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The effect of the incorporation of grape marc powder in fettuccini pasta properties

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ABSTRACT

Several studies have been conducted to evaluate the potentiality of grape residues to be used in the food industry. In the present work, the incorporation of 25, 50 and 75 g/kg of grape marc powder in fettuccini pasta preparation was evaluated over its cooking, nutraceutical and sensory properties. The results show that the incorporation of the dried by-product did not interfere in the water absorption and in the solid loss of the pasta after cooking. The addition of grape marc powder increased the total phenolic, condensed tannins, monomeric anthocyanin and compounds antioxidant capacity concentration in the cooked pasta due to the incorporation of polyphenols stemmed from grape. Sensory analysis showed that the incorporation of grape marc powder reduced the acceptance of aroma, aftertaste, flavor and appearance, regardless of the concentration of the dried residue added. Furthermore, the incorporation of 25 g/kg of grape marc powder presented the best overall acceptance, with lower changes of color, according to the CIELAB method. Based on the results, the addition of grape marc powder to pasta is an interesting alternative of use of this by-product, potentially reflecting on final product costs and representing an environmentally friendly way to manage industrial waste.

1. Introduction

In the last years, the consumers' demand for nutritional diets rich in compounds with functional properties has been increasing since several researches have shown the beneficial effects of those properties for human health, preventing and combating several diseases Grapes have world-wide economical and nutritional importance, since they have good sensory acceptance by consumers and are phenolic-rich fruits, presenting well-documented protective effect against LDL oxidation, reduction of platelet aggregation, improvement of coronary blood flow, among other beneficial effects for human health (Cui, Juhasz, Tosaki, Maulik, & Das, 2002; Demrow, Slane and Folts., 1995; Kevil, Osman, Reed and Folts, 2000; Stein Keevil, Wiebe, Aeschlimann and Folts, 1999). In the industrial processing of grapes, large amounts of solid residue are generated and, in general, they are discarded. However, several studies have shown that grape marc presents high contents of dietary fibers and polyphenolic compounds (Sant'Anna, Brandelli, Marczak, & Tessaro, 2012; Saura-Calixto, 2011), indicating that the dried grape by-product has great potential to be used as functional ingredient in different kinds of food.

Antioxidant dietary fibers are now being of great interest due to their source of polyphenolic compounds, vitamins, carotenoids, fibers, among others (Saura-Calixto, 2011). In this sense, yogurt, frankfurters and bread, with added grape by-products have been developed to increase the concentration of beneficial compounds in the final product (Coda, Lanera, Trani, Gobbetti, & Di Cagno, 2012; Mildner-Szkudlarz, Zawirska-Wojtasiak, Szwengiel, & Pacynski, 2011; Özvural & Vural, 2011; Peng et al., 2010). Mildner-Szkudlarz et al. (2011) added grape by-products in the range of 40–100 g/kg into sourdough mixed rye bread formulation and verified a significant increase of insoluble and soluble dietary fiber and compounds with antioxidant activity. Similar results were observed by Peng et al. (2010) who detected increased antioxidant activity when bread was fortified with grape seed extract; the authors also verified intense decrease of antioxidant activity in the breads due to thermal processing of the product.

One way to increase nutritional properties of foods is the incorporation of functional ingredients in staple foods; this is still a challenge: increase the potential health benefits retaining the

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consumer acceptability of the food (Foschia, Peressini, Sensidoni, & Brennan, 2013). Pasta is a traditional cereal-based product which represents a good product for the addition of nutrients because it is accepted worldwide due to the low cost, easy production and sensory attributes (Chillo, Laverse, Falcone, Protopapa, & Del Nobile, 2008). In this context, fettuccini pasta may be an interesting way to incorporate grape marc powder. To the best of our knowledge, no studies of fortification of pasta with dried grape by-products and the impact of the cooking procedure on the product quality have been found in literature. The objective of the present work is to evaluate the incorporation of grape marc powder in the preparation of fettuccini pasta. On this basis, nutritional, sensory and cooking properties of the pasta were analyzed.

2. Material and methods

2.1. Chemicals

Standard polyphenols (gallic acid and epicatechin) and 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) were obtained from Sigma Chemical Co. (St. Louis, MO, USA). Folin–Ciocalteau reagent was purchased from ALZ (São Paulo, Brazil) and all other chemicals were obtained from Vetec (São Paulo, Brazil).

2.2. Grape marc powder

Grape juice marc from *Vitis labrusca* cv. "Isabel" was kindly supplied by Vinícola Garibaldi (Garibaldi, RS, Brazil), harvested in 2012. The by-product was dried in a forced convection drying equipment at 70 °C, and then was crushed in a domestic blender (RI1764, Walita, Brazil) for 1 min and passed through a 0.811 mm sieve. The grape marc powder utilized in the present work, according to the centesimal analysis, had 108.7 g/kg of moisture, 95.8 g/kg of crude protein, 81.5 g/kg of lipids, 25.5 g/kg of ashes and 689.5 g/kg of carbohydrates in wet basis.

2.3. Pasta preparation and cooking

Fresh pasta was prepared with soft wheat flour (*Triticum aestivum*, 12 g/kg moisture, 98 g/kg protein), (Orquídea, Moinho Tondo, Brazil), water and different concentrations of grape marc powder. Fettuccini pastas were coded as FP0, FP25, FP50, FP75, according to the concentration of grape marc powder incorporation: 0 g/kg, 25 g/kg, 50 g/kg and 75 g/kg, respectively. For each formulation, wheat flour, grape by-product powder and water (300 g/kg) were mixed using an industrial mixer (G. Paniz, Mod 90334, Brazil) for 10 min, to obtain homogeneous dough. The premixed dough was extruded (G. Paniz, Mod 90334, Brazil) (40 ± 2 °C), through a die, in the same equipment, to obtain the fettuccini shaped pasta. Then, samples of 10 g of pasta were submitted to cooking in 170 ml boiling distilled water for 10 min.

2.4. Pasta quality

2.4.1. Pasta cooking properties

The American Association of Cereal Chemists Official Methods 16-50 and 16-51 (AACC, 2000) were used to determine optimum cooking time, cooking loss and cooked weight (water absorption). Pasta products (10 g), broken to a length of 5 cm, were heated in boiling distilled water (170 ml) to determinate the optimal cooking time (OCT). The OCT (*al dente point*) is defined as the time required to observe the disappearance of the white uncooked core in a small pasta sample manually squeezed between two glass plates. After cooking, fettuccini was rinsed with water for 30 s and drained for 1 min to expel the remaining water. Cooking and rinsing water were combined and a 10 ml aliquot was dried at 105 °C and weighed, in order to evaluate the presence of dry matter from pasta. The solid loss was expressed as percentage of raw fettuccini. At this stage, fettuccini samples were weighed to determine the cooked weight and the percentage weight increase.

2.4.2. Extraction and evaluation of polyphenols

Extraction of total phenolic content and monomeric anthocyanins was performed according to Sant'Anna, Brandelli, et al. (2012), Sant'Anna, Marczak, & Tessaro (2013). Briefly, dried samples (1 g) were added to 50 ml of 0.5 l l^{-1} ethanol solution and extraction was performed at 60 °C for 1 h. Total phenolic content in the extracts was determined by the Folin–Ciocalteau method (Singleton & Rossi, 1965) using Gallic acid as standard. The absorbance of the reaction mixture was measured at 765 nm by UV-1600 spectrophotometer (Pró-Análise, Brazil), and the results were expressed as mg Gallic acid equivalent per gram of dry pasta (mg Gallic acid equivalent 100 g^{-1}). Analysis of condensed tannin content was carried out according to the method of Price, Van Scoyok, and Butler (1978), which involves the reaction of the samples with vanillin solution. The absorbance was measured at 500 nm and the results were expressed as mg epicatechin equivalents (mg of epicatechin equivalent/100 g of dried sample). Monomeric anthocyanins were determined using the pH differential method (Lee, Durst, & Wrolstad, 2005). Absorbance was measured at 520 and 700 nm of samples diluted separately in 0.025 mol l^{-1} potassium chloride buffer pH 1.0 and 0.4 mol l^{-1} sodium carbonate buffer pH 4.5. Monomeric anthocyanins values were expressed as cyanidin-3-glucoside (molar extinction coefficient of 26,900 l cm^{-1} mol^{-1} and molecular weight of 449.2 g mol^{-1}), according to Lee et al. (2005). The units for extracted monomeric anthocyanins were expressed as mg of cyanidin 3-glucoside per 100 g of dry samples (mg C3G 100 g^{-1}).

Antioxidant analysis was performed by the determination of 2,2-azino-bis-(3-ethylbenzothiazoline)-6-sulfonic acid (ABTS) radical scavenging activity (Re et al., 1999). The ABTS radical cation was produced by reacting 7 mmol l^{-1} ABTS stock solution with 140 mmol l^{-1} potassium persulfate, and allowing the mixture to stand in the dark for 16 h at room temperature before use. For the assay, the $ABTS^{\bullet+}$ solution was diluted with ethanol to an absorbance of 0.7 at 734 nm. An aliquot of 30 μl of extract was mixed with 1 ml of $ABTS^{\bullet+}$ solution and an absorbance (734 nm) reading was taken after 6 min. Trolox solutions (0.1–2.0 mol l^{-1}) were used as standards and results were expressed as mol l^{-1} Trolox Equivalent per 100 g of dried pasta.

2.4.3. Color evaluation of pasta

The color of fresh and cooked (10 min/100 °C) fettuccini pasta was measured with a Hunter Lab Colorimeter (MiniScan XE Plus, Reston, VA). The samples were placed in the colorimeter and the color reading expressed by Hunter L^*, a^* and b^* values. Results were stated as color differential (ΔE) between fresh (pasta not cooked) and cooked pasta, calculated as follows:

$$\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2} \quad (1)$$

where, ΔL was calculated as $L^*_{\text{fresh sample}} - L^*_{\text{cooked sample}}$; Δa was calculated as $a^*_{\text{fresh sample}} - a^*_{\text{cooked sample}}$ and Δb was calculated as $b^*_{\text{fresh sample}} - b^*_{\text{cooked sample}}$.

Results are the means of independent duplicate determinations.

2.4.4. Sensory analysis

A 50-member panel performed the sensory profiling of the four samples, which were presented simultaneously. The panel members assigned the intensity of liking or disliking, using verbal hedonic 9-point scale (1 represented low intensity of liking and 9 represented high intensity of liking) of cooked fettuccini pasta: appearance, color, texture, flavor, aftertaste and overall acceptance.

2.5. Data analysis

Results are shown as average standard deviation of at least triplicate measurements. Analysis of Variance (One-way ANOVA) followed by Fisher LSD post hoctest was performed using Statistica 7.1 (StatSoft, USA), and differences were considered statistically significant when $p < 0.05$.

3. Results and discussion

3.1. Water absorption and cooking loss

The processing parameters were the same for all pasta samples (control pasta – 100% wheat flour – and grape marc powder enriched pastas). Table 1 shows the cooking quality characteristics of control fettuccini pasta and grape marc powder enriched fettuccini pastas (FP25, FP50 and FP75). As can be observed, there was no statistically significant ($p > 0.05$) difference in optimum cooking time. According to Borneo and Aguirre (2008) this parameter was defined as the cooking time needed for "white pasta center core" to disappear when pasta was squeezed between 2 glass plates (2.5 cm × 2.5 cm). For all samples, the optimum cooking time was around 4 min and the other cooking characteristics (solid loss and percentage weight increase) were evaluated at this standard cooking time.

Measurement of solid loss (or cooking loss) is an important parameter in assessing its overall quality. According to recent studies, during pasta cooking, soluble parts of starch and other soluble components including non-starch polysaccharides leach into the water and, as a result, the cooking water becomes cloudy and thick (Aravind, Sissons, Egan, & Fellows, 2012; Fu, 2008; Tan, Li, & Ta, 2008). The results of the present work indicated that solid loss of the fettuccini pasta significantly went up only when the incorporation of grape marc powder increased from 25 g/kg to 50 g/kg. No differences ($p > 0.05$) were found between control and FP25, as well as between FP50 and FP75. Ajila, Aalami, Leelavathi, and Prasada Rao (2010) found similar results for dried macaroni with mango peel powder addition, though with higher values of solid loss for 50 g/kg and 75 g/kg (8.24 ± 0.08 and 8.71 ± 0.36, respectively) of mango peel powder incorporation.

Granito, Torre and Guerra (2003) reported the influence of temperature on the cooking loss, indicating that the use of higher temperatures (drying stage) in pasta manufacture produces lower cooking losses. In the present work, fresh pasta was produced without a drying step, and, even so, the solid losses were lower than the results reported by Ajila et al. (2010) for semolina dried macaroni (85 °C/3 h, at different levels of mango peel powder addition, 25 g/kg, 50 g/kg and 75 g/kg). Therefore, even without the use of semolina, as well as without undergoing a drying stage, pasta can be manufactured without loss of quality.

Table 1
Cooking characteristics of control and grape marc powder enriched pasta[a].

Samples	Percentage weight increase (%)	Solid loss (%)
Control	89.2 ± 7.5^{b}	5.45 ± 0.09^{b}
FP25	95 ± 7^{b}	5.38 ± 0.16^{b}
FP50	88.70 ± 0.10^{b}	6.18 ± 0.20^{c}
FP75	85.24 ± 0.44^{b}	6.35 ± 0.07^{c}

b,c Different superscripts letters within same column indicate statistical differences ($p < 0.05$).
Present data are mean values of three replication.
[a] Cooking time: 4 min.

In the particular case of this work, as reported by Aravind et al. (2012), the cooking loss could be attributed to changes in the gluten protein network because of the interference of grape marc powder, which is rich in dietary fiber content. Indeed, several reports have shown that the addition of non-gluten flours in the production of pasta dilutes the gluten strength, and interrupt and weaken the overall structure of pasta (Rayas-Duarte, Mock, & Saterlee, 1996); which can result in a negative change (Gallesgos-Infante et al., 2010). According to Hoseney (1999), for good-quality pasta, cooking loss should be lower than 12%, which is reached in the present work by the pastas made with grape marc power, for all levels of addition.

The percentage of weight increase with 4-min cooking was statistically equal for all fettuccini pasta samples, indicating that the grape marc power incorporation did not affect the product quality.

3.2. Polyphenols

Total phenolic content, condensed tannin content and the monomeric anthocyanins are related to the benefits that the consumption of the fruit may bring to human health due to their antioxidant capability. Additionally, the combined effect of dietary fibers and antioxidant compounds has shown to be more effective than each of their effects separately (Pérez-Jiménez et al., 2008; Saura-Calixto, 2011). Grape juice marc is a phenolic-rich by-product of the food industry and presents high concentration of total phenolic content and condensed tannin content strongly bound to the plant matrix, indicating to be an interesting alternative as functional ingredient (Sant'Anna, Brandelli, et al., 2012). Table 2 shows the total phenolic content, condensed tannin content, monomeric anthocyanins and the antioxidant capability extracted from the raw and cooked pasta.

The raw control pasta presented 69.5 mg Gallic acid equivalent 100 g^{-1} of total phenolic content, 52 mg epicatechin equivalent g^{-1} of condensed tannin content and antioxidant activity of 10^{-4} mol l^{-1} TEC 100 g^{-1}. Monomeric anthocyanins were not detected only in the pasta produced with wheat flour. FP25 – the pasta with the incorporation of 25 g/kg of grape marc powder – enhanced significantly ($p < 0.05$) the concentration of total phenolic content to 104 mg Gallic acid equivalent 100 g^{-1}, condensed tannin content to 139 mg epicatechin equivalent 100 g^{-1}, monomeric anthocyanins to 6.70 mg C3G 100 g^{-1} and antioxidant activity to 336 mM TEC 100 g^{-1}. As expected, higher incorporation of the dried by-product to the pasta blend enhanced significantly ($p < 0.05$) the concentration of polyphenols and the antioxidant capability in the fettuccini pasta (Table 2). Similar

Table 2
Total phenolic content (TPC), condensed tannin content (CTC), monomeric anthocyanin (MA) and ABTS scavenging activities of fettuccini pasta added to grape marc powder.

Samples	TPC (mg GAE $100g^{-1}$)	CTC (mg ECE $100g^{-1}$)	MA (mg C3G $100g^{-1}$)	ABTS (10^{-3} mol L^{-1} TEC $100g^{-1}$)
RFP0	69.5 ± 6^{aA}	52 ± 4^{aA}	n.d.	100 ± 9^{aA}
CFP0	61 ± 5^{aA}	59 ± 5^{aA}	n.d.	92 ± 4^{aA}
RFP25	104 ± 7^{aB}	139 ± 21^{aB}	6.70 ± 0.45^{aA}	336 ± 7^{aB}
CFP25	95 ± 3^{aB}	145 ± 18^{aB}	5.25 ± 0.50^{bA}	305 ± 10^{bB}
RFP50	215 ± 16^{aC}	253 ± 3^{aC}	13.25 ± 0.80^{aB}	557 ± 21^{aC}
CFP50	194 ± 10^{aC}	242 ± 6^{aC}	10.05 ± 0.91^{bB}	453 ± 45^{bC}
RFP75	295 ± 14^{aD}	380 ± 9^{aD}	20 ± 2^{aA}	776 ± 55^{aD}
CFP75	299 ± 9^{aD}	365 ± 10^{aD}	17.94 ± 0.89^{aA}	656 ± 45^{bD}

n.d. not detected.
a,b Different superscripts indicate statistical differences ($p < 0.05$) between raw and cooked pasta.
A,B,C,D Different superscripts indicate statistical differences ($p < 0.05$) due to the addition of grape marc powder.
Present data are mean values of three replication.

results were found by Ovando–Martinez, Sáyago-Ayerdi, Agama-Acevedo and Bello-Pérez (2009), when banana flour was added to spaghetti pasta, and by Mildner-Szkudlarz et al. (2011) adding grape marc powder to bread formulations.

Additionally to the incorporation of the grape by-product to the pasta formulation, it is essential to evaluate the availability of the polyphenol in the ready-to-eat product. The cooking procedure affected significantly ($p < 0.05$) the monomeric anthocyanins content and the antioxidant activity of the evaluated fettuccini pasta. RFP25 presented 6.70 mg C3G 100 g^{-1} and antioxidant activity of 336 mM TEC 100 g^{-1}; after the cooking procedure, the samples showed lower content of both parameters (5.25 mg C3G 100 g^{-1} and antioxidant activity of 305 mM TEC 100 g^{-1}) Anthocyanins, largely present in grape products, are soluble and heat-sensitive pigments with high antioxidant activity present outside the cellular vacuoles of vegetable cells (Torres, Díaz-Maroto, Hermosín-Gutiérrez, & Pérez-Coello, 2010). Thus, the lower content of monomeric anthocyanins in the cooked pasta may be due to intense leaching during the cooking procedure and/or due to thermal degradation. Results suggest that the capability of the pasta of scavenging the ABTS free radicals is related to the presence of anthocyanins in the final product.

The concentration of total phenolic content and condensed tannin content in the raw and cooked pasta was not affected ($p > 0.05$) by the cooking procedure. Most glycosides of phenolics are stored inside the organelles of vegetable cells (Chism & Haard, 1996; Sakihama, Cohen, Grace, & Yamasaki, 2002; Torres et al., 2010), which may cause a protective effect for these compounds. Moreover, Sant'Anna, Brandelli, et al. (2012) observed that condensed tannin content from grape marc are phenolics that are highly bounded to the plant matrix, which suggests that these compounds are not suitable to the leaching phenomenon. The results indicate that the presence of polyphenols was little affected by the processing conditions, and incorporation of grape juice residue in fettuccini pasta may be a viable way to allocate this phenolic-rich ingredient.

3.3. Color analysis

The results of the CIELAB analysis of the fettuccini pasta are presented in Table 3. L^*-values decreased with the increase of incorporation of grape marc powder in the pasta blend, indicating that the samples turned darker, as the formulation was changed by the incorporating a blackish ingredient instead of a white ingredient (wheat flour). The increase of the a^*-values were accompanied by the increase of the incorporation of the grape marc powder; this was expected, since the a^* parameter is related to the redness of the analyzed sample and the grape residue added to the pasta blend is an anthocyanin-rich product. Positive b^*-values, on the other hand, are related to the yellowness of samples, thus it did not present any pattern in the fettuccini preparation. The cooking procedure implied in high reduction of the L^* and a^* parameter, possibly due to the leaching process of the anthocyanins. The difference of color (ΔE) calculated by the Equation (1) showed that control pasta presents slight color difference with ΔE of 8.52. Incorporation of the grape marc powder resulted in high loss of changes of color of the pasta after the cooking procedure. ΔE for incorporation of FP25, FP50 and FP75 were 22.26, 15.67 and 21.23, respectively, due to leaching and thermal degradation of pigments in the fettuccini pasta.

Table 3
Color parameters of raw and cooked fettuccini pasta by CIELAB method.

Samples	L^*	a^*	b^*
RFP0	70.6 ± 4.5^{aA}	0.41 ± 0.00^{aA}	15 ± 1^{aA}
CFP0	65 ± 1^{aA}	-0.16 ± 0.00^{bA}	15.13 ± 0.09^{aA}
RFP25	69 ± 6^{aA}	2.76 ± 0.11^{aB}	10.21 ± 0.54^{aB}
CFP25	47 ± 2^{bB}	3.15 ± 0.19^{bB}	7.84 ± 0.31^{bB}
RFP50	70 ± 4^{aA}	2.19 ± 0.11^{aC}	11.44 ± 0.73^{aB}
CFP50	54 ± 1^{bC}	1.66 ± 0.01^{bC}	9.04 ± 0.26^{bC}
RFP75	50.5 ± 2.5^{aB}	5.25 ± 0.31^{aD}	6.92 ± 0.63^{aC}
CFP75	30 ± 3^{bD}	2.90 ± 0.03^{bD}	2.18 ± 0.14^{bD}

^{a,b} Different superscripts indicate statistical differences ($p < 0.05$) between raw and cooked pasta.
^{A,B,C,D} Different superscripts indicate statistical differences ($p < 0.05$) due to the addition of grape marc powder.
Present data are mean values of three replication.

3.4. Sensory analysis

Fig. 1 shows the results of the sensory analysis of the fettuccini pasta developed with the substitution of wheat flour by grape marc powder, where higher scores are related to better acceptance of the evaluated attribute.

Sensory evaluation of fettuccini pasta samples showed that, in general, the substitution of wheat flour resulted in lower level of liking. Fig. 1 also shows that the acceptance of flavor, aftertaste and texture did not depend of the concentration of grape marc powder added to the pasta formulation. Foschia et al. (2013) stated that the main challenge of adding rich-fiber ingredients in cereal products is the adverse effects on the end product quality, mainly due to changes on texture and color properties. The analysis of variance (ANOVA) showed that the appearance of FP25, the product with the lowest addition of grape marc powder, did not differ significantly ($p > 0.05$) from the control samples, while this attribute in FP50 and FP75 had significant change ($p < 0.05$). Since there was the incorporation of a different ingredient, panel members possibly identified a variation of the aspect of traditional pastas, leading to a slight rejection of this sample pasta in comparison to the pasta made only with wheat flour. Likewise, product color was significantly affected ($p < 0.05$) due the substitution of the wheat flour. However, the fettuccini pasta added to grape marc powder in different concentrations did not differ significantly ($p > 0.05$) among them.

Pasta is a complex matrix and the mechanisms of interaction of plant residues incorporation in the formulation still remain unknown. In relation to texture, fettuccini pasta added to dried grape residue had significantly ($p < 0.05$) lower acceptance in relation to the control sample, but did not differ significantly ($p > 0.05$) among them,

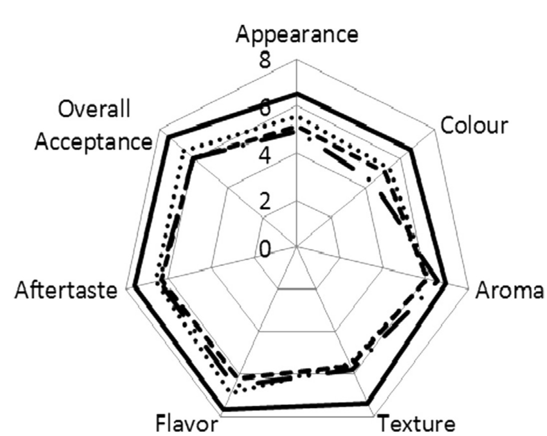

Fig. 1. Sensory analysis of four different fettuccini pasta: FP0 (control samples, without addition of grape marc powder), FP25 (substitution of 25 g/kg of wheat flour by grape mar powder), FP50 (substitu tion of 50 g/kg of wheat flour by grape marc powder), FP75 (substitution of 75 g/kg of wheat flour by grape marc powder). ——— FP0, ······ FP25, - - - - FP50 and — · FP75.

according to the ANOVA. Addition of fiber-rich products may increase the water absorption of the blend, due to the interaction between water and hydroxyl groups of polysaccharides through hydrogen bonding, resulting in higher hardness of the final product (Mildner-Szkudlarz et al., 2011). In this agreement, Brennan and Tudorica (2008) observed that the incorporation of 100 g/kg of inulin in semolina decreased pasta firmness. This fact may possibly have induced lower acceptance of the fettuccini pasta added to dried grape marc.

FP25 samples had similar ($p > 0.05$) acceptance of flavor and overall acceptance in comparison with the control sample, although it presented significant ($p < 0.05$) rejection in relation to aftertaste. Higher substitution resulted in lower acceptability ($p < 0.05$) of flavor, aftertaste and overall acceptance. Fettuccini pasta added to grape marc powder did not differ significantly ($p > 0.05$) among them in these attributes. This fact is possibly related to the fact that grape juice residue presents high concentration of catechins and tannins (Sant'Anna, Brandelli, et al., 2012, Sant'Anna et al., 2013; Torres et al., 2010), which are responsible for astringent flavors (Scharbert & Hofmann, 2005). Then, the increase of the incorporation of grape marc powder may increase the undesirable sensory attribute, implying in high rejection of the product.

Mildner-Szkudlarz et al. (2011) verified that it is possible to mix rye bread with up to 60 g/kg of grape marc with satisfactory sensory performance. The FP25 formulation presented the best global acceptance among the samples developed, corroborating the idea of using plant residues as an alternative to produce foods.

4. Conclusion

The present work investigated the incorporation of grape marc powder in fettuccini pasta composition. The results showed that the incorporation of 25 g/kg of grape marc powder did not interfere in the pasta cooking quality, and increased the polyphenolic concentration and the antioxidant activity in the product. Sensory analysis suggested that this formulation had similar acceptance and color changes, according to the CIELAB method, in comparison with the traditional fettuccini pasta. Acceptance of pasta flavor, aftertaste and texture did not depend of the concentration of grape marc powder added to the pasta formulation in the incorporation range evaluated. It is important to understand the bioavailability of these polyphenols in a product matrix, in order to provide real values for our health and well-being. Therefore, more studies are essential to allow the proper utilization of grape marc powder as a functional ingredient.

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