Chapter 21

Brazilian Soybean Varieties for Human Use

Neusa Fátima Seibel, Fernanda Périco Alves,
Marcelo Álvares de Oliveira and
Rodrigo Santos Leite

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/52602

1. Introduction

In the present days, the export trade in soybean and its derivatives has a major impact on the Brazilian agro-industrial system and economy. Brazil is the second largest producer, behind only the United States, and three states represent 63% of national production: Mato Grosso, Paraná and Rio Grande do Sul. The 2010/2011 crop has maintained its growth momentum, with higher volume than the previous one, with the climatic factor as primarily responsible for these results.

Soybean has a high nutritional and functional value, is source of quality protein and some essential nutrients to human diet. Due to this nutritional quality, high production, low cost and variety of derivate products, the soybean grain is an alternative for feed [10]. The benefits of soybean have increased its consumption both *in natura* and processed. Studies have shown the association between soy consumption and reduced incidence of esophageal, lung, prostate, breast and colorectal cancer, cardiovascular disease, osteoporosis, diabetes, Alzheimer's disease and menopausal symptoms. The joint action of high-quality protein and polyunsaturated and saturated fats present in soybean helps reduce LDL [37, 28].

In Brazil, the consumption of soybean and its products is still not widespread, due to the few options, exotic flavor to the Brazilian palate and presence of antinutritional factors in the grain. Some of these factors, as the protease inhibitors and lipoxygenase enzymes, can be reduced by suitable thermal processing. Coupled with this, the genetic breeding is responsible by eliminate lipoxygenase enzymes, reducing the flavor which limits the acceptability of the soy products [10, 28].

The soymilk is nutritive, lactose-free, contains no cholesterol and is highly digestible. Can be sold in liquid or powder, pasteurized or sterilized, and commonly flavored, such as juices and vitamins. The extract can also be incorporated as ingredient in breads, cakes, biscuits, chocolates and more.

The results of production, yield, chemical composition and nutritional value of soymilk depend directly on the soybean cultivar, and the quality of soymilk may also be interfered by the water proportion and initial conditions of the grains. There are 316 soybean cultivars currently available in Brazil, with different characteristics of productivity, production cycle, grain size, adaptation to regional climate and lipoxygenase presence. Some are considered commodities, and other cultivars have special purpose.

Cultivars specially developed for human consumption can contribute to the sensory quality of the extract, which directly increases the acceptability of soy as a food, since the sensory quality is decisive in the buying process. Even with important nutritional characteristics, products with undesirable sensory aspects normally lose market to other similar foods. Therefore, sensory evaluation is important to determine the consumer preference, in order to provide support for research, manufacturing, marketing and quality control in new product development [15].

2. Brazilian soybean cultivars

Soybean is currently the most important source of edible oil and high-quality plant protein for feeding both human and animals worldwide [43, 20, 40]. Originated from mid latitude regions, these species are expanding in tropical areas as a result of the development of new genotypes tolerant to the environmental adversities of these localities [9, 40]. One of the largest soybean producers of the world is Brazil, a tropical country that comprises an extensive ecological region with wide variation in the environmental conditions. In Brazil, soybean was firstly grown in the South (in mid latitude areas) and more recently next to Equator line, in the Northeastern region, owing to the development of genotypes with high productivity, well adapted to photoperiod effect and resistant to local pathogens and pests [1, 40]. Presently, in these places, soybean cultivation has great economic and social importance [40]

Water is the main factor changing soybean productivity in time and space [32, 19]. Water use by soybeans varies with climatic conditions, management practices and the life cycle of the cultivar. This crop's response to photoperiod and temperature defines the areas to which it is adapted. Water use by soybean crop increases as the crop grows and is maximal during flowering and pod-fill [19].

Most soybean cultivars respond to photoperiod as quantitative short-day plants and are adapted in a narrow band of latitudes. The soybean has a juvenile stage after emergence when it is especially sensitive to temperature and insensitive to day length [23, 19]. Cultivars with the genetically controlled long juvenile trait have wider adaptability and can be utilized over a wider range of latitudes and planting dates than cultivars without these characteristics [19].

Soybean develops well under a wide range of temperatures, although regions in which the warmest mean monthly temperature is below 20ºC are considered inappropriate for soy-

http://dx.doi.org/10.5772/52602

bean [7, 19]. Brown (1960) affirmed that vegetative growth is slow or nil at temperature 10ºC or less and optimum at 30ºC, decreasing thereafter. Temperatures above 40ºC are known to have adverse effects on growth rate, flower initiation and pod-set [19].

Nearly all soybean cultivars exhibit one of two possible growth habits. Cultivars with determinate growth habit have rather distinct vegetative and reproductive development periods. In the other side, indeterminate cultivars have overlapping vegetative and reproductive growth periods.

In recent years, the early planting date and harvest of soybeans, this ensures a lower use of pesticides and makes possible the cultivation of winter maize, resulted in a growth of cultivars of indeterminate habit, principal in South of Brazil. Now, they are dominating the market. Therefore, all breeding programs in Brazil have been working with the introduction of the specific characteristics on indeterminate cultivars.

Embrapa Soybeans has a specific breeding program that develops cultivars with special characteristics for human consumption. However there is still no one cultivar of indeterminate growth habit, but will be released in the near future. It is noteworthy that all cultivars and genotypes that are part of the active Germplasm Bank that give rise to these are conventional. The main cultivars released to date by this program are:

Embrapa 48 – cultivar with more than 15 years on the market. It is knew to processing soymilk with superior flavor when compared with other cultivars. However, due the market need for early cultivars, the cycle has become very long. Regarding the productivity also produces about 20% less than the current more productive cultivars.

BRS 213 – cultivar triple-null for lipoxigenase enzyme, which is responsible for a taste of the "beany flavor" in the extract. This cultivar has light hilum, but almost no more seed on the market, due to some fitossanitary problems and productivity. The cycle is also too long for the demands of today's market.

BRS 216 – cultivar with very small seeds and high protein value but the productivity is at least 30% less compared with the current cultivars. Mainly because of this very small size, a higher loss in the harvest occurs. It is indicated to produced soybean sprouts, especially because the high protein value and the small seed size.

BRS 257 – cultivar triple-null for lipoxigenase enzyme, with similar productivity with current cultivars. The soymilk and soybean flour industries are very interested in this cultivar.

BRS 258 – cultivar originated from an old Embrapa Soybean cultivar called BR 36. It also has a long cycle for the current market requirements and a lower productivity, however the soymilk and flour of this cultivar is well accepted.

BRS 267 – cultivar with very large seeds, sweet flavor and ideal for prepare soymilk and tofu. Also ideal to be consumed as a vegetable soybeans. However the cycle is long and the productivity at least 20% lower when compared with the current cultivars.

BRS 282 – cultivar originated from Embrapa 48 and was launched three years ago. This cultivar does have a cycle consistent with what the market wants today, but studies of the special characteristics of this cultivar are still scarce. The productivity is similar with current cultivars. The soymilk has excellent acceptance and is a cultivar that should be encouraged to be cultivated.

Among the cultivars released by Embrapa, there is a cultivar that did not originate in the program of special cultivars for human consumption but is suitable for this purpose, the BRS 232 cultivar. It has a size large seed and light hilum, ideal characteristics for this purpose. It is always recommended for human consumption when there isn´t a special cultivar. This cultivar has well accepted soymilk and flour when compared with current cultivars.

3. Characterization of eight brazilian soybean cultivars for human use

3.1. Chemical composition

The grains of cultivars EMBRAPA 48, BRS 213, BRS 216, BRS 232, BRS 257, BRS 258, BRS 267 and BRS 282, planted in various locations in the state of Paraná, Brazil, during the 2009/10 crop were characterized, and the average results of the composition are shown in Table 1.

The calculated values were similar to those reported by other authors [6, 31]. The highest protein content was found for BRS 258 (44.37%), and differed significantly (p> 0.05) from other grains.[36] have analyzed the same variety, in organic cultivation, and reported lower levels (42.84%). [16] also reported lower contents, with values of 41.70%.

Cultivar	Moisture	Protein	Lipids	Ash	Carbohydrate
Embrapa 48	6.14 ± 0.95^{a}	40.11 ± 0.58^{bc}	22.45 ± 1.31^{a}	4.97 ± 0.10^{de}	32.47
BRS 213	5.35 ± 0.19^{a}	39.50 ± 0.26^{c}	21.86 ± 0.65^{ab}	4.90 ± 0.30^{e}	33.74
BRS 216	5.61 ± 0.23^{a}	41.08 ± 0.54^{bc}	19.19 ± 1.32^{cd}	4.45 ± 0.15^{e}	35.28
BRS 232	5.69 ± 0.07^{a}	40.99 ± 0.51^{bc}	20.72 ± 0.71^{abcd}	5.47 ± 0.16^{cd}	32.82
BRS 257	5.67 ± 1.11^{a}	41.66 ± 1.38^{b}	21.17 ± 0.70^{abc}	6.60 ± 0.12^{a}	30.57
BRS 258	6.63 ± 0.18^{a}	44.37 ± 0.06^{a}	18.76 ± 0.62^{d}	5.86 ± 0.21^{bc}	31.01
BRS 267	6.02 ± 0.16^{a}	39.41 ± 1.08^{c}	20.03 ± 0.39^{bcd}	6.45 ± 0.30^{a}	34.11
BRS 282	6.16 ± 0.38^{a}	39.96 ± 0.27^{bc}	20.70 ± 0.90^{abcd}	6.35 ± 0.13^{ab}	32.99

Table 1. Centesimal composition of eight soybeans cultivars ($g.100g^{-1}$). Means followed by same letters in columns do not differ by Tukey test ($p \leq 0.05$). Means from three replicates on a dry basis. * Calculated by difference.

As reported by [11], the soybean features a unique high quality protein source. In general, the industry focus is the production of soybean meal and soybean oil. Therefore, the cultivar BRS 258, due to higher protein content, can be an interesting alternative to the industry, which seeks yield and for high protein content in soybean meal.

According with Embrapa Soja results, the average levels of protein from cultivars Embrapa 48, BRS 213, BRS 232, BRS 257, BRS 267 and BRS 282 are very similar to those found in this study [16]. An exception was found for BRS 216, which presented values of 41.08%, lower than those reported in the literature (43.06%) [17]. [25] has determined the composition of different soybeans cultivars, and found a mean value of 38% in protein. [12] reports values between 33% and 42%. In the present study, the cultivar which surpassed this variation was BRS 258. BRS 216, BRS 232, BRS 257, BRS 258 and BRS 267 were analyzed by [6], and the protein content varied between 38.47% and 39.61%.

Regarding lipids, Embrapa 48 had the highest content (22.45%), but did not differ significantly from BRS 213, BRS 232, BRS 257 and BRS 282. BRS 258 presented the lowest lipid content (18.76%) and did not differ significantly ($p \leq 0.05$) from BRS 216, BRS 232, BRS 267 and BRS 282.

In general, literature reports levels between 13 and 25% for lipids in soybean [6]. According to [10], the oil content in soybeans (20%) provides enough calories, so the consumed protein is metabolized for the synthesis of new tissues, and not converted into energy, as commonly seen in diets with low caloric content. However, since industry has as main objective the production of soy oil, cultivars Embrapa 48, BRS 213, BRS 232, BRS 257 and BRS 282 are the best choice for this market.

Some authors report an inverse relation between lipids and protein in soybean [29, 41]. This relation is confirmed by the results for BRS 258, with higher protein, and consequently, lower lipids contents. The average results found in this study were lower compared to lipids and higher for the protein, when compared to that reported in the literature [16, 36].

According to [3], increasing of the planting site temperatures directly affects the oil content in the grains, increasing it. Woodrow and [31] studies about the harvest in 1999, a hot and dry year, showed smaller grains with a reduction in protein concentration, when compared to the previous crop grains (1998). However, there was an increase in lipid content of the grains. For the protein content, the temperature directly influences the composition of amino acids. At higher temperatures, the proteins are rich in methionine, desirable for human consumption.

The higher ash content was the BRS 257 (6.60%), but this did not differ significantly from cultivars BRS 267 and BRS 282. The lowest content was the BRS 216 (4.45%), with no significant differences from the levels of BRS 213 and Embrapa 48. The mineral composition of soybean has quantities that normally exceed the recommended daily dose, when consumed 100 grams of grain, with calcium as the less useful in the consuming of the whole grain [10, 37]. The highest content for total carbohydrates was found in BRS 216 (35.28%), and the lowest in grains of BRS 257 (30.57%).

It is noteworthy that the variations in results between the cultivars, and comparison with literature data using the same varieties, are normal, since the planting site, year and climatic conditions affect these values [29, 33, 31, 36].

3.2. Trypsin inhibitor of soybean grains

Trypsin inhibitor is normally present in the soybean fresh grains, and considered an antinutritional factor. The average values found in literature goes up to 18 milligrams of inhibitor per gram of soybean (HAFEZ, 1983 apud [2]). In this work, however, the average value for BRS 232 (13.82) was lower than usually reported in the literature, and did not differ statistically from BRS 216 (Table 2).

Cultivar	Trypsin Inhibitor(mg TI/g)
Embrapa 48	20.28 ± 0.35[a]
BRS 213	22.97 ± 2.42[a]
BRS 216	18.12 ± 1.63[ab]
BRS 232	13.82 ± 0.73[b]
BRS 257	21.02 ± 2.18[a]
BRS 258	19.61 ± 0.90[a]
BRS 267	23.18 ± 1.64[a]
BRS 282	22.76 ± 1.92[a]

Table 2. Trypsin inhibitor in soybean grains for eight different cultivars. Means followed by same letters in columns do not differ by Tukey test ($p \leq 0.05$). Means from three replicates.

Although the soybean provides high quality protein, these biochemical agents (protease inhibitors) cause a limitation in the biological utilization of the amino acids present in the grains, and may reduce protein digestibility [28, 21], by the blockade of some proteases, including human digestive enzymes. Trypsin is an enzyme secreted by the pancreas, responsible for digestion of proteins by peptide bonds break, and the presence of trypsin inhibitor causes metabolic changes in the pancreas, since the inhibitor binds with the trypsin and inhibits the digestion of proteins. With the protein concentration increasing, the pancreas is stimulated to produce more trypsin, causing pancreatic hypertrophy. Most of these proteases inhibitors are inactivated or inhibited when suitable thermal treatments are applied [11, 21, 30, 35].

3.3. Soybean Isoflavones

The Isoflavones, present in soybean with greater concentration than in the other legumes, belong to the class of phytoestrogens, and have the capacity to assist in the effects of menopause. Besides, the isoflavones are known as having anticancer properties, and antioxidant action that neutralizes free radicals, contributing to reduce LDL (bad cholesterol). The main isoflavones determined in soybean are genistein, daidzein and glycitein, which can be found in the form of aglycones (unconjugated) and glycosylated (conjugated) [4, 18].

http://dx.doi.org/10.5772/52602

In the present study, there was a large variation in the total isoflavones content for the studied cultivars, (Tables 3 and 4), with the highest levels in the BRS 213 (386.60 mg.100g-1) and BRS 282 (364.56 mg.100 g-1) and the lowest in BRS 258 (54.06 mg.100g-1).

The soybean grain naturally presents the isoflavones in the aglycone and glycoside form. The aglycones are absorbed directly, since they are not linked to a sugar, while the other conjugated forms require a hydrolysis for their absorption [27, 18].

The isoflavones profiles for the studied cultivars were very similar, with higher levels of the M-genistein form. However, daidzein, genistein and glycitein forms have been receiving most of attention from researchers. According to [42], genistein has the potential effect of inhibiting the growth of cancer cells at physiological concentrations, and daidzein has effect only if combined with genistein. In the present study, BRS 213 presented the highest level of genistein. Only BRS 267 and BRS 282 showed levels of glycitein, while, BRS 232 showed no levels for the isoflavones highlighted.

The acetyl form was not found in any samples, proving that the soybean did not suffer thermical treatment. According to [2], and [26], in the heat treated products the malonyl form is unstable and may be transformed into the acetyl form. [28] also points out that the processing parameters, the varieties and planting condition affect the composition and / or the isoflavones profile in soy products.

Isoflavones	EMBRAPA 48	BRS 213	BRS 216	BRS 232
G-Daidzin	34.03 ± 1.44	78.26 ± 8.82	75.64 ± 3.38	13.06 ± 0.76
G-Glycitin	8.19 ± 1.05	11.35 ± 1.61	16.84 ± 1.17	4.65 ± 0.53
G-Genistin	22.94 ± 0.59	63.71 ± 5.28	50.03 ± 1.76	10.14 ± 0.20
M-Daidzin	88.91 ± 4.83	75.12 ± 7.81	73.08 ± 3.02	33.84 ± 1.42
M-Glycitin	21.69 ± 3.35	13.94 ± 1.33	20.74 ± 1.63	12.43 ± 1.20
M-Genistin	107.45 ± 2.70	111.46 ± 9.00	89.11 ± 3.34	48.89 ± 0.97
A-Daidzin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
A-Glycitin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
A-Genistin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Daidzein	2.47 ± 0.21	19.03 ± 0.81	5.79 ± 0.43	0.00 ± 0.00
Glycitein	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Genistein	1.87 ± 0.03	13.71 ± 0.65	3.63 ± 0.15	0.00 ± 0.00
TOTAL	**287.57 ± 14.04**	**386.60 ± 33.66**	**334.86 ± 12.80**	**123.01 ± 2.74**

Table 3. Isoflavones profile in soybean grains from the cultivars EMBRAPA 48, BRS 213, BRS 216 and BRS 232 (mg. 100g-1).

Isoflavones	BRS 257	BRS 258	BRS 267	BRS 282
G-Daidzin	39.34 ± 1.19	7.23 ± 0.32	29.82 ± 5.89	29.53 ± 2.96
G-Glycitin	10.38 ± 0.44	2.70 ± 0.32	10.55 ± 3.70	17.19 ± 1.62
G-Genistin	33.98 ± 0.94	4.09 ± 0.01	23.61 ± 1.47	35.43 ± 2.12
M-Daidzin	88.89 ± 2.35	18.31 ± 0.42	25.94 ± 6.95	69.78 ± 4.59
M-Glycitin	24.47 ± 1.41	5.97 ± 0.51	11.13 ± 4.66	31.91 ± 2.68
M-Genistin	134.59 ± 3.96	15.04 ± 0.35	35.82 ± 2.10	150.94 ± 4.97
A-Daidzin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
A-Glycitin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
A-Genistin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Daidzein	2.05 ± 0.25	0.43 ± 0.12	4.77 ± 0.68	8.89 ± 2.08
Glycitein	0.00 ± 0.00	0.00 ± 0.00	3.08 ± 0.66	10.96 ± 2.30
Genistein	2.59 ± 0.09	0.30 ± 0.09	4.02 ± 0.13	9.93 ± 2.57
TOTAL	**329.29 ± 6.24**	**54.06 ± 1.05**	**148.74 ± 25.69**	**364.56 ± 12.87**

Table 4. Isoflavones profile in soybean grains from the cultivars BRS 257, BRS 258, BRS 267 and BRS 282 ($mg.100g^{-1}$).

4. Soymilk production

The soymilk was produced at a 1:6 ratio [soybean (g): water volume (mL)], with the eight characterized cultivars (Embrapa 48, BRS 213, BRS 216, BRS 232, BRS 257, BRS 258, BRS 267 and BRS 282). Initially, the beans were submitted to soaking for five minutes at 95°C in 1:3 ratio with boiling water, and then water was discarded. After this, the soybean was submitted to heat treatment at 95°C for ten minutes, at the proportion of 1:6 with water, and seeds were ground for three minutes. The soymilk was separated from the wet okara by filtration, in which it was applied a heat treatment for two minutes under boiling.

4.1. Efficiency of the soymilk process

The yield is an important processing variable for the food industry, and should be calculated by the ratio between the mass of raw materials and final volume of extract. Thus, from the volume of processed grain, the greater the volume obtained, the better the utilization of production. According to [17], from 500 grams of grain and 4.5 liters of water, 1.5 liters of soymilk are produced. Following the same method, the extraction was performed with 250g of grains and 2.25 liters of water, splitted in 750 mL for maceration (which was discarded) and 1500 mL for grinding. The extraction yields are calculated on the weight of macerated grains, which absorbs water during this process, and the water used in grinding (Table 5).

Cultivar	Weight after soaking (g)	Soymilk(mL)	Yield (%)
Embrapa 48	385	800	42.44
BRS 213	370	820	43.85
BRS 216	390	670	35.44
BRS 232	405	720	37.79
BRS 257	365	820	43.96
BRS 258	385	760	40.32
BRS 267	390	605	32.01
BRS 282	405	840	44.09

Table 5. Yield of the process for soymilk of eight different soybean cultivars.

In this study, it was found that the different soybean cultivars resulted in different yield for the soymilk. The cultivar that showed the best results was BRS 282 (44.09%), higher than that reported by [17]. BRS 213 and BRS 257 showed very similar yields, 43.85% and 43.96% respectively. And BRS 232 (37.79%), BRS 216 (35.44%) and BRS 267 (32.01%) had the lowest yields.

4.2. Soymilk characterization

4.2.1. Freeze-dried

In accordance with the results of fresh grains, the freeze-dried soymilk with the highest protein content was the BRS 258 (42.25%) (Table 6). The lowest level was the extract of BRS 267 (35.34%), but did not differ significantly from extracts of BRS 282 and BRS 213.

Cultivar	Moisture	Protein	Lipids	Ash	Carbohydrates*
Embrapa 48	3.52 ± 0.08^{d}	36.25 ± 0.40^{d}	18.34 ± 0.14^{a}	8.37 ± 0.33^{c}	33.52
BRS 213	7.78 ± 0.16^{a}	36.02 ± 0.10^{de}	18.13 ± 0.22^{a}	9.08 ± 0.24^{b}	28.99
BRS 216	7.95 ± 0.26^{a}	33.48 ± 0.54^{f}	16.95 ± 0.89^{abc}	9.19 ± 0.27^{b}	32.43
BRS 232	7.49 ± 0.40^{a}	38.60 ± 0.39^{c}	14.99 ± 0.89^{cd}	8.69 ± 0.15^{bc}	30.23
BRS 257	7.88 ± 0.09^{a}	40.44 ± 0.12^{b}	17.73 ± 0.25^{ab}	8.52 ± 0.02^{bc}	25.43
BRS 258	4.74 ± 0.02^{c}	42.45 ± 0.23^{a}	13.57 ± 0.24^{de}	8.52 ± 0.30^{bc}	30.72
BRS 267	5.31 ± 0.27^{bc}	35.34 ± 0.22^{e}	12.24 ± 0.48^{e}	9.91 ± 0.30^{bc}	37.20
BRS 282	5.91 ± 0.16^{b}	35.63 ± 0.19^{de}	15.52 ± 1.20^{bcd}	10.07 ± 0.20^{a}	32.87

Table 6. Composition of freeze-dried soymilk from eight different soybeans cultivars ($g.100g^{-1}$). Means followed by same letters in columns do not differ by Tukey test ($p \leq 0.05$). Means from three replicates on a dry basis. * Calculated by difference.

The higher lipid content was found in the soymilk of Embrapa 48 (18.35%), and did not differ significantly from extracts of BRS 213, BRS 216 and BRS 257. The lowest level was the soymilk of BRS 267 (12.24%), which did not differ from the extract of BRS 258. The soymilk of BRS 267 showed the highest content of carbohydrate, 37.20%.

4.2.2. In natura (Liquid)

The results for chemical composition of the fresh soymilk were determined indirectly, through the results of total solids (Tables 7 and 8).

Cultivar	Moisture	Solids
Embrapa 48	92.16 ± 0.06^{cd}	7.84 ± 0.06^{cd}
BRS 213	92.35 ± 0.06^{c}	7.65 ± 0.06^{d}
BRS 216	92.97 ± 0.06^{b}	7.03 ± 0.06^{e}
BRS 232	89.00 ± 0.06^{f}	11.00 ± 0.06^{a}
BRS 257	91.85 ± 0.06^{de}	8.15 ± 0.06^{bc}
BRS 258	93.71 ± 0.06^{a}	6.29 ± 0.06^{f}
BRS 267	93.68 ± 0.06^{a}	6.32 ± 0.06^{f}
BRS 282	91.67 ± 0.06^{f}	8.33 ± 0.06^{b}

Table 7. Moisture and solids of the soymilk from eight different soybean cultivars (%). Means followed by same letters in columns do not differ by Tukey test ($p \leq 0.05$). Means from three replicates.

Cultivar	Protein	Lipids	Ash	Carbohydrates*
Embrapa 48	5.49 ± 0.06^{c}	2.78 ± 0.02^{ab}	1.27 ± 0.05^{cde}	6.14
BRS 213	5.08 ± 0.01^{d}	2.56 ± 0.21^{b}	1.28 ± 0.03^{c}	6.38
BRS 216	4.33 ± 0.07^{e}	2.19 ± 0.12^{c}	1.19 ± 0.04^{de}	6.35
BRS 232	7.86 ± 0.08^{a}	3.05 ± 0.18^{a}	1.77 ± 0.03^{a}	9.32
BRS 257	6.07 ± 0.02^{b}	2.66 ± 0.04^{b}	1.28 ± 0.00^{cd}	6.29
BRS 258	5.09 ± 0.03^{d}	1.63 ± 0.03^{d}	1.02 ± 0.04^{f}	4.84
BRS 267	4.23 ± 0.03^{e}	1.46 ± 0.06^{d}	1.19 ± 0.04^{e}	5.76
BRS 282	5.59 ± 0.03^{c}	2.43 ± 0.19^{bc}	1.58 ± 0.03^{b}	7.06

Table 8. Centesimal composition of soymilk from eight different soybeans cultivars ($g.200mL^{-1}$). Means followed by same letters in columns do not differ by Tukey test ($p \leq 0.05$). Means from three replicates, wet basis. * Calculated by difference.

A simple comparison between the composition of soybeans and their respective soymilk allows observing that the solubilization rate of compounds in aqueous solutions is critical to the final results. The extract of BRS 232 showed the highest levels of soluble compounds (11.01%) obtained during the processing, being superior to others in protein levels (7.86 $g.200mL^{-1}$). BRS 267 has presented high protein content in the grains (39.41%), but after processing the content was reduced and the soymilk showed the lowest level (4.23 $g.200mL^{-1}$), when compared to the other extracts. This reduction indicates that the cultivar has a low content of soluble proteins.

4.2.3. Trypsin Inhibitor and Isoflavones in the soymilk

The results for soymilk confirmed that the heat treatment for 15 minutes at 100°C, performed during the processing, was enough for complete inactivation of the inhibitor, with final values equal to zero. According to [35] and [28] when foods are submitted to appropriate heat treatment, the inhibitor is inactivated.

Regarding to the isoflavones in the freeze-dried soymilk, all cultivars were significantly different, and the extract of BRS 213 had the highest average (421.61 mg.100g-^{1}). The lowest level was found in the extract of BRS 258. For the liquid soymilk, the liquor obtained from BRS 213 maintained the highest isoflavones content (64.50 mg.200mL-^{1}). However, for the equivalent amount to one cup of drink, this did not differ from cultivar BRS 257 (62.01 mg.200mL-^{1}). There was no significant difference between the BRS 216 (53.02 mg.200mL-^{1}) and BRS 282 (53.65 mg.200mL-^{1}) (Table 9).

Cultivar	Freeze-dried soymilk (mg.100g^{-1})	Liquid soymilk (mg.200mL^{-1})*
Embrapa 48	370.65 ± 0.88^{b}	58.12 ± 0.91^{b}
BRS 213	421.61 ± 2.55^{a}	64.50 ± 1.31^{a}
BRS 216	377.18 ± 3.57^{b}	53.02 ± 0.50^{c}
BRS 232	143.45 ± 3.70^{e}	31.55 ± 0.81^{e}
BRS 257	380.44 ± 3.51^{b}	62.01 ± 1.25^{a}
BRS 258	79.59 ± 0.55^{f}	10.01 ± 0.07^{f}
BRS 267	279.91 ± 8.61^{d}	39.58 ± 2.20^{d}
BRS 282	322.03 ± 4.41^{c}	53.65 ± 0.74^{c}

Table 9. Total isoflavones content of the soymilk produced from eight different cultivars. Means followed by same letters in columns do not differ by Tukey test ($p \leq 0.05$). Means values from three replicates. * Equivalent to a glass of drink.

The isoflavones concentration reported in the literature, for soy beverages with original or chocolate flavor, varies between 4 and 13 mg.200mL-^{1} [8]. [13] reported 12.2 mg.200mL-^{1}, and [22] found a content of 16.6 mg in 200mL. The isoflavones content and profile are also affected by the processing, environment, and the soybean varieties [8]. In the present study, the soymilk prepared with cultivars Embrapa 48, BRS 213, BRS 216, BRS 257 and BRS 282 showed values over 50 mg.200mL-^{1}, which surpass the literature values in more than three times.

The isoflavones profile of soymilk was also determined (Tables 10 and 11), in order to verify alterations after the processing. However, it was observed that the pasteurization did not cause the appearance of acetyl form, as observed by [2] and [26]. According to them, malonyl form in products that suffered heat treatment is unstable, and can be converted in the acetyl form.

M-genistein maintained its high concentration, and after processing the glycitein form was found in all cultivars. The appearance of glycitein after soybean processing has already been reported by [24] who noted the absence of this form in raw soybean, with subsequent detection in soy-based beverage.

Isoflavones	EMBRAPA 48	BRS 213	BRS 216	BRS 232
G-Daidzin	47.16 ± 2.61	89.45 ± 1.72	86.38 ± 1.26	15.28 ± 0.41
G-Glycitin	10.99 ± 0.86	12.22 ± 1.13	19.56 ± 0.68	5.63 ± 0.16
G-Genistin	29.47 ± 0.70	63.73 ± 1.43	49.32 ± 1.11	11.99 ± 0.31
M-Daidzin	116.17 ± 0.52	91.39 ± 2.87	90.35 ± 1.47	38.12 ± 0.89
M-Glycitin	27.55 ± 0.47	16.62 ± 0.63	26.11 ± 0.65	13.50 ± 0.45
M-Genistin	127.95 ± 2.14	121.76 ± 2.62	94.01 ± 1.43	50.38 ± 0.81
A-Daidzin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
A-Glycitin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
A-Genistin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Daidzein	1.98 ± 0.09	9.78 ± 0.26	3.02 ± 0.26	1.13 ± 0.50
Glycitein	8.27 ± 0.89	9.77 ± 1.04	6.35 ± 0.96	7.07 ± 1.94
Genistein	1.12 ± 0.07	6.89 ± 0.13	2.03 ± 0.10	0.37 ± 0.07
TOTAL	**370.65 ± 5.77**	**421.61 ± 8.59**	**377.14 ± 3.57**	**143.45 ± 3.69**

Table 10. Isoflavones profile in the freeze-dried soymilk obtained from soybean cultivars EMBRAPA 48, BRS 213, BRS 216 and BRS 232 (mg.100g-^{1}).

Isoflavones	BRS 257	BRS 258	BRS 267	BRS 282
G-Daidzin	43.46 ± 0.41	8.33 ± 0.63	37.88 ± 1.27	38.99 ± 1.11
G-Glycitin	12.84 ± 0.84	3.35 ± 0.19	16.40 ± 0.95	18.30 ± 0.41
G-Genistin	36.41 ± 1.06	6.15 ± 0.47	32.63 ± 1.92	35.74 ± 1.01
M-Daidzin	100.23 ± 1.75	23.84 ± 0.23	60.07 ± 3.94	70.42 ± 0.89
M-Glycitin	29.21 ± 1.35	9.02 ± 0.38	25.78 ± 1.77	30.11 ± 0.58
M-Genistin	144.84 ± 6.87	18.43 ± 0.20	95.25 ± 7.09	116.37 ± 1.75
A-Daidzin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
A-Glycitin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
A-Genistin	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Daidzein	1.62 ± 0.53	0.44 ± 0.17	1.75 ± 0.03	1.66 ± 0.05
Glycitein	9.42 ± 1.63	9.63 ± 0.31	7.92 ± 0.56	8.69 ± 0.21
Genistein	1.76 ± 0.04	0.40 ± 0.12	1.84 ± 0.06	1.76 ± 0.09
TOTAL	**380.44 ± 7.64**	**79.59 ± 0.54**	**279.91 ± 17.44**	**322.03 ± 4.41**

Table 11. Isoflavones profile in the freeze-dried soymilk obtained from soybean cultivars BRS 257, BRS 258, BRS 267 and BRS 282 (mg.100g-^{1}).

http://dx.doi.org/10.5772/52602

4.2.4. Sensory analysis of soymilk

Sensory analysis was performed in order to differentiate the studied cultivars, and to discuss the best features of each one in the food industry. The panel consisted of 59 judges, comprising 40% women and 60% men, aged between 16 and 54 years, and with good educational level (82.24%), ranging from Superior Incomplete (32.25%), Superior (20.96%) and Postgraduate (29.03%).

When asked about their consumption habits of soybeans "milk", 55% of the judges affirmed to consume the commercial soymilk regularly. Of these, 68% consumed with the addition of flavor, 11% consumed the original extract, and 21% affirmed to consume both (Figure 1).

Judges evaluated the samples, applying scores from 1 (dislike very much) to 10 (like very much), with 5 as an intermediary, in the scale. The mean scores given varied between 4.14 and 6.75, close to "did not like, nor dislike."

Averages were very close between the attributes and cultivars, and this turned into one of the difficulties of implementing the analysis. Judges accustomed to the consumption of commercial extract may have been hindered due to their lack of consumption habit of original extract, with no sugar added (Table 12).

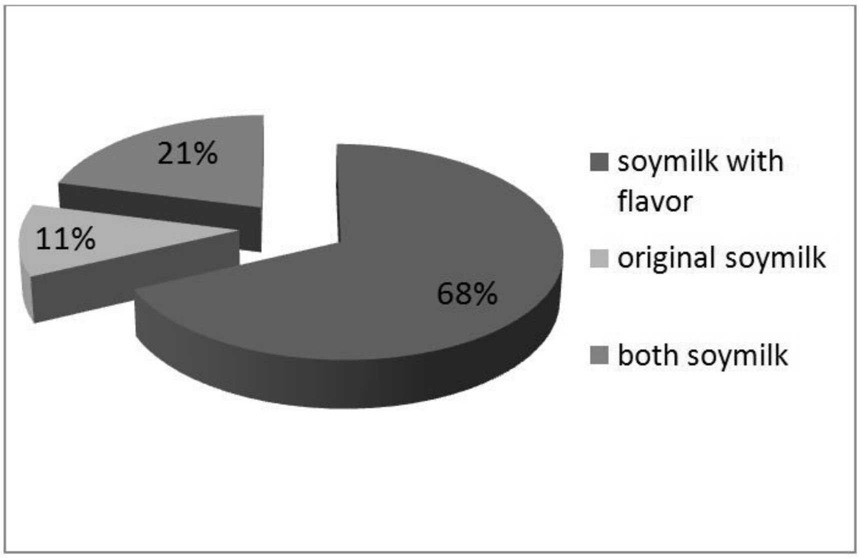

Figure 1. Type of soymilk normally consumed by the judges.

The evaluated attributes showed significant differences ($p \leq 0.05$) only for the flavor and aftertaste, with the extract of BRS 232 receiving the highest average in flavor. The highest average for aftertaste was found in BRS 213, considered the preferred for this attribute. The differences in the averages are directly linked to the composition of the grains and their extracts, and it is important to notice the relationship between the presence of lipoxygenase and the aftertaste of the extract. The soybean grain from BRS 213 has none of the lipoxygenases, which certainly contributed to achieving the highest score in the aftertaste attribute.

Cultivar	Taste	Flavor	Aftertaste	Overall appearance
Embrapa 48	4.27 ± 2.52^{a}	5.16 ± 2.50^{b}	4.14 ± 2.28^{b}	4.75 ± 2.39^{a}
BRS 213	5.24 ± 2.44^{a}	6.44 ± 2.05^{a}	5.61 ± 2.08^{a}	5.76 ± 2.11^{a}
BRS 216	4.31 ± 2.36^{a}	5.75 ± 2.00^{ab}	4.71 ± 2.32^{ab}	5.12 ± 2.22^{a}
BRS 232	5.12 ± 2.84^{a}	6.50 ± 2.33^{a}	4.73 ± 2.78^{ab}	5.82 ± 2.65^{a}
BRS 257	5.26 ± 2.26^{a}	6.05 ± 2.18^{ab}	5.14 ± 2.27^{ab}	5.90 ± 2.11^{a}
BRS 258	5.17 ± 2.35^{a}	5.87 ± 2.04^{ab}	5.37 ± 2.37^{ab}	5.78 ± 2.26^{a}
BRS 267	4.74 ± 2.23^{a}	5.80 ± 2.17^{ab}	4.84 ± 2.11^{ab}	5.34 ± 2.16^{a}
BRS 282	4.97 ± 2.53^{a}	5.98 ± 2.17^{ab}	4.98 ± 2.51^{ab}	5.51 ± 2.63^{a}

Table 12. Points attributed to soymilk of eight different soybean cultivars. Means followed by same letters in columns do not differ by Tukey test ($p \leq 0.05$).

The lipoxygenase enzymes (L1, L2 and L3) can be considered the primarily responsible for the undesirable taste of soybean in Brazil. The beany flavor is result of the three isoenzymes present in the grain, which catalyze the lipids oxidation. The enzyme action only begins with the breakdown and hydration of the grain, since the reaction substrate does not remain exposed in the intact grain. N-hexanal is the volatile compound produced in greater quantity, responsible for the characteristic flavor and taste [11, 29].

Although there was no significant difference between samples for the overall appearance and taste, the extract of BRS 257 deserves special attention for the highest average in both attributes. In other hand, the extract obtained from Embrapa 48 had the lowest average scores for all attributes (flavor, taste, aftertaste and overall appearance). It is interesting to note the need to produce an extract with sensory characteristics similar to the usual habits of consumption, such as the addition of flavor and aroma, allowing a better sensory evaluation.

5. Soybean products application in the food industry

Knowing the consumers profile is critical to the food industry. During the research and development of a new product, the industry focuses on knowing the market and its potential consumers, and many industries apply the sensory analysis as a tool to start or even innovate their activities. The changing of habits related to consumption of soy products has been essential for the growth of the sector [34].

[5] conducted a survey on consumer attitudes in relation to soybeans and their derivatives. They interviewed 100 individuals, 50 men and 50 women, aged 18-40 years, and mostly between 18 and 25, featuring a younger audience. When asked about soy products, tofu and "milk" were the most remembered products, and 40% of the interviewed reported never having consumed these products. A very small portion (8%) reported the consumption of soybean "milk" at least once a week. The soymilk consumption has gradually increased over

http://dx.doi.org/10.5772/52602

the years, by the addition of flavors capable to create a product of good flavor, which little resembles with soybean flavor.

The link between chemical composition and sensory analysis must be directly connected to yield, for the studied cultivar to become an industrial alternative. The extracts from eight soybean cultivars differed significantly in their chemical composition, and the highest protein content was found in BRS 232 (7.86 g.200mL^{-1}). In the sensorial analysis, the samples differed only in aroma and aftertaste, with the extract from BRS 232 achieving satisfactory mean. In the aroma attribute, this same cultivar had the highest average, 6.50.

The highest yield was found in BRS 282 (44.90%), followed by the cultivars Embrapa 48 (42.44%), BRS 213 (43.85%), BRS 257 (43.96%) and BRS 258 (40.32%). These values allow the use of all the studied cultivars, even those with lower yields, when considering the results of chemical composition and sensory analysis. An example is BRS 232, which showed higher levels for all compounds, but had a yield of 37.79%.

6. Final considerations

The soybean cultivars currently available in Brazil have different characteristics of productivity, production cycle, grain size, climate adaptation, lipoxygenase activity, and others. However, the Brazilian consumption of soybean as a food is still small, due to its exotic flavor to the palate, since it is an Asian grain and its development was based on the habits and customs of the orientals. These exotic flavors can be assigned to the presence of lipoxygenase enzymes, saponins and phenolic compounds, responsible for rancid or beany flavors, bitter and astringent, respectively.

A lot of products can be obtained from the soybean. However, the Brazilian food industry had to adapt them to the consumers habits, like the soymilk applied in soy beverages, which for a better acceptance is developed and commercialized with the addition of flavors or fruit juice. This is the most popular and consumed soy derivative in Brazil.

Fortunately, with more information published about the benefits of soybean consumption, its nutritional value and functional properties, this scenario is changing. After recognizing the great importance of this legume, several studies on the development of cultivars with better acceptability started, with the goal to insert soybean as an essential part of the human food. To achieve this, however, in addition to the cultivar adaptation, it is also necessary to check if this cultivar is interesting for industrialization.

The yield is a very important variable in the food industry, but cannot be considered an exclusion factor, since other important variables, such as composition, functional characteristics (isoflavones) and antinutritional compounds (trypsin inhibitor) should be observed for the choice of a soybean cultivar. Therefore, the use of cultivars specially developed for soybean based products, directed to human consumption, may contribute to improve the sensory quality and increase the soybean acceptability as a food.

Author details

Neusa Fátima Seibel[1*], Fernanda Périco Alves[2], Marcelo Álvares de Oliveira[3] and Rodrigo Santos Leite[4]

*Address all correspondence to: neusaseibel@utfpr.edu.br

1 Mestrado Profissional em Tecnologia de Alimentos. Universidade Tecnológica Federal do Paraná (UTFPR). Londrina/PR, Brasil

2 Tecnóloga em Alimentos (UTFPR). Londrina/PR, Brasil

3 Embrapa Soja. Londrina/PR, Brasil

4 Mestrando em Tecnologia de Alimentos (UTFPR). Embrapa Soja. Londrina/PR, Brasil

References

[1] Almeida, L. A., Kiihl, R. A. S., Miranda, M. A. C., & Campelo, G. J. A. (1999). Melhoramento da soja para regiões de baixas latitudes. In: Recursos genéticos e melhoramento de plantas para o nordeste brasileiro Available in http://www.cpatsa.embrapa.br/catalogo/livrorg/temas.html , 15.

[2] Anderson, R. L., & Wolf, W. J. (1995). Compositional Changes in Trypsin Inhibitors, Phytic Acid, Saponins and Isoftavones Related to Soybean Processing. *The Journal of Nutrition*, 125, 581S-588S.

[3] Barros, H. B., & Sediyama, T. (2009). Luz, umidade e temperatura. *In: SEDIYAMA, T. Tecnologias de produção e usos da soja. Londrina: Mecenas*, 17-27.

[4] Bedani, R., & Rossi, E. A. (2005, jul.-dez.) Isoflavonas; Bioquímica, fisiologia e implicações para a saúde. *Boletim CEPPA. Curitiba*, 23(2), 231-264.

[5] Behrens, BJ. H., & Silva, M. A. A. P. (2004, jul.-set..) Atitude do consumidor em relação à soja e produtos derivados. *Ciênc. Tecnol. Aliment., Campinas*, 24(3), 431-439.

[6] Benassi, V. T., Benassi, M. T., & Prudêncio, S. H. (2011). Cultivares brasileiras de soja: características para a produção de tofu e aceitação pelo mercado consumidor. *Semina: Ciências Agrárias, Londrina*, 32(1), 1901-1914.

[7] Berlato, M. A. (1981). Bioclimatologia da soja. *In: Miyasaka, S.; MEDINA, J.C. A soja no Brasil, Institute of Food Technology (ITAL), Campinas*, 175-184.

[8] Callou, K. L. A. (2009). Teor de isoflavonas e capacidade antioxidante de bebidas à base de soja. *124 f. Dissertação (Mestrado- Ciência dos Alimentos)- Faculdade de Ciências Farmacêuticas, Universidade de São Paulo, São Paulo.*

[9] Campelo, G. J. A., Kiihl, R. A. S., & Almeida, L. A. (1999). Características agronômicas e morfológicas das cultivares de soja desenvolvidas para as regiões de baixas latitudes. In: Recursos genéticos e melhoramento de plantas para o nordeste brasileiro. Available in http://www.cpatsa.embrapa.br/catalogo/livrorg/temas.html , 15.

[10] Carrão-Panizzi, M.C., & Mandarino, J.M.G. (1998). Soja: potencial de uso na dieta brasileira. *In: EMBRAPA SOJA. Documento 113. Londrina: Embrapa Soja.*

[11] Carrão-Panizzi, M.C., Mandarino, J.M.G., Bordingnon, J. R., & Kikuchi, A. (2000). Alternativa alimentar na dieta humana. *In: A cultura da soja no Brasil. Londrina: Embrapa Soja,. CD-ROM.*

[12] Cecchi, H.M. (2003). Fundamentos teóricos e práticos em análise de alimentos. 2 ed.. , 122-133.

[13] Chan, S., Ho, S. C., Kreiger, N., Darlington, G., So, K. F., & Chong, P. Y. Y. (2007). Dietary sources and determinants of soy isoflavone intake among midlife chinese women in Hong Kong. *Journal of Nutrition.*, 137, 2451-2455.

[14] Chang, Y. K. (2001). Alimentos Funcionais e AplicaçãoTecnológica: Padaria de Saúde e Centro de Pesquisas em Tecnologia de Extrusão. *In: EMBRAPA Soja. (Org.). Anais do I Simpósio Brasileiro sobre os benefícios da soja para a Saúde Humana. Londrina: Embrapa da soja*, 41-45.

[15] Dutcosky, S. D. (2007). Análise Sensorial de alimentos. *2 ed., Curitiba: Champagnat*.

[16] Embrapa soja. (2010). Cultivares de soja 2010/2011 região centro-sul. *Londrina: Embrapa Soja: Fundação Meridional*, 60.

[17] Embrapa soja. (2003). Manual de receitas com soja. Londrina: Embrapa Soja Documentos, 206 , 60.

[18] Esteves, E. A., & Monteiro, J. B. R. (2001, jan-abr.) Efeitos benéficos das isoflavonas de soja em doenças crônicas. *Revista de Nutrição,Campinas*, 14(1), 43-52.

[19] Farias, J. R. B. (1994). Climatic requirements. *In: EMBRAPA-CNPSo. (Ed.) Tropical soybean: improvement and production. Rome: FAO*, 13-17.

[20] Friedman, N. M., & Brandon, D. L. (2001). Nutritional and health benefits of soy proteins. *Journal of Agricultural and Food Chemistry*, 49, 1069-1086.

[21] Genovese, M. I., & Lajolo, F.M. (2006, jan./fev.) Fatores antinutricionais da soja. *Informe Agropecuário, Belo Horizonte*, 27(230), 18-33.

[22] Genovese, M. I., & Lajolo, F. M. (2002). Isoflavones in soy based foods consumed in Brazil: levels, distribution and estimated intake. *Journal of Agricultural and Food Chemistry*, 50(21), 5987-5993.

[23] Hodges, T., & FRENCH, V. (1985). Soyphen: soybean growth stages modeled from temperature, day length and water availability. *Agronomic Journal*, 77, 500-505.

[24] Jackson, J. C., Dini, J. P., Lavandier, C., Rupasinghe, H. P. V., Faulkner, H., Poysa, V., Buzzell, D., & DeGrandies, S. (2002). Effects of processing on the content and composition of isoflavones during manufacturing of soy beverage and tofu. *Process Biochemistry*, 37, 1117-1123.

[25] Kagawa, A. (1995). Standard table of food composition in Japan. *Tokyo University of Nutrition for women*, 104-105.

[26] Kurzer, M. S., & Xu, X. (1997). Dietaryphytoestrogens. *Annual Review Nutrition*, 17, 353-381.

[27] Laudanna, E. (2006, jan.-fev.) Propriedades funcionais da soja. *Informe Agropecuário, Belo Horizonte*, 27(230), 15-18.

[28] Mandarino, J. M. G. (2010). Compostos antinutricionais da soja: caracterização e propriedades funcionais. *In: COSTA, N.M.B.; ROSA, C.O.B. (ed.). Alimentos funcionais: componentes bioativos e efeitos. Rio de Janeiro: Rubio*, 177-192.

[29] Morais, A. A. C., & Silva, A. L. (1996). Complicações e resistência ao consumo. *In: MORAIS, A.A.C.; SILVA, A.L.. Soja: suas aplicações. Rio de Janeiro: Medsi*, 151-155.

[30] Morais, A. A. C., & Silva, A. L. (2000). Valor nutritivo e funcional da soja. *Rev. Bras. Nutr. Clin*, 14, 306-315.

[31] Poysa, V., & Woodrow, L. (2002). Stability of soybean seed composition and its effect on soymilk and tofu yield and quality. *Food Research International, Barking*, 35(4), 337-345.

[32] Ravelo, A. C., & Decker, W. L. (1979). Soybean weather analysis models. *In: 14thConf. Agric. Forest Meteorol*, 72-74.

[33] Rocha, V. S. (1996). Cultura. *In: MORAIS, A.A.C.; SILVA, A.L. Soja: suas aplicações. Rio de Janeiro: Medsi*, 29-66.

[34] Sediyama, T. (2009). Tecnologias de produção e usos da soja. *Londrina: Mecenas*, 306.

[35] Silva, M. R., & Silva, M. A. P. (2000). Fatores antinutricionais: inibidores de proteases e lectinas. *Rev. Nutr.*, 13(1), 3-9.

[36] Santos, H. M. C., Oliveira, M. A., Oliveira, A. F., & Oliveira, G. B. A. (2010, jul-dez). Composição centesimal das cultivares de soja BRS 232, BRS 257 e BRS 258 cultivadas em sistema orgânico. *Revista Brasileira de Pesquisa em Alimentos, Campo Mourão*, 1(2), 07-10.

[37] Teixeira, R. C., Sediyama, H. A., & Sediyama, T. (2009). Composição, valor nutricional e propriedades funcionais. *In: SEDIYAMA, T. Tecnologias de produção e usos da soja. Londrina: Mecenas*, 247-259.

[38] Vasconcelos, I.M., Siebra, E. A., Maia, A. A. B., Moreira, R. A., Neto, A. F., Campelo, G. J. A., & Oliveira, J. T. A. (1997). Composition, toxic and antinutritional factors of

newly developed cultivars of Brazilian soybean (Glycine max). *Journal of the Science of Food and Agriculture*, 75, 419-426.

[39] Vasconcelos, VI. M., Maia, A. A. B., Siebra, E. A., Oliveira, J. T. A., Carvalho, A. F. F. U., Melo, V. M. M., Carlini, C. R., & Castelar, L. I. M. (2001). Nutritional study of two Brazilian soybean (Glycine max) cultivars differing in the contents of antinutritional and toxic proteins. *Journal of Nutritional Biochemistry*, 12, 1-8.

[40] Vasconcelos, I. M., Campello, C. C., Oliveira, J. T. A., Carvalho, A. F. U., Souza, D. O. B., & Maia, F. M. M. (2006). Brazilian soybean Glycine max (L.) Merr.cultivars adapted to low latitude regions: seed composition and content of bioactive proteins. *Rev. Bras. Bot., São Paulo*, 29(4).

[41] Wilcox, J. R., & Shibles, R. M. (2001). Interrelationships among seed quality attributes in soybean. *Crop Science*, 41, 11-14.

[42] Zava, D. T., & Duwe, G. (1997). Estrogenic and antiproliferative properties of genistein and other flavonoids in human breast cancer cells in vitro. *Nutrition and Cancer, Hillsdale*, 27(1), 31-40.

[43] Zeller, F. J. (1999). Soybean (Glycine max (L.) Merril): utilization, genetics, biotechnology. *Bodenkultur*, 50, 191-202.