* L.), peas (*Pisum sativum* L.), peanuts (*Arachis hypogaea* L.) and soybeans (*Glycine max* L.). Furthermore, vegetarian protein supplements consumption makes the pulseslikely to grow considerably, since they are lactose-free and non-animal based protein products (FAO, 2016; Aykroyd et al, 1982). Among the different pulses, the high oil content - soybeans followed by peanuts, as well as lentils and beans are the main protein sources, with 42.0, 32.0, 31.0, and 30.0%, respectively (Table 1).

1.2 Storage conditions and protein quality

There are physicochemical and biological changes that occur during pulses storage and affect considerably their components' quality and quantity. Therefore the storage conditions require a special care to maintain the quality and safety of the raw material utilized for protein extraction (Nasar-abbas et al, 2008). Data reported in the literature (especially during hot seasons) lead to protein denaturation. Inactivation starts taking place at temperature around 35°C. The same for humidity, as most proteins have globular shape, low moisture content (mc) and water activity (a_w) lead to their 3D structure alteration (the opposite - high humidity contents - lead to living organisms proliferation). That includes also the storage *length of time*, which, when pulses are kept under adverse conditions for long time, they may add to the other components reactions and so to the proteins (Labuza et al, 1982). Regarding *pH*, its reduction, causes pulses alterations (due to fermentation and oxidative reactions by fungi/bacteria & insects/mites activities to carbohydrates and lipids, respectively) leading to protein denaturation (including enzymes inactivation affecting catalysis) (Klupsaite et al, 2015). Furthermore, the Living Organisms (L.O.) infestation/ infection, such as insects, mites and fungi, can lead to protein reduction (components consumed by (L.O.), thus interfering with quality and quantity. In addition, pesticide residues (from field and storage applications) and mycotoxins (from toxigenic fungi) play a role in contamination of peas/lentils protein extracts (Cegielska et al, 2003). Regarding the impurities that may come from the field (foreign matter & broken/deteriorated/toxin contaminated pulses), despite of their pre-cleaning and cleaning reduction, they can bring also contamination to pulse in storage (Waliyar et al, 2014).

Considering the lack of information regarding specifics on pulses proximate composition, aiming the proteins and amino acids profile, also their alterations under storage conditions: the current work gathered literature data regarding pulses characteristics, storage specifics for protein quality/quantity improvement and extraction methodologies, including contaminants and impurities that may be brought into the protein process.

Tab 1. Protein percentages in the proximate composition of different pulses

Pulses	Proximate composition (%)						
	Protein	Carbohydrate	Lipid	Fiber	Ash	mc[a]	Kcal/100 g
Beans[b]	27.1-29.5	54.3-64.1	0.5-16.3	12.7-24.9	2.70-4.30	9.0-13.4	333-409
Chickpeas[b]	22.9-24.8	60.8	6.2	17.4	2.64	11.5	36
Lentils[b]	26.1-31.3	58.2	2.1	30.5	2.55	10.8	353
Peas[b]	22.8-26.5	60.4-63.2	0.8-1.5	15.0-25.5	2.70-3.45	0.6-10.6	341-343
Peanut[b]	28.8-32.0	1.8	47.0	3.7	3.80	5.8	620
Soybean[b]	38.6-42.0	29.8-33.3	22.2-23.8	5.8	5.24-5.57	5.4	172

Tiwari et al (2012); Vieira et al (1999); Atasie et al (2009); Iqbal et al (2006); Bhatty et al (1976); Radhakrishnan et al (2016); Shelepina et al (2016); [a]moisture content [b]rangefromdifferentvarieties.

2. 2. Pulses *versus* amino acids profile and proteins

2.1 Bean (*P. vulgaris*)

They represent nearly 80% of total pulse production in Latin America (Pachico, 1989), in which Brazil remains the largest grower and consumer of common beans worldwide (Torres et al, 2009; Duranti, 2006).Table 2 presents the amino acids profile and protein range among 6 Northern American (Canadian) beans varieties (Pires et al, 2005). Their protein content ranges from 27.1 to 29.5% (Freya and Ed Hoff varieties, respectively). Amino acids amounts are similar for all bean varieties, however, beans show high levels of Glutamic and Aspartic Acid, followed by Arginine. There is evidence that environmental factors such as geographic location and season may significantly influence the protein content and lipids of beans (Bhatty et al, 1976). Raw beans are also good source of water-soluble B vitamins; however, they are poor sources of lipo-soluble vitamins and vitamin C (Pires et al, 2005).

2.2 Chickpeas (*C. arietinum*)

Chickpeas are one of the oldest and most widely consumed pulses in the world, especially in India (Angulo et al, 2018; McVay et al, 2016). It is a healthy vegetarian food, a good source of fiber, vitamins (thiamine, riboflavin and niacin) and micro-minerals. However the chemical composition of crops changes with their varieties, soil and area climatic conditions (Iqbal et al, 2016). Table 3 shows the amino acid profile of different chickpea varieties grown in Pakistan. The protein content ranges from 22.9 to 24.8% (Nifa-95 and Nifa-88 varieties, respectively). Although amino acid amounts vary among varieties, they are rich in Glutamic, Aspartic Acids and Leucine (Radhakrishnan et al, 2014).

2.6 Lentils (*L. culinaris*)

Lentils are a staple food grown in West Asia, Africa and India, being their primary component of farming systems. Lentil plays a significant role in human and animal nutrition, besides the maintenance and improvement of soil health. They are particularly high in protein and low in fat (Iqbal et al, 2006), an excellent source of both soluble and insoluble fibers, as well as complex carbohydrates, B vitamins and minerals (Adsule et al., 1989; Muehlbauer et al., 1985; Yadavet al, 2007). Table 4 presents the range of protein of lentil varieties grown in Chile and Iraq (27.7 to 31.3% for Pioneer Red and Amasya varieties, respectively). Lentils show high levels of Glutamic and Aspartic Acid, followed by Arginine. ´

2.4 Peas (*P. sativum*)

Peas are widely produced in Russia and China, followed by Canada, Europe, Australia and United States (Henchion et al, 2017). Sevey (2008) showed that peas have by far the highest protein content (21-25%) and total digestible nutrients (86-87%). Pea contains 5 to 20% less Trypsin inhibitors than soybean, that allows it to be fed directly to livestock without having to go through the extrusion heating process (Amarakoon, 2012). Globulins (up to 80-90%), followed by albumins and glutenins are the main pea proteins. Separate groupings of salt-soluble proteins contain unequal amount of essential amino acid, limiting nutritional value (Methionine, Tryptophane and Cysteine). Their low content is characteristic of vicilines and viciline-related protein (Shelepina et al, 2016). Table 5 presents the range of protein (22.1-26.6%) content with the amino acids profile, showing high levels of Glutamic and Aspartic Acids, followed by Arginine.

2.5 Peanuts (*A. hypogaea*)

Also known as groundnut, is originated in South America and it's one of the world's major food pulse (oil seed) (Singh et al, 1992). It became the fourth most important source of edible oil and thethird most important source of vegetable proteins (Hammons, 1994; Savage, 1994). Its concentrate and isolate products have the advantage of removing the insoluble and partly indigestible carbohydrates (one third of the raw material) (Singh, 1991; Lusas, 1985). Protein makes from 12.0 to 36.4% of the peanuts kernel (Sekhom et al, 1970), but can also cause hypersensitivity reactions (angioedema, asthma, abdominal discomfort and anaphylactic shock), (Moneret et al, 1998), being the second food to produce such allergic symptoms, only after milk and eggs (Hammons, 1994; Yu et al, 2007). Table 6 presents Korean peanuts varieties amino acid profile (high in Isoleucine, Glutamic and Aspartic acid) and protein content (from 28.8 to 32.0% for Suwon 88 and Pungan, respectively).

2.6 Soybean (*G.max*)

The oil seed, native of Southeastern Asia, has the highest protein content and the highest gross output of vegetable oil among the cultivated crops in the world (Morse et al, 1949; Singh, 2010), with high expansion in Brazil. (Agroanalysis, 1996; Vieira et al, 1999; Fearnside, 2001). The Food and Drug Administration (FDA) approved in 1999 a health claim on food labels for products containing soy protein about the association between soy protein and a reduced risk of coronary heart disease, and the beneficial effects of isoflavones, saponins and fiber (Barbosa, 2006). Various epidemiological studies have demonstrated a lower incidence of breast, prostate and colon cancer in Asian populations (for which consumption is 20 to 50 times higher than for occidental populations).Based on six varieties aimed to human consumption, it is possible to see the difference in amino acid (Table 7). All varieties present a superior and excellent balance of essential amino acids by the FAO/WHO pattern (protein: 39.5 to 45.0 g protein) and high levels of Glutamic and Aspartic Acids, followed by Phenylalanine and Tyrosine (Vieira et al, 1999).

Tab. 2. Protein amino acids profile from BEANS (*P. vulgaris*) - Canadian varieties

Amino acid	FAO[a]	Bean - Canadian varieties (%)					
		Ed Hoff	Erfordia	Frey a	Fribo	Klein-K.	Maris Bread
ESSENTIAL							
Histidine	1.6	2.7	2.6	2.6	2.6	2.6	2.6
Isoleucine	1.3	4.3	4.2	4.3	4.4	4.3	4.2
Leucine	1.9	8.2	8.1	8.3	8.4	8.5	8.2
Lysine	1.6	6.7	6.6	6.6	6.7	6.6	6.5
Methionine	NI[c]	0.8	0.8	0.7	0.8	0.7	0.7
Cysteine (half)[b]	NI[c]	1.9	1.6	2.0	1.7	1.5	1.7
Phenylalanina	NI[c]	4.4	4.5	4.3	4.5	4.4	4.4
Tyrosine[b]	NI[c]	2.8	2.8	2.9	2.7	2.8	2.9
Threonine	0.9	3.4	3.3	3.3	3.3	3.3	3.2
Tryptophan	0.5	1.1	1.0	1.1	1.1	1.0	1.1
Valine	1.3	3.8	3.8	3.9	4.0	3.9	3.8
NON ESSENTIAL							
Arginine[b]	NI[c]	10.3	11.0	10.7	10.3	9.9	10.6
Alanine	NI[c]	4.2	4.2	4.1	4.2	4.3	4.2
Aspartic Acid	NI[c]	13.0	13.0	1.9	12.8	13.3	12.9
Glutamic Acid	NI[c]	20.2	20.4	20.2	20.2	20.3	20.4
Glycine	NI[c]	4.2	4.2	4.1	4.2	4.3	4.2
Proline	NI[c]	3.9	4.0	4.1	4.0	4.4	4.0
Serine	NI[c]	4.0	4.1	4.0	3.9	4.0	4.0
PROTEIN (%)	NI[c]	27.1	28.3	29.5	28.2	27.9	29.1

Kaldyet al (1974)[a] adults essential amino acid reference pattern from Food and Agriculture Organization, [b]considered essential or non-essential, [c]NI:NotInformed.

Tab. 3. Protein amino acids profile from CHICKPEAS (*C. arietinum*) -Pakistani varieties

Amino acid	FAO[a]	Chickpeas - Pakistan varieties (%)

		Nifa-88	Nifa-95	Kabuli Hassan-2k
ESSENTIAL				
Histidine	1.6	2.9	3.2	3.0
Isoleucine	1.3	4.5	4.8	5.2
Leucine	1.9	8.2	8.1	8.3
Lysine	1.6	6.7	7.0	7.8
Methionine	NI[c]	0.8	1.1	1.3
Cysteine(half)[b]	NI[c]	0.4	0.6	0.8
Phenylalanine	NI[c]	5.0	5.3	6.2
Tyrosine[b]	NI[c]	2.8	2.8	2.9
Threonine	0.9	2.7	3.0	3.5
Tryptophan	0.5	0.6	0.9	1.1
Valine	1.3	4.1	4.0	5.2
NON ESSENTIAL				
Arginine[b]	NI[c]	8.2	8.5	9.5
Alanine	NI[c]	5.0	5.2	4.7
Aspartic Acid	NI[c]	11.3	11.5	10.2
Glutamic Acid	NI[c]	17.6	17.8	16.5
Glycine	NI[c]	3.4	3.6	4.0
Proline	NI[c]	3.9	4.1	3.5
Serine	NI[c]	3.3	5.0	4.2
PROTEIN (%)	NI[c]	22.9	24.1	24.8

Iqbal et al (2006) [a] adults essential amino acid reference pattern from Food and Agriculture Organization, [b]considered essential or non-essential, [c]NI: NotInformed.

Tab. 4. Protein amino acids profile from LENTIL (*L.culinaris*) - Chilean and Persian varieties

Amino acid	FAO[a]	Lentil - Chilean and Persian varieties (%)					
		Tekoa	Morden	Amasaya	Eskiseher	Pioneer Red	Sloven
ESSENTIAL							
Histidine	1.6	2.3	2.0	2.3	2.0	1.9	2.1
Isoleucine	1.3	3.4	3.7	3.5	3.3	3.5	3.7
Leucine	1.9	6.1	6.7	6.4	6.1	6.3	6.7
Lysine	1.6	6.3	6.5	6.5	5.9	6.1	6.3
Methionine	NI[c]	0.6	0.6	0.6	0.5	0.7	0.6
Cysteine(half)[b]	NI[c]	1.4	1.2	1.3	.12	1.4	1.5
Phenylalanine	NI[c]	3.9	4.3	4.1	3.9	4.1	4.3
Tyrosine[b]	NI[c]	2.4	2.4	2.1	2.3	2.4	2.4
Threonine	0.9	3.0	3.2	3.1	3.0	3.2	3.3
Tryptophan	0.5	0.9	0.9	0.9	0.9	1.0	0.8
Valine	1.3	3.9	4.1	4.1	3.8	4.1	4.0
NON ESSENTIAL							
Arginine[b]	NI[c]	6.8	6.4	7.0	7.3	6.6	7.1
Alanine	NI[c]	3.6	3.8	3.6	3.4	3.7	3.9
Aspartic Acid	NI[c]	9.4	9.7	10.0	9.8	10.0	10.3
Glutamic Acid	NI[c]	13.5	14.2	14.1	13.4	14.1	14.8
Glycine	NI[c]	3.5	3.3	3.5	3.3	3.3	3.7
Proline	NI[c]	3.9	4.0	4.1	4.0	4.4	4.0
Serine	NI[c]	3.4	3.4	3.3	3.3	3.5	3.6
PROTEIN (%)	NI[c]	28.3	26.1	30.3	31.3	27.7	28.9

Bhatty et al (1976) [a] adults essential amino acid reference pattern from Food and Agriculture Organization, [b]considered essential or non-essential, [c]NI:NotInformed.

3. Pulses composition

3.1 Protein and nutritional quality

Protein-calorie malnutrition is a big problem that has been affecting mankind, also indicating that the protein gap may increase in the future unless something addresses the issue. Access adequate proteins of animal origin are difficult and expensive (Reach, 2012). An alternative to improve the nutritional status of those countries is to supplement the diet with pulse proteins (Leterme, 2002).

Tab. 5. Protein amino acids profile from PEAS (*P. sativum*) - Russian varieties

Amino acid	FAO[a]	Pea - Russian varieties(%)			
		Express	**Highlight**	**Baroness**	**Titan**
ESSENTIAL					
Isoleucine	1.3	4.7	4.4	4.6	4.6
Leucine	1.9	7.5	7.2	7.1	7.2
Lysine	1.6	7.7	7.6	7.8	7.8
Methionine(half)	NI[c]	2.8	2.6	2.5	2.5
Cysteine(half)	NI[c]	2.5	2.5	2.5	2.5
Phenylalanine	NI[c]	5.2	4.9	5.0	5.0
Tyrosine[b]	NI[c]	3.6	3.6	3.7	3.5
Threonine	0.9	4.3	4.1	3.9	4.0
Valine	1.3	5.1	4.9	5.0	5.0
Histidine	NI[c]	2.6	2.6	2.5	2.5
NON ESSENTIAL					
Arginine[b]	NI[c]	8.5	8.5	8.6	8.6
Alanine	NI[c]	4.6	4.5	4.6	4.6
Aspartic Acid	NI[c]	11.5	11.4	11.9	11.8
Glutamic Acid	NI[c]	16.6	16.5	16.7	16.7
Glycine	NI[c]	4.6	4.7	4.5	4.6
Proline	NI[c]	4.4	4.5	4.5	4.9
Serine	NI[c]	4.9	5.0	4.9	4.9
PROTEIN (%)	NI[c]	25.0	26.5	22.8	25.1

Shelepina et al (2016) [a] adults essential amino acid reference pattern from Food and Agriculture Organization, [b]considered essential or non-essential, [c]NI: NotInformed.

Tab. 6. Protein amino acids profile from PEANUTS (*A. hypogaea*) - Korean varieties

Amino acid	FAO[a]	Peanut - Korean varieties (%)			
		Suwon 88	**Daewon**	**Daekwang**	**Sonan**
ESSENTIAL					
Histidine	1.6	0.6	0.6	0.5	0.6
Isoleucine	1.3	7.8	7.7	6.9	7.8
Leucine	1.9	1.8	1.8	1.6	1.8
Lysine	1.6	0.9	0.9	0.8	0.9
Methionine	NI[c]	2.2	2.5	2.6	2.4
Cysteine(half)[b]	NI[c]	0.2	0.2	0.2	0.1
Phenylalanine	NI[c]	1.4	1.4	1.2	1.4
Tyrosine[b]	NI[c]	1.0	0.9	0.8	1.0
Threonine	0.9	0.7	0.7	0.6	0.7
Valine	1.3	1.0	1.0	0.8	1.0
NON ESSENTIAL					
Arginine[b]	NI[c]	3.0	3.0	2.7	3.0
Alanine	NI[c]	1.1	1.0	0.9	1.0
Aspartic Acid	NI[c]	3.1	3.1	2.7	3.1
Glutamic Acid	NI[c]	5.3	5.3	4.8	5.4
Glycine	NI[c]	1.6	1.6	1.6	1.5
Proline	NI[c]	1.1	1.0	0.9	1.7
Serine	NI[c]	1.4	1.4	1.3	1.4
PROTEIN (%)	NI[c]	32.0	31.4	28.8	31.8

Radhakrishnan et al (2016) [a] adults essential amino acid reference pattern from Food and Agriculture Organization, [b] considered essential or non-essentia, I[c]NI: NotInformed.

Tab. 7. Protein amino acids profile from SOYBEAN (*G. max*) - Brazilian varieties

Amino acid	FAO[a]	Soybean - Brazilian varieties (%)					
		IAS-4	Embrapa-4	Davis	BR-16	Iguaçu	IAS-5

ESSENTIAL							
Histidine	1.6	1.9	1.8	1.9	2.0	2.4	2.4
Isoleucine	1.3	1.4	3.5	3.8	3.7	4.1	4.0
Leucine	1.9	7.8	7.1	7.4	7.3	7.8	7.9
Lysine	1.6	6.4	5.6	5.8	6.0	6.8	6.9
Methionine	NI[c]	1.3	1.2	1.3	1.3	1.4	1.3
Cysteine[b]	NI[c]	2.5	2.0	2.5	2.2	2.4	2.3
Met+Cys	1.7	3.8	3.2	3.8	3.5	3.8	3.6
Phenylalanine	NI[c]	6.2	6.1	6.2	6.0	6.5	6.7
Phe+Tyr	1.9	9.4	9.1	9.5	9.1	9.9	10.2
Threonine	0.9	3.9	3.5	3.9	3.8	4.0	4.1
Tryptophan	0.5	1.7	1.6	1.5	1.6	1.5	1.5
Valine	1.3	4.1	4.1	4.3	4.1	4.6	4.4
NON ESSENTIAL							
Arginine[b]	NI[c]	7.4	7.4	6.8	6.8	7.3	7.2
Alanine	NI[c]	4.3	3.8	4.0	3.9	4.2	4.4
Aspartic Acid	NI[c]	12.8	13.1	14.2	13.7	14.6	14.7
Glutamic Acid	NI[c]	18.3	20.9	22.1	20.7	23.6	23.3
Glycine	NI[c]	3.7	3.6	3.6	3.4	3.8	3.9
Proline	NI[c]	8.3	7.5	7.9	7.6	8.0	8.7
Serine	NI[c]	5.3	4.8	5.2	5.0	5.5	5.0
PROTEIN (%)	NI[c]	9.30	41.95	38.55	38.56	38.57	40.17

Vieira et al (1999) [a] adults essential amino acid reference pattern from Food and Agriculture Organization, [b] considered essential or non-essential, [c]NI: NotInformed.

According to FAO (2011), it is necessary to increase food production by 70%. It should be satisfied by the most promising and valuable crops (low-cost and complete vegetable protein). The main types of protein preparations obtained from pea, for example, are defatted flour (56–59% of protein), concentrated pea protein (65–72% of protein) and isolate (90% of protein). According to Shelepina et al (2016), in terms of amino acid composition and assimilation of pulses protein (isolates and concentrates), they are close to proteins of animal origin.

Pulses have many good qualities and can be considered most suitable for protein extraction. They are mainly storage proteins belonging to the groups of albumins, globulins and glutelins, with the salt-soluble globulins constituting the main proteins found in the seeds. These proteins are part of the defensive mechanism of the seed, but are considered as anti-nutritional factors for the human diet (Tiwari et al, 2011).

Apart from their nutritional properties, pulses proteins also possess functional properties (gelling and emulsifying), playing an important role in food formulation and processing. Intrinsic factors (amino acid composition), extrinsic (pH, temperature, solvent, salt) or environmental factors, besides processing treatments (heating, drying, concentrating) or other intentional modifications (chemical or enzymatic modification) can all contribute to influence the functional properties of these proteins (Klupsaite et al, 2015).

3.2 Pulses anti-nutritional factors

To reduce the ANFs and improve quality, seeds are processed by several physical and chemical methods to remove the undesirable compounds: soaking, cooking, germination, fermentation, selective extraction, membrane filtration, irradiation and enzyme treatments (Vidal-valverde, 1994). Those treatments lead to a significant reduction or total elimination of ANFs. Germination and fermentation processes lead to catabolism of the seed components whereas other processes (cooking) may cause thermal degradation or may involve extraction of non-nutritional components. ANFs found in pulses can be separated into several groups based on their chemical and physical properties (non-protein amino acids, quinolizidine alkaloids, cyanogenic glycosides, pyrimidine glycosides, isoflavones, tannins, oligosaccharides, saponins, phytates, lectins or protease inhibitors) (Bell and Charlwood, 1980). Many ANFs are toxic, unpalatable or indigestible, but can be eliminated by selection of plant genotypes or postharvest processing (germination, boiling, leaching, fermentation), including protein extraction (Ali et al, 2000).

4 Pulses` contaminants and storage conditions

The quality of post-harvest conditions (cleaning, sorting, drying, storage, transport and marketing) can cause high amount of losses and health risks that conflict with national and international standards regulations. It is important to avoid the microorganism's development, especially due to the fungi contamination, with potential production of micotoxins (Anderson, 1954).

Freshly harvested pulses can be safely stored in silos, with a filling and a proper sealing to prevent its deterioration. During uploading, the quantity of air must be minimized, decreasing pulses and microorganism's respiration (21- 0.02%) and pH (due to fermentation). Immediate treatment is essential to prevent quality and quantity deterioration from mold development, ensuring short and long-term preservation of pulses. That includes sealed storage, chemical treatment, chilling and drying. Otherwise, pulses were not being appropriate to further protein extraction (Brooker, 1992)

4.1 Environmental contaminants

It is becoming increasingly apparent that although the major part of the food supply is both safe and nutritious, some risk is unavoidable. The very nature of the industrial society, which includes a substantial part of the world`s population, has increased the risk that foods may become contaminated by a wide variety of chemicals introduced into the environment by man, intentionally or accidentally (Hathcock, 2012).

The polychlorinated biphenyls, polybrominated biphenyls, aflatoxins, nitrites, nitrates and nitroso compound, and metals such as mercury and lead, havedifferent contaminant properties which make them potential problems in the environment. That includes relatively widespread use or distribution of the chemical, in some cases a long biological half-life persistence in the environment, increased residue levels along the food chain, and the potential of an increased risk for adverse health effects in human and food producing animals (Cordle et al, 1982; Hathcock, 2012).

4.2 Fungal and mycotoxins contamination *versus* storage conditions

A high number of toxic microbial metabolites contaminates agricultural products due to the diversity of fungal and bacterial species that coloniesthem from field to storage (Maciorowskiet al, 2007). One of the most important effects of post harvest decays of seed and feed by fungi is the induction of mycotoxicoses, in animals and humans. This is caused by foods and feed consumption invaded by toxigenic fungi (producing mycotoxins). They are secondary metabolites produced by filamentous fungi which may contaminate food, feed and raw materials used in producing them (Agrios, 1978; Moss, 1989; Amadi et al, 2009; Savi et al, 2015; Scussel et al, 2018). Mycotoxicoses caused by widespread fungi such as *Aspergillus*, *Penicillium*, *Fusarium* and *Stachybotrys* can result in severe illness and death. *Aspergillus* and *Penicillium* produce their toxins mostly in stored seeds, hay or commercially processed foods and feeds although infection of seeds usually takes place in the field. Adams (1977) has reported that storage fungi especially *Aspergillus*, *Penicillium*, *Rhizopus* and *Mucor* species infect grains after harvest and can grow on them during storage, although other toxigenic fungi are also found on grains, such as *Alternaria*, *Trichoderma*, *Fusarium*, *Paecilomyces*, *Chaetomium* and *Acremonium*. Generally, mycotoxins have been implicated as causative agents of different health disorders (Ciegler and Bennett, 1980). Both, the toxigenic fungi and the mycotoxins they produce, are potential problems economy perspectives wise. Aflatoxinsare the most commonand widespread mycotoxin, and it is known to be produced by different species of *Aspergillus* (*A.flavus, A.oryzae and A.terreus*). The liver is the target organ, but it is also hepatoxic and carcinogenic (Eaton et al, 1994). While more than 25 different species of fungi are known to invade stored grains and pulses (Duan et al., 2007), species of *Aspergillus* and *Penicillum* are responsible for most spoilage and germ damage during storage. They cause reduction on cooking / baking quality, nutritive values, produce undesirable odors and color, also change appearance of stored food grade grains. In addition, they make products unacceptable for edible purposes or lower their market quality (Embaby et al, 2003).

5. Conclusions

Pulses are widely cultivated, and a good food resource, once it has easy adaptation to different climates and highly nutritious. It is considered most suitable for protein isolates preparation due to their high protein content, low cost and wide acceptability. Several methods are used for protein extraction and every technique has its own advantages. The functionality of pulse proteins is closely related to their physical and chemical properties, such as molecular weight, amino acid composition and sequence, structure, surface electrostatic charge, and effective hydrophobicity. Storage conditions (impaired/ aggressive temperature/humidity) can lead to physical, chemical, enzymatic or genetic proteins modifications thus altering their functionality, interfering also to food industries final products (Klupsaite et al, 2015).

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Mites in aromatic, condiment and medicinal dehydrated plants in bulk sale in the city of São Paulo.

Marcia da Fonseca Valbuza[1], André Luis Matioli[2], Mario Eidi Sato [2], Marcos Roberto Potenza*[3], Ana Eugênia de Carvalho Campos.[3]

[1.] Instituto Biológico,Pós-Graduação em Sanidade Alimentar e Ambiental no Agronegócio, Av. Conselheiro Rodrigues Alves, 1252, São Paulo, Brasil. E-mail:valbuza@uol.com.br.

[2.] Instituto Biológico, Alameda dos Vidoeiros, 1097 - Campinas, Brasil. E-mail: matioli@biologico.sp.gov.br and mesato@biologico.sp.gov.br.

[3.] Instituto Biológico, Av. Conselheiro Rodrigues Alves, 1252, São Paulo, Brasil. E-mail: mpotenza@ig.com.br and anaefari@biologico.sp.gov.br.

*Corresponding author: mpotenza@ig.com.br

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Mites infest stored goods, especially when the environment is hot and humid. Infested foods may have their taste altered and, in some cases, cause diseases to consumers. In this way, the detection of arthropods in food must be carried out throughout the production chain, as the external and internal markets are increasingly demanding for the quality and health of food. Aromatic, condiment and medicinal dehydrated plants are largely sold in bulk, but little is known about infestations by mites. The objective of this work was to evaluate the diversity of mites in 10 samples of *Coriandrum sativum*, *Pimpinella anisum*, *Petroselinum sativum*, *Chamomila recutita*, *Baccharis trimera*, *Bixa Orellana*, *Cassia angustifolia*, *Origanum vulgare*, *Ocimum basilicum*, *Melissa officinalis*, *Mentha piperita*, *Rosmarinus officinalis*, *Peumusboldus*, *Salvia officinalis*, *Thymus vulgaris*, *Laurus nobilis*, *Hibiscus sabdariffa*, *Myristica fragans*, *Capsicum annum* and *Curcuma longa* acquired in the establishments of bulk sale in the city of São Paulo. A total of 2,589 specimens of mites corresponding to 10 species, *Tyrophagus putrescentiae*, *Glycyphagus destructor*, *Ameroseius* sp., *Blattisocius tarsalis*, *Typhlodromus transvaalensis*, *Tetrabdella* sp., *Cheyletus malaccensis*, *Pronematulus* sp., *Raphignatus* sp. and *Tydeus* sp. The mite *Typhlodromus transvaalensis* was recorded for the first time in Brazil infested stored products.

Key words: Mite, stored products.