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Development of cookies from agroindustrial by-products

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Abstract – The aim of this study was to evaluate the potential use of dry grape marc obtained of drying and milling operations with parboiled rice bran for cookies production. By-products were characterized with respect to moisture content, proteins, lipids, carbohydrates, fiber, and ashes, besides the analysis of absorption index, solubility in water and acidity. The proposed formulations were prepared by varying the amount of by-products to replace wheat flour. Elaborate cookies were subjected to microbiological and sensory analysis. The formulation with greater acceptance contained 5% of flour grape marc and 10% of parboiled rice bran. The physicochemical characterization of the cookies with greater acceptance was highlighted by the protein and fiber that presented 5.15% and 28.42%, respectively. The result obtained from this study shows a suitable product for consumption for microbiological as well as nutritional point of view.
Index terms: drying; grape marc; rice bran; sensory analysis.

Desenvolvimento de biscoitos a partir de subprodutos da agroindústria

Resumo – O objetivo deste trabalho foi avaliar a potencial utilização do bagaço de uva seco (FBU) obtido a partir das operações de secagem e moagem, juntamente com o farelo de arroz parboilizado (FAP), para a elaboração de biscoitos. Os subprodutos foram caracterizados com relação ao conteúdo de umidade, proteínas, lipídeos, carboidratos, fibras e cinzas, além das análises de índice de absorção, solubilidade em água e acidez. As formulações propostas foram elaboradas variando a quantidade dos subprodutos em substituição à farinha de trigo. Os biscoitos elaborados foram submetidos à análise microbiológica e à análise sensorial. A formulação com maior aceitação a partir da análise sensorial foi a que continha 5% de farinha do bagaço de uva e 10% de farelo de arroz. A caracterização físico-química do biscoito com maior aceitação teve como destaque os teores de proteínas e fibras, que apresentaram 5,15% e 28,42%, respectivamente. A partir dos resultados obtidos, o presente estudo apresenta um produto adequado para o consumo tanto do ponto de vista microbiológico quanto do nutricional.
Termos para Indexação: secagem, bagaço de uva, farelo de arroz, análise sensorial.

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Introduction

Food agribusiness is responsible for generating thousands of tons of by-products that are an environmental problem if not disposed properly. Facing the economic and environmental concept, the use of the by-products from food industry is becoming evident and promising, since it is biodegradable material, and generally excellent sources of vitamins, minerals and other compounds that, with the aid of appropriate treatment can be used in the elaboration of new products (MAKRIS et al., 2007). In the south of Rio Grande do Sul, there are several wineries and rice industries which allow the accumulation of different agro-industrial by-products.

The grape (*Vitis vinifera*) is one of the most valued conventional fruits in the world (GARCÍA-LOMILLO and GONZÁLEZ-SANJOSÉ, 2017). The marc generated in the pressing operation is the main by-product of the winemaking. Approximately nine million tons from this waste is produced annually in the world, representing 20-30% of the total grapes weight used for the wine production (TEIXEIRA et al., 2014; DWYER et al., 2014).

Just like the grapes, the by-products derived from their processing have the content of natural antioxidants and fibers with beneficial properties for human health (LLOBERA and CAÑELLAS, 2007). The grape marc is mainly composed by seeds (38-52%) and skin (5-10%) as suitable material to be used in different processes (BERES et al., 2017; BRENES et al., 2016). The drying operation is employed to obtain the grape marc flour, and in this way, increase the product life of this by-product and consequently its use in other products.

Rice (*Oryza sativa L.*) is one of the staple foods in the table of the world population and especially in Asian countries (HAM et al., 2015). The rice bran obtained in grain processing, corresponds to the outer layer of the rice and is derived in the grinding process (RYAN, 2011). This bran is rich in nutrients such as proteins, minerals, fatty acids, dietary fiber content and antioxidants such as oryzanol, tocopherol, tocotrienol and ferrulic acid (ZUBAIDAH et al., 2012). Evidence indicates that the bioactive compounds found in rice bran possess properties that combat or inhibit chronic and infectious diseases. Some studies have shown that rice bran intake has positive effects on rats and human health in terms of protection against gastrointestinal cancer, improving lipid metabolism and lowering cholesterol levels (HAM et al., 2015; IQBAL et al., 2005).

Currently, the demand of the food industry is high for the development of new products with nutritional value that meets the demanding consumer market, as well as the use of by-products of agro-industries corroborating with the reduction of the environmental impact caused by the inappropriate disposal of them. With the above, the objective of this study was to perform the physicochemical characterization of by-products generated from the wine and rice industry of local companies and to evaluate the insertion of these by-products in the preparation of cookies, as well as consumer acceptance and physicochemical properties of the cookies with better acceptance.

Material and methods

The by-products used in this study were the fermented grape marc and the parboiled rice bran supplied by industries of the Campanha region, Rio Grande do Sul, Brazil. Upon receipt, the by-products were stored in plastic bags and conditioned at -18 °C until analysis. The grape marc was dried in a tray dryer with parallel air flow (ECO Educacional, Florianópolis, Brazil) under the following conditions determined in previous studies: temperature of 70 °C, drying air velocity of 1 m s^{-1} and total drying time of 140 min. After drying the sample was submitted to an analytical grinding mill (IKA model A11Basic, Campinas, Brazil) to obtain the flour from the grape marc.

The water absorption index (WAI) and the water solubility index (WSI) of grape marc flour (GMF) and parboiled rice bran (PRB) were determined according to the methodology by Assis (2009). The content of moisture, proteins, lipids and ashes of by-products (grape marc, grape marc flour and parboiled rice bran) and cookies (formulation with better sensorial acceptance) were determined using the methodology described by *Association of Official Analytical Chemists* - AOAC (2000) and Adolfo Lutz Institute - IAL (2008). The carbohydrate content was determined by difference from the centesimal analyzes. The crude fiber content was determined by the method proposed by Rodrigues (2010) according to Equation 1.

$$\%CF = \frac{(WC + \%TR) - (WC + \%A) \cdot 100}{SW \cdot \%DM}$$

In which CF corresponds to the crude fiber content, WC the weight of the crucible (g), TR total residue (g), A the ash obtained after incineration (g), SW is the sample weight (g) and DM is the weight of the dried sample at 105 ° C (g).

In the by-products (grape marc, GMF and PRB) were evaluated pH and acidity. The pH was determined by the potentiometric method, using a bench pH meter (MS TECNOPON Scientific Instrumentation, model MPA210, Piracicaba, Brazil). The titratable acidity was performed by titration with 0.1N NaOH solution and phenolphthalein solution as indicator. Both methodologies described by the Adolfo Lutz Institute - IAL (2008).

Table 1 presents four elaborated "*cookie*" formulations (F0, F1, F2 and F3), with F0 being the control formulation without addition of by-products. In the other formulations, the added by-products were calculated in relation to 100% of the wheat flour and the other components remained constant. For the preparation of the cookies, the components were homogenized manually and the obtained dough was cut with circular stainless steel molds of 60 mm diameter and submitted to 150 °C for 15 min in an electric oven (Eletrolux, 15 L EOC30,Brazil). The cookies were cooled to room temperature and packed in metallized polyethylene coating, resistant to gaseous exchange and water vapor.

The four formulations were submitted to microbiological analyzes according to Resolution RDC No.12 (January 2, 2001) of ANVISA (BRASIL, 2001). These analyzes were performed with 25 g of sample (cookies), as function of the most probable number (MPN) for coliforms at 45 ºC (result expressed in MPN/g), coagulase staphylococci positive count (result expressed in UFC g^{-1}) and *Salmonella* sp. through the MLG/ FSIS / USDA method (result expressed in the absence of *Salmonella* sp in 25g of product). Microbiological analyzes were performed five days after the preparation of the cookies according to the methodologies described by Silva et al. (2007).

Table 1 - Cookies formulations added with different contents of by-products.

Ingredients	F0*(%)	F1*(%)	F2*(%)	F3*(%)
Wheat Flour	100	80	85	85
Grape Marc Flour (GMF)	0	10	5	10
Parboiled Rice Bran (PRB)	0	10	10	5
Refined sugar	19	19	19	19
Brown sugar	27	27	27	27
Salt	0.4	0.4	0.4	0.4
Egg	19	19	19	19
Butter without salt	30	30	30	30
Baking powder	2	2	2	2
Vanilla essence	2.6	2.6	2.6	2.6

*F0: Control, F1: 10% of GMF and 10% of PRB; F2: 5% of GMF and 10% of PRB; F3: 10% of GMF and 5% of PRB.
The proportion of ingredients was calculated on the basis of wheat flour (100%).

The sensorial evaluation of the cookies was performed from the acceptance test and the preference sorting test, following the IAL (2008) adapted methodology. To perform the sensory analysis, each tester received four samples, each referring to a formulation (F0, F1, F2, F3), coded and arranged in random order. The formulation F0 (control) was present in the sensory analysis tests only for comparison purposes in relation to the others, and no judgment was necessary for this formulation. The tests were carried out with 30 non-trained tasters who are accustomed to the consumption of cookies from both sexes and aged between 18 and 50 years. For the acceptance test, a card was distributed to the testers containing a hedonic scale composed of seven points; "I liked it very much", "I liked it", "I liked moderately", " Neither liked nor disliked it", "I disliked it moderately", "I did not like it", "I did not like it at all" for attributes color, appearance, aroma, texture and taste. From this test it was possible to obtain the acceptance index (AI) calculated according to the following equation % AI = (A.100) / B; where A corresponds to the average grade obtained for said formulation and B the maximum grade of the used scale (value 7, referring to the item "I liked it very much") (TEIXEIRA et al., 1987).

For the preference ordering test, cards were distributed for three analyzed samples (F1, F2 and F3) and the judgment was required in the order of preference for coded formulations with three-digit random numbers.

The formulation with the best obtained results in the tests of sensorial analysis was submitted to the physical-chemical characterization (humidity, proteins, ashes, lipids, carbohydrates and fibers), in order to observe the effect of the added by-products in relation to the nutritional quality of the final elaborated product.

Results and discussion

Table 2 presents the physical-chemical characterization of the evaluated by-products, grape marc, grape marc flour and parboiled rice bran.

As there is no specific legislation for grape flour, this study took into account the Resolution RDC nº 263, from September 22nd, 2005 (BRASIL, 2005), which establishes the maximum moisture value for wheat flour of 15% (g $100g^{-1}$). The humidity found after the drying operation in the grape marc was lower than that established by the related resolution. The moisture content of the parboiled rice bran found in this study was close to those estimated by Silva et al. (2006) who reported 9.96% on wet basis (w.b.). As there is no specific legislation for parboiled rice bran we took the values of the current legislation for cereal meal as base (BRASIL, 2005), which establishes a maximum moisture content of 15% (g 100g^{-1}).

The physicochemical characteristics of grape marc after the drying operation and the parboiled rice meal presented satisfactory results, highlighting the high crude fiber content. Flour from grape marc has 75% higher crude fiber content in relation to parboiled rice bran. The protein content of the grape marc flour was close to Ferreira (2010) study which found 14.65% (w.b.). In the parboiled rice bran, Lacerda et al. (2010) found higher values than this study, 17.17% (w.b.). In relation to the mineral content of grape marc flour, this by-product presented ash quantities consistent with other studies reported in the literature, such as Ferreira (2010) who found 7.36% (w.b.) for grape marc and Lacerda et al. al. (2010) who found 7.01% (w.b.) for the parboiled rice bran. The lipid content differed between grape marc and grape flour with an increase in this constituent after milling and drying operations, probably due to seed rupture, rich in lipid. The lipid content in grape seeds depends on the used variety, although the usual range is 10 to 16% of dry weight (LUQUE-RODRIGUEZ et al., 2005). For rice bran, the value found by Lacerda et al. (2010) was in the range of 10 to 23% (w.b.), values consistent with the present study. It is noteworthy that both the composition of grape marc and parboiled rice bran may change depending on the variety of the corresponding raw materials, as well as the cultivation and processing techniques adopted in each industry.

Table 2 also shows the WAI and WSI values for the by-products (GMF and PRB) used. The WAI is related to the capacity of water absorption and retention by the constituents of raw material. The low values found may be justified because of the low moisture content of the raw materials which hinders the interaction between the starch and the water leading to the solid phase structure in the extrusion processing of starch (GOMEZ and AGUILERA, 1983). The WSI reflects the degradation suffered by the fiber constituent being the sum of the effects of gelatinization, dextrinization and solubilization. The differentiated value of WSI among the evaluated by-products is due to the fact that rice bran presents moisture content higher than flour from grape marc which also justifies this by-product presenting better water solubility.

The microbiological analyzes evaluated presented lower results than those established by the current resolution. According to the Brazilian legislation (BRAZIL, 2001), the microbiological standard for Coliforms at 45ºC is 10 MPN g^{-1}. In the analyzed cookies presented values lower than 3 MPN g^{-1} in all samples. For the microorganism *staphylococci coagulase* positive the maximum allowed by the legislation is 5.0 x 10^{2} CFU g^{-1} and in the analyzed samples, values below 1.0x10^{2}. In addition, all samples were absent in 25 g for *Salmonella* sp analysis. Therefore, cookies are considered to be satisfactory and safe for human consumption.

The cookies made with addition of different contents of the by-products and submitted to microbiological and sensorial analysis are presented in Figure 1. The results for acceptance test using the hedonic scale are shown in Figure 2. The F2 formulation (substitution of 5% of GMF and 10% of PRB) obtained an acceptability index (AI) of 70.95% been a sample with better acceptance in relation to their sensorial attributes. According to Teixeira et al. (1987) for a sample to be considered sensorial accepted the acceptability index must be equal to or greater than 70%. The F1 and F3 samples presented the AI of 63.3 and 43.8%, respectively. According to Figure 2, the formulation F2 presented the highest indexes for the items “I liked it very much”, “I liked it”, “I liked moderately” and neither liked nor disliked it despite of obtaining by the judges the lowest rejection indices not being judged on the scale “I did not like it at all”.

Regarding the order test preference the F2 formulation was also the sample that showed the highest acceptance by the tasters with 44% choice, followed by the formulations F1 and F3 with 36 and 20%, respectively. The lower acceptance of the formulations F1 and F3 may have been due to a higher concentration of grape marc meal which provided a higher acidity and a residual bitter taste in the cookies, according to the judges’ report. The acidity found in flour from grape marc (7.76% in w.b.) and pH (3.84) probably inferred in the acceptance of the cookies by tasters with higher concentrations of this by-product. In addition, formulations F1 and F3 presented more intense coloring compared to the control formulation (F0) which may also have influenced the judgment.

Due to the best presented results in the sensory analysis, F2 formulation was submitted to the physical-chemical analysis (centesimal composition in wet basis). As a result, the cookie presented 5.12% moisture and 1.83% ash. The value of the cookie moisture is in accordance with ANVISA (BRASIL, 2005) which must present a maximum of 15% in w.b.. Regarding to carbohydrate and lipid contents, the cookie presented results of 42.83% and 16.65%, respectively.

The formulation F2 showed the main characteristics of the used by-products, 5.15% of proteins and 28.42% of fibers. Through these results, the prepared cookie containing 5% of GMF and 10% of the PRB can be considered a source product of proteins and with high fiber content, since according to the Administrative Rule no. 27 of January 13th, 1998, ANVISA (BRAZIL, 1998) a food to be considered a source of protein must contain 10% of the RDI (Recommended Daily Intake) for adult / 100 g of product, which corresponds to a minimum of 5 g protein / 100 g product. A food to be classified as high fiber content must have at least 6g of fiber / 100g^{-1} of product. In this way, the by-products generated by the wine and rice industries can be added for the preparation of cookies, since they have satisfactory nutritional characteristics.

Table 2 - Physico-chemical characterization of by-products used.

	Grape Marc *	Grape Marc Flour*	Rice bran *
WAI (g g^{-1})	-	1.58 ± 0.09	1.87 ± 0.09
WSI (%)	-	3.07 ± 0.12	5.48 ± 0.15
pH	3.64 ± 0.02	3.84 ± 0.03	6.25 ± 0.02
Acidity (%)	0.98 ± 1.08	7.76 ± 0.98	1.04 ± 1.12
Moisture (% w.b.)	63.61 ± 2.07	6.31 ± 0.08	9.39 ± 0.17
Proteins (% W.b.)	6.28 ± 2.04	13,13 ± 0.91	13.69 ± 1.47
Ashes (% w.b.)	5.06 ± 0.26	10,00 ± 0.35	9.60 ± 0.33
Lipids (% w.b.)	1.87 ± 0.02	5,87 ± 0.20	21.43 ± 0.56
Carbohydrates (% w.b.)	4.81 ± 1.02	29.28 ± 0.60	37.25 ± 0.57
Fibers (% w.b.)	18.37 ± 1.87	35.41 ± 1.54	8.64 ± 1.21

* Mean values ± standard deviation. WAI – Water absorption index and WSI – Water Solubility index.

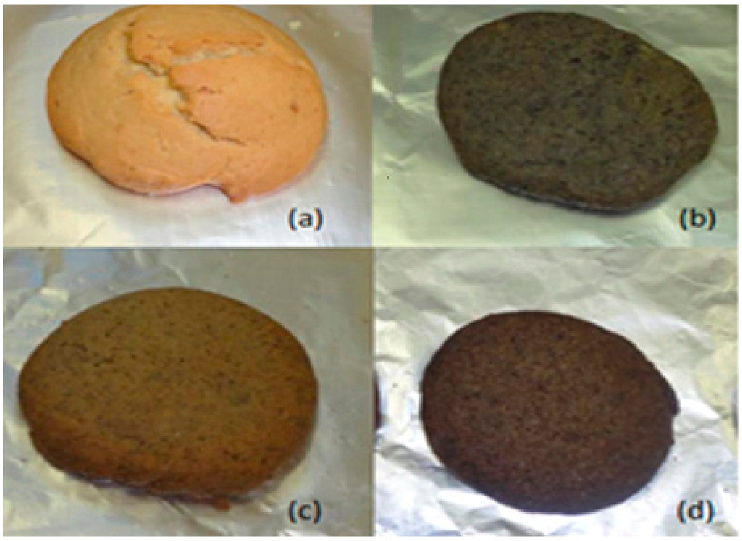

Figure 1 - Visual appearance of the cookies made with different formulations.

*(a) F0 (control sample); (b) F1(replacement of 10% of FBU and 10% of PRB); (c) F2 (replacement of 5% of FBU and 10% of PRB) and (d) F3 (replacement of 10% of FBU and 5% of PRB).

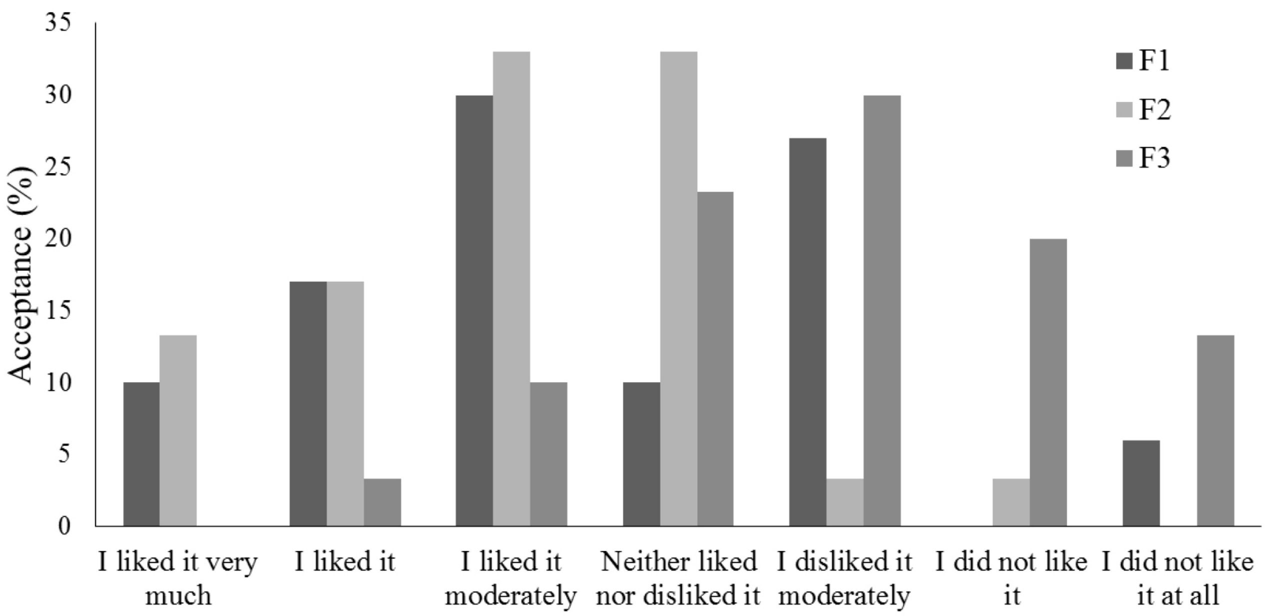

Figure 2 - Preference rank test of the three different formulations prepared with grape marc flour and parboiled rice bran.

Conclusion

The flour from grape marc and parboiled rice bran presented high fiber and protein contents, showing potential ingredients for the nutritional enrichment of cookies. The use of by-products in the preparation of cookies presented desirable characteristics for potential consumers. The cookie prepared with 5% of flour from grape marc and 10% of parboiled rice bran was the selected formulation by the judges in the sensorial analysis. The produced cookie resulted in a food source of proteins, with high fiber content and offers no health risks to consumers, as well as the use of these by-products as an alternative for the destination of the agro industrial by-product adding value and enabling a possible reduction in environmental impact.

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