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SENSORY PROFILE OF SOYBEAN EXTRACTS MADE WITH GENOTYPES SPECIAL FOR HUMAN CONSUMPTION

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ABSTRACT: Soybeans contain primary and secondary metabolites responsible for specific flavors and odors which may interfere with the sensory quality, once the soybean extract can improve these undesirable characteristics. It is worth noting the importance of this study in evaluating the acceptability of soybean extracts made with special genotypes with different tegument colors for human consumption, using the Internal Preference Mapping, that can identify the extracts of greater acceptability in relation to the attributes appearance, color, aroma, flavor and overall impression. The soybean extracts produced with the black tegument genotypes showed the lowest acceptability for all attributes. The extracts produced with brown and black soybeans were the least accepted concerning the appearance and color, thus these genotypes should not be used for the production of soybean extracts. The extract produced with the cultivar BRS 213 which is lipoxygenase-free stood out for the aroma, while the extracts from the cultivar BRSMG 790A and the free lipoxygenase lineage were the most accepted for the attribute flavor. In the overall impression, the two extracts made with the lipoxygenase-free lineage had better acceptability. Therefore, the soybeans with yellow tegument, preferably the genotypes free of the lipoxygenase isoenzymes, have proven to be more suitable to produce the soybean extract since it provided a soft flavor and aroma and greater consumer acceptability.

Palavras-chave: Genetic improvement, black tegument, brown tegument, flavor, color.

CARACTERÍSTICAS SENSORIAIS DE EXTRATOS DE SOJA PRODUZIDOS COM GENÓTIPOS ESPECIAIS PARA A ALIMENTAÇÃO HUMANA

RESUMO: A soja contém na sua constituição química metabólitos primários e secundários os quais caracterizam os sabores e odores específicos desta leguminosa, que podem interferir na qualidade sensorial, sendo que o extrato de soja é o que mais realça os sabores e odores indesejáveis. Vale salientar a importância deste estudo em avaliar a aceitabilidade de extratos de soja obtidos com genótipos especiais para alimentação humana com diferentes colorações de tegumento, utilizando o mapa de preferência interno que identificou os extratos de maior aceitabilidade em relação aos atributos de aparência, cor, aroma, sabor e impressao globlal. Os extratos de soja obtidos dos genótipos de tegumento preto foram os de menor aceitabilidade em todos os atributos. Nas características de aparência e cor os produzidos com a soja marrom e preta foram os menos aceitos, concluindo que estes genótipos não devem ser utilizados para a produção de extratos. O extrato de soja processado com a cultivar BRS 213, livre de lipoxigenase, se destacou na característica do aroma. Os melhores sabores aceitos pelos consumidores foram dos extratos obtidos da cultivar BRSMG 790A e da linhagem livre de lipoxigenase. No aspecto global, os dois extratos obtidos com a soja livre de lipoxigenase foram os de melhor aceitabilidade. Para a produção de extrato de soja deve-se utilizar soja de tegumento amarelo e de preferência as livres das isoenzimas de lipoxigenase pois apresentam sabor e aroma mais suaves e de maior aceitabilidade.

Keywords: Melhoramento genético, soja de tegumento preto, soja de tegumento marrom, sabor, cor.

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INTRODUCTION

The genetic improvement of soybeans for human consumption aims to develop lineages with nutritional and sensory characteristics superior to those destined to the industry, which is limiting factors for human consumption of soybeans and soy-derived products in the West. Soybeans contain primary and secondary metabolites in its chemical constitution responsible for the specific flavors and odors of this leguminous plant that may interfere with the sensory quality depending on several conditions, including genetic factors, cultivar, growing conditions, storage and processing technology.

The undesirable flavor and odor of the soybean extract stand out among the soy-derived products. Lipid oxidation is responsible for the propagation of volatile compounds through the formation of hydroperoxides from the polyunsaturated fatty acids by the action of lipoxygenase isoenzymes (AXEROLD et al., 1981). The instability of the hydroperoxides can lead to the formation of aldehydes, ketones, furans, alcohols, polymers among other compounds (CUNHA et al. 2015). The Maillard and Strecker reactions contribute to the formation of volatile compounds by the reaction between saccharides and amino acids during the thermal processing of the soybean extract. Approximately 63 chemical compounds have been identified in soybean extracts, including aldehydes, ketones, alcohols, furans, esters, acids and hydrocarbon compounds. Different studies have demonstrated hexanal as a major indicator for lipid oxidation which is responsible for the off flavor in soybean grains and soy-derived products and can be decisive in the sensory quality reducing the product's acceptance. Other authors have reported the following sensory attributes in soybean extract: beany, grassy, oxidized, astringency mouthfeel, thickness and darkness. Astringency mouthfeel is generally known as derived from non-volatile compounds such as phenolic acids and isoflavones commonly found in soybean products (POLISELI-SCOPEL; FERRAGUT 2016). Thus, acceptance tests are required in the selection of soybean lineages of the genetic improvement program for human consumption in view of the sensory characteristics of the soybean extract.

The acceptance tests can reflect the degree of preference for a particular product. However, when acceptance data are analyzed by univariate analysis, it is assumed that the consumer acceptance criterion is homogeneous, which may not reflect the true scores. Thus, the individual variability of the data must also be considered and data structure analyzed. The Internal Preference Mapping together with the Analysis of Variance and mean tests can complement the acceptance test of a product, explaining consumer preferences, providing thus valuable information for a given product (CARDELLO; FARIA, 2000)

The Internal Preference Mapping provides a multidimensional representation of consumer and products through the decomposition of a singular value (i.e. principal component analysis, PCA) of a data matrix that has products as rows and consumers as columns. For a specific consumer, the data are the hedonic scores assigned to a set of products. The internal map is a graphical representation of products and consumers on which the direction of the increasing preferences for each individual consumer is observed, providing the graphical representation of products (PCA score), the sensory data (PCA load) and consumers (regression coefficients of the adjusted model) (PINHEIRO et al., 2013).

In view of the above, this study aimed to evaluate the acceptability of soybean extracts made with special soybean genotypes with different tegument colors for human consumption, using the internal preference mapping.

MATERIAL AND METHODS

Suitable for human consumption soybeans (*Glycine max* (L.) Merrill) with tegument of different colors were used to produce the extracts. They came from a partnership breeding program of Embrapa/Epamig/Triângulo Foundation in Uberaba-MG (Table 1) and four cultivars and six lineages.

Table 1. Soybean cultivars and lineages from the genetic breeding program of the partnership Embrapa / Epamig / Fundação Triângulo, Uberaba-MG.

	Genotypes	Characteristics
Cultivars	Conquista	Yellow tegument and black hilum. Used in the food industry.
	BRS 213	Special for human consumption, Yellow tegument.
	BRSMG 790A	
	BRSMG 800A	Special for human consumption, Brown tegument and hilum.
Lineages	MGBR10-16601	Special for human consumption, Yellow tegument and hilum
	MGBR10-16301	
	MGBR10-16201	
	MGBR07-7043	Special for human consumption, brown tegument
	MGBR09-9161	Special for human consumption, black tegument and large grain
	BRN07-50543	Special for human consumption, black tegument and small grain

For the experiment, 100 g of grains were hydrated in 500 mL for 10 hours. The water was discarded and the 100 grams of the hydrated grains were homogenized with 1 liter of cold water (6 ± 2 °C), (ratio 1:10) in a blender for 3 minutes and filtered through fine cotton cloth. The filtrate was heated under constant stirring until the first boil, which continued on low heat for more 10 minutes. The volume was completed for 1 liter with potable water.

The soybean extracts were stored at 7-8º C until the following day to perform the sensory evaluation that was carried out at the Sensory Analysis Laboratory of Instituto Federal de Educação, Ciência e Tecnologia do Triângulo Mineiro - Uberaba - MG. The present study was approved by ethics committee (CAAE: 18971613.0.0000.5145).

The soybean extracts (30 mL, Table 1) were presented at 6 ± 2 °C in disposable plastic cups encoded with 3-digit random number. Each consumer received water at room temperature for the palate cleansing. The test was performed in individual booths with white fluorescent light. Each consumer who participated in the acceptance test was considered as an experimental unit.

The participants were invited to participate the tests through posters at the Instituto Federal de Educação, Ciência e Tecnologia do Triângulo Mineiro – Uberaba Campi. Sixty consumers including 49 female and 11 male aged between 18 and 60 years participated in the acceptance test who evaluated the appearance, color, aroma, flavor and overall impression of the samples. The samples were presented through balanced blocks in two sessions in a monadic form. All samples were evaluated and served in a balanced order. A structured hedonic scale of nine points ranging from "disliked very much" to "liked very much" was used (STONE & SIDEL, 2004).

The results were analyzed by analysis of variance and internal preference maps and they were constructed using data from each of the attributes that were arranged in a matrix with the treatments (samples) in the rows and consumers in the columns. The analyses were performed using the statistical program Sensomaker® developed by Pinheiro et al. (2013).

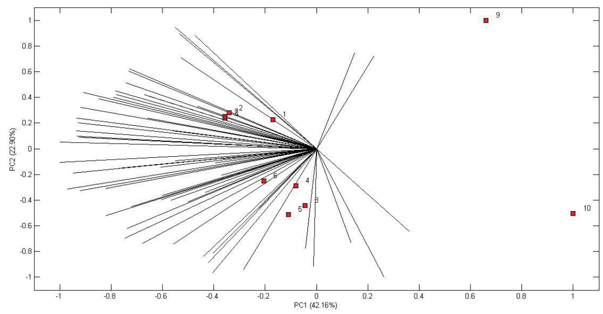
RESULTS AND DISCUSSION

Appearance

The Internal Preference Mapping was performed using the results of the appearance test of ten samples of soybean extract (FIGURE 1). The first principal component explained 42.16% of the variability between the samples and the second principal component accounted for 22.90% of the variation. The first and second dimensions explained 65.06% of the variability between the individuals with respect to the attribute acceptance.

The soybean extracts from the lineages 9 (MGBR09-9161) and 10 (BRN07-50543), both made with soybeans with black tegument, were the least preferred for the attribute appearance as observed in the quadrants of the preference map, once few assessors preferred these samples. The cluster analysis identified 2 major groups on which the majority of consumers located on the right side of the map, although a higher percentage approval was observed for the samples 2 (BRS 213-lipoxygenase-free), 3 (BRSMG 790A) and 7 MGBR10-16201-lipoxygenase-free) all of them with yellow tegument and hylo. These results may be due to the characteristic of the grains for commercial production of the soymilk and tofu, which should preferably contain yellow tegument and hylo (CUNHA et al. 2015), that makes the appearance of the extract more acceptable, once consumers are used to the lighter color of this product found in the market.

Figure 1: Internal preference mapping for the appearance scores of the soybean extracts made with different tegument colors.



1 – Conquista; 2 – BRS 213 (lipoxygenase-free); 3 – BRSMG 790A; 4 – BRSMG 800A; 5 – MGBR10-1661; 6 – MGBR10-16301; 7 – MGBR10-16201 (lipoxygenase-free); 8 – MGBR07-7043; 9 – MGBR09-9161 and 10 – BRN07-50543 (black tegument).

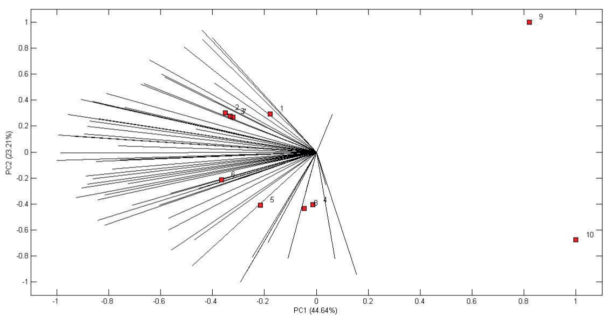
In addition to the agronomic aspects, the genetic improvement program of soybeans for human consumption in Brazil should consider the reduction of the unpleasant flavor, the color, the size and the overall appearance of the grain (JUHÁSZ, CIABOTTI and TEIXEIRA, 2017). In recent years, the availability of high-quality soy products has increased due to sales and greater consumption in the Brazilian market. Cultivars with yellow tegument and hylo were intended for human consumption by having large seeds, ideal flavor for processing soy-derived foods, including tofu, soybean flour and soybean extract (CUNHA et al. 2015).

In this study, the appearance was closely related to color (FIGURE 2). It's noted that the spatial location of the extracts had the same behavior as the attribute appearance with two distinct groups occurring in the right quadrants of the map.

Collor

With respect to the attribute color, the first principal component accounted for 44.64% of the variation and the second 23.21%, totaling 67.85% of the variance among the samples. The genotypes 2 (BRS 213 lipoxygenase-free), 3 (BRSMG 790A) and 7 (MGBR10-16201) were the most accepted, all of them with yellow tegument and hylo. Intermediate acceptance scores were observed for the other extracts obtained from soybeans with yellow tegument. Several factors can explain the difference in color between soybeans and their final products. In addition to the genotype, the enzymatic and non-enzymatic reactions in soybean grains are accelerated at low and/or very high temperatures of storage and the dark pigments formed are transferred to the soybeans and tofu extract (CIABOTTI et al., 2007).

Figure 2: Internal preference mapping for the collor scores of the soybean extracts made with different tegument colors.



1 – Conquista; 2 – BRS 213 (lipoxygenase-free); 3 – BRSMG 790A; 4 – BRSMG 800A; 5 – MGBR10-1661; 6 – MGBR10-16301; 7 – MGBR10-16201 (lipoxygenase-free); 8 – MGBR07-7043; 9 – MGBR09-9161 and 10 – BRN07-50543 (black tegument).

Lower acceptance scores were observed for the attribute color of the extracts from the lineage 9 (MGBR09-9161) and 10 (BRN07-50543), both with black tegument, which can be visualized through the distance between the samples in the map quadrants and the consumers (vectors). The darker color of the extracts made with soybeans with black tegument may have influenced the color since this extract was darker and the most rejected for all the attributes evaluated. The processing of soybeans to obtain the extracts usually uses soybeans with yellow tegument and hylo rather than the varieties with brown and black teguments that can significantly alter the sensory results, mainly the color attribute. The brown soybean extracts were also not accepted (4 - BRSMG 800A and 8 - MGBR07-7043) as observed in the positioning in the map (center of lower quadrants) due to the dark color of the extract caused by the dark tegument.

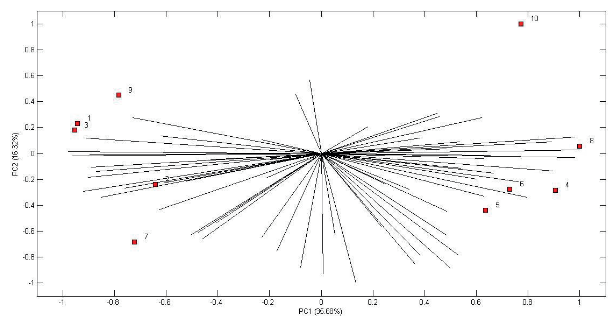
Odor

Figure 3 presents the Internal Preference Mapping for the attribute odor of all soybean extracts. The first principal component accounted for 35.69% of the variation among the samples and the second principal component explained 16.32% of the variation. The first two principal components together explained 52.01% of the variation among the samples. It is worth noting that the spatial separation of the samples for the attribute odor had the same behavior when compared to the flavor and overall impression with the formation of two distinct groups.

The extract 10 (BRN07-50543) was more distant from the consumers (vectors) followed by the extract 9 (MGBR09-9161), both with black tegument, with a lower acceptance then. The extract 2 (BRS213) made from lipoxygenase-free soybeans showed greater acceptability, probably due to the smoother odor. The enzyme lipoxygenase is a propagator of a series of volatile and non-volatile chemical compounds that interfere in the acceptance of the soybean extracts.

Studies have found volatile compounds in soybean extract subjected to ultra-high pressure homogenization (UHPH) such as hexanal, ethanol, 1-hexanol, 1-pentanol, hexanoic acid, 1-octen-3-o1,2-penthyl furan, pentanol, 2,3-pentanedione, benzaldehyde, 2,3-octanedione and 1-octen-3-one. Different studies have pointed out the hexanal as an indicator of the degree of oxidation responsible for the off flavor in soybean extracts, being decisive in the sensory quality with a better consumers' acceptance at a low incidence of this compound in the extracts (POLISELI-SCOPED & FERRAGUT, 2016). Intermediate scores were observed in the acceptance of the other soybean extracts, according to the location on the map and distance of the vectors. A group of consumers was located almost parallel to the "y" axis, which is not focused on any sample, presenting very similar results for the acceptance of the attribute odor.

Figure 3: Internal preference mapping for the odor scores of the soybean extracts made with different tegument colors.



1 – Conquista; 2 – BRS 213 (lipoxygenase-free); 3 – BRSMG 790A; 4 – BRSMG 800A; 5 – MGBR10-1661; 6 – MGBR10-16301; 7 – MGBR10-16201 (lipoxygenase-free); 8 – MGBR07-7043; 9 – MGBR09-9161 and 10 – BRN07-50543 (black tegument).

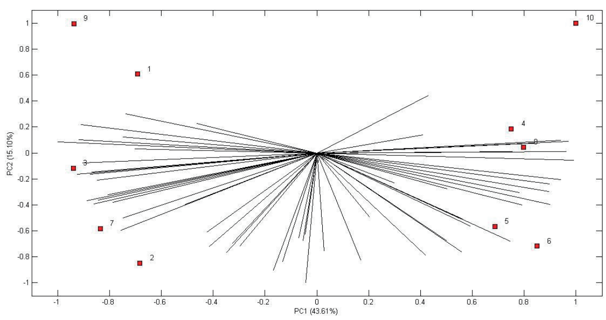
Flavor

The Internal preference mapping of the attribute flavor was generated by two components that together explained 58.71% of the variation among the soybean extracts (FIGURE 4). The first principal component explained 43.61% of the variation while the second component explained 15.01%, representing the location of the consumers within the same vector space. CALLEGUER et al. (2006) have reported that consumers are represented by vectors and those with similarity in one or more properties are close to each other. The concentration of consumers in the sample region indicates greater or lower acceptance.

The Cluster Analysis identified two major groups. The majority of the consumers belonged to the lower left quadrant (58.71%), with the samples 3 (BRSMG

790A) and 7 (MGBR10-16201) presenting the highest percentage approval for the attribute flavor. Sample 7 was identified as lipoxygenase free that improves the sensory characteristics of soybean derivatives. TORRES-PENARANDA and REITMEIER (2001) studied the flavor of the soybean extracts obtained from conventional soybeans and conventional free-lipoxygenase soybeans and verified differences in almost all flavor attributes. In another study with soybean extracts, TORRES-PENARANDA et al. (1998) found lower intensity for raw beans flavor in the extracts obtained from the conventional lipoxygenase-free soybeans as reported by the Americans rather than Chinese assessors in comparison with to the soybean extract obtained from the conventional soybeans, whereas the Japanese assessors found no differences between both extracts.

Figure 4: Internal preference mapping for the flavor scores of the soybean extracts made with different tegument colors.



1 – Conquista; 2 – BRS 213 (lipoxygenase-free); 3 – BRSMG 790A; 4 – BRSMG 800A; 5 – MGBR10-1661; 6 – MGBR10-16301; 7 – MGBR10-16201 (lipoxygenase-free); 8 – MGBR07-7043; 9 – MGBR09-9161 and 10 – BRN07-50543 (black tegument).

Not all cultivars used in human food are triple-null lipoxygenase genotypes, but differences in composition make them more palatable due to the higher carbohydrates content, as observed in the cultivar BRSMG 790A. The sensory evaluation of the linages in the final stages of the genetic improvement, both in the form of soybean extract and cooked grains and regardless of the presence of the lipoxygenase isoenzymes showed great variability of flavor that allows to phenotype in qualitative classes such as an astringent, soft, sweet among others (JUHÁSZ et al., 2017). Astringency is generally derived from non-volatile compounds such as phenolic acids and isoflavones commonly found in soybean products (POLISELI-SCOPEL & FERRAGUT 2016).

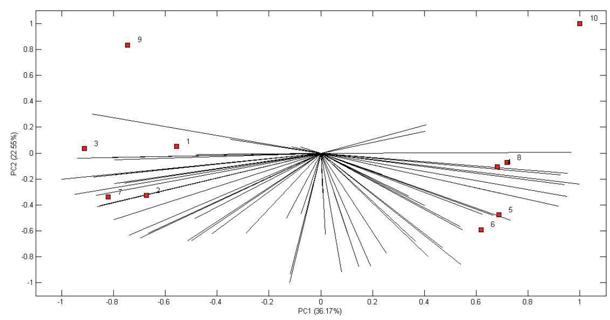
The extracts made with the genotypes 1 (Conquista), 9 (MGBR09-9161) and 10 (BRN07-50543) showed lower acceptance scores for the attribute flavor as they were located further away from the vectors (consumers). The genotype 1 is a conventional non-food specific cultivar used as a control and the genotypes 9 and 10 are of black tegument. The soybeans with black tegument is used in China as food and also in medicine, once it has multiple clinical functions depending on the methods of preparation (TAN et al., 2016) since it contains isoflavones and other phytochemicals that are potentially effective in human health, including sterols, phytic acid, saponins and phenolics. Recent research has shown that the black soybeans had the highest antioxidant activity (KOH al. 2014). Those phytochemicals may have influenced the lower sensory acceptability of the samples. Jeng et al. (2013) reported higher isoflavone concentrations in black soybeans when compared to yellow soybeans. Other authors (POLISELI-SCOPEL & FERRAGUT, 2016) stated that isoflavones are responsible for astringency in soybean derivatives.

Overall impression

The samples were evaluated by a set of attributes for appearance, color, aroma, flavor, and overall impression. The Internal Preference Mapping generated a multidimensional space through principal components that together explained 58.72% of the variation among the samples in relation to the overall impression (FIGURE 5). The first principal component explained 36.17% of the variation while the second principal component accounted for 22.55%.

Similar aroma and flavor behavior was observed in the overall impression of the soybean extracts with the formation of two clusters. This result may be confirming that Global Impression was influenced by odor and flavor attributes. The samples with black tegument (9-MGBR09-9161 and 10-BRN07-50543) were distant from the consumers (vectors), confirming the other attributes. The lipoxygenase-free genotypes had the best overall acceptance while intermediate acceptance scores were observed for the other samples.

Figure 5: Internal preference mapping for the overall impression scores of the soybean extracts made with different tegument colors.



1 – Conquista; 2 – BRS 213 (lipoxygenase-free); 3 – BRSMG 790A; 4 – BRSMG 800A; 5 – MGBR10-1661; 6 – MGBR10-16301; 7 – MGBR10-16201 (lipoxygenase-free); 8 – MGBR07-7043; 9 – MGBR09-9161 and 10 – BRN07-50543 (black tegument).

CONCLUSION

The Internal Preference Mapping demonstrated that the soybean extracts made with the genotypes with black tegument presented lower acceptability for all sensory attributes. For the attributes appearance and color, the extracts produced with brown and black soybeans were the least accepted, thus they should not be used for the production of soybean extracts. The aroma of the soybean extract made with the cultivar BRS 213, lipoxygenase-free, stood out among the other extracts. Higher flavor scores were observed for the cultivar BRSMG 790A and the lipoxygenase-free genotype. In the overall impression, the two extracts made with lipoxygenase-free soybeans were the most acceptable. Therefore, the soybeans with yellow tegument, preferably the genotypes free of the lipoxygenase isoenzymes, have proven to be more suitable to produce the soybean extracts since it provided a soft flavor and aroma and greater consumer acceptability.

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