ROOTS AND TUBERS WHOLEMEAL IN INSTANT NOODLES: TECHNOLOGICAL AND FUNCTIONAL EVALUATION

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RESUMO – O consumo de macarrão instantâneo (MI) cresceu significativamente entre a categoria de massas alimentícias. No entanto, o MI apresenta grande quantidade de gordura residual por ser um produto frito. A ingestão de alimentos com altos teores de gordura pode predispor o desenvolvimento de doenças cardiovasculares bem como a obesidade. Deste modo, o objetivo deste trabalho foi elaborar MI com substituição parcial da farinha branca por farinha de batata doce, beterraba, cenoura ou açafrão. Os MI elaborados foram analisados quanto ao teor de gordura, propriedades de cozimento, textura instrumental, capacidade antioxidante e índice glicêmico. Os resultados mostraram que é possível realizar a maior substituição da farinha de trigo dentro dos ensaios estudados, obtendo-se MI com características semelhantes à amostra padrão, com maior capacidade antioxidante e baixo índice glicêmico.

ABSTRACT – The instant noodle (IN) consumption has increased significantly among the pasta global consumption. However, the IN has a significant quantity of residual fat due to being a fried product. The consumption of food with high-fat content might predispose the development of cardiovascular diseases and obesity. This work aimed to evaluate the partial replacement of refined wheat flour by purple sweet potato, beet and carrot wholemeal, or turmeric wholemeal in IN production. The INs were evaluated regarding the fat content (after frying and rehydration), cooking properties, instrumental texture, antioxidant capacity and glycemic index. The results indicated that is possible to replace partially the wheat flour in the studied conditions, achieving an IN with similar technological characteristics to the standard sample, but with higher antioxidant capacity and low glycemic index.

PALAVRAS-CHAVE: batata doce roxa, beterraba, cenoura, açafrão, capacidade antioxidante.

KEYWORDS: purple sweet potato, beet, carrot, turmeric, antioxidant capacity.

1. INTRODUCTION

The world market of instant noodles (IN) is increasing every year due to the practice of preparation and low cost. The high consumption of IN leads to a health concern seeing that it is a fried product, with a high fat content (15-25%). The fat content of the noodles is incorporated during the dehydration process in hot oil (frying) after the steam cooking. When the IN is submerged in the hot
oil, the water on the surface evaporate, resulting in a migration of the remaining water to the external layers, forming a porous structure (Guilia and Khatkar, 2013; Bae et al., 2015).

The consumption of foods with high fat content, such IN, acts as a risk to cardiovascular diseases, obesity and other health diseases (Saguy and Dana, 2003). Furthermore, the IN is predisposed to fat oxidation and hydrolysis, promoting physical and chemical changes, releasing compounds related to functional and nutritional modifications which modulate the final product quality (Gupta et al., 2004).

The scientific advances about beneficial compounds and its connection with health enhance the search for functional foods. Between these compounds, there are some that have the antioxidant capacity, with a health claim for regular consumers. The antioxidants work by delaying and/or inhibiting the oxidation of the substrates involved in oxidative processes, preventing the formation of free radicals.

Among the sources of antioxidant compounds, the purple sweet potato figures acting in the prevention of chronic noncommunicable diseases due to being rich in phenolic compounds that present a high antioxidant capacity (Rodrigues-Amaya, 2008); the beet, containing the betalain compound, acts on the cancer prevention; the carrot, that is rich in β-carotene, a carotenoid; and the turmeric, rich in curcuminoids which act by decreasing cholesterol levels and operate as anticarcinogenic agents. In addition of the antioxidant compounds, these raw of materials are rich in dietary fibers, which are connected with the prevention of type 2 diabetes, whereas they help to reduce the glycemic index and regulating the insulin release (Mello et al., Laaksomen et al., 2009). Moreover, the use of the whole roots and tubers contribute to aggregate nutritional value, reducing waste belong the agroindustrial chain, since there are major losses of materials which have no apparent economic value between the productions and consumption.

Finally, the aim of this work was to evaluate the partial replacement of refined wheat flour by 5 or 10% of purple sweet potato, beet or carrot wholemeal or 1 or 2% of turmeric wholemeal in instant noodles production. The trials were evaluated by the fat content (after frying and rehydration), cooking properties, instrumental texture, antioxidant capacity and glycemc index.

2. MATERIAL AND METHODS
2.1 Materials

The raw materials used were wheat flour - WF (Moinho Paulista, Santos, BRA), sodium chloride and palm fat 370F (Cargill, Belém, BRA). Purple sweet potato (PSP), carrot (C) and beet (B) in the whole form and the turmeric (T) in powder form were purchased from the local market.

2.2 Methods

PSP, B and C were cleaned, sanitized, cut, blanched, frozen, freeze-dried and ground. Together with WF and T, the raw materials were characterized regarding lipids, protein, ash, total starch and total dietary fiber, according to methods 30-25.01, 46-13.01, 08-01.01, 76-13.01 and 32-05.01 (AACC, 2010), respectively.

The INs were elaborated according to Vernaza et al. (2011). The trials were identified as: WF – 100% WF; PSP5 and PSP10 with 5 and 10% of PSP; B5 and B10 with 5 and 10% of B; C5 and C10 with 5 and 10% of C; T1 and T2 with 1 and 2% of T; being that in replacement of WF. The INs were analyzed regarding the fat uptake after frying and fat loss by rehydration through the method 30-25.01, and solid loss and weight gain by the method 66-50.01 (AACC, 2010). The instrumental texture was analyzes in a TA-XT2i texturemeter (Stable Micro Systems, Haslemere - GBR) through the method 66-50.01 (AACC, 2010) using a platform HDP/90, for evaluating the firmness and adhesiveness. The parameters used were: pre-test (2.0mm.s⁻¹), test (0.17mm.s⁻¹), post-test (10.0mm.s⁻¹), distance (4.7mm), and probe (A/LKB) for firmness and pre-test (1.0mm.s⁻¹), test (0.5mm.s⁻¹), post-test (10.0mm.s⁻¹), distance (10.0mm), force (1000g), time (2s) and probe (HDP/PFS) for adhesiveness.

A control sample (WF) and with the highest levels of WF replacement (PSP10, B10, C10 and T2) were evaluated in relation to antioxidant capacity through the ORAC (Dávalos et al., 2004)
and ABTS (Re et al., 1999) methods. For these same samples was evaluated the glycemic index according to the method described by Goñi et al. (1997). All the results were analyzed by analysis of variance and mean comparison through Scott-Knott test, at 5% of significance level.

3. RESULTS AND DISCUSSION

The WF showed a high protein level and low ash content, indicating that the wheat flour was a good flour for pasta and noodles preparation and for gluten network development. There was also verified that wheat flour, purple sweet potato and turmeric presented higher levels of total starch, while beet and carrot presented the highest levels of total dietary fiber and other components (probably sugars) Table 1.

The technological parameters results are shown in Table 2. The fat loss by rehydration was higher (P<0.05) for all the trials with higher levels of roots and tubers addition. This found make the use of this kind of flours newsworthy, because the Brazilian people has the habit to discard the excess of rehydration water, resulting in a lower fat intake. The weight gain was higher for B10 and no differences were observed for PSP10, C10 and T2 when compared to the standard sample. Like this, the higher levels of PSP and B showed no difference, lofty for C (probably due to the sugar content and the gluten network weakened by the fibers) and reduced for T, in relation to the standard sample.

Table 1 – Chemical composition of the flours

<table>
<thead>
<tr>
<th>Sample</th>
<th>Wheat</th>
<th>Purple sweet potato</th>
<th>Beet</th>
<th>Carrot</th>
<th>Tumeric</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fat</td>
<td>Ash</td>
<td>Protein</td>
<td>Total starch</td>
<td>Total dietary fiber</td>
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<tr>
<td></td>
<td>(g.100g&lt;sup&gt;1&lt;/sup&gt;)</td>
<td>(g.100g&lt;sup&gt;1&lt;/sup&gt;)</td>
<td>(g.100g&lt;sup&gt;1&lt;/sup&gt;)</td>
<td>(g.100g&lt;sup&gt;1&lt;/sup&gt;)</td>
<td>(g.100g&lt;sup&gt;1&lt;/sup&gt;)</td>
</tr>
<tr>
<td>WF</td>
<td>1.37±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.58±0.01&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.40±0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.70±0.38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.94±0.08&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>B5</td>
<td>0.62±0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.55±0.05&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.68±0.38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.68±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.36±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>B10</td>
<td>12.67±0.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.96±0.50&lt;sup&gt;c&lt;/sup&gt;</td>
<td>16.56±0.22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.66±0.14&lt;sup&gt;d&lt;/sup&gt;</td>
<td>7.57±0.03&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>PSP5</td>
<td>71.23±4.57&lt;sup&gt;b&lt;/sup&gt;</td>
<td>51.68±3.30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.71±0.09&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.65±0.49&lt;sup&gt;d&lt;/sup&gt;</td>
<td>40.13±3.38&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>PSP10</td>
<td>3.80±0.26&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12.39±0.19&lt;sup&gt;d&lt;/sup&gt;</td>
<td>27.85±0.16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>30.81±0.54&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23.71±0.39&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>C5</td>
<td>10.31±2.05&lt;sup&gt;d&lt;/sup&gt;</td>
<td>25.84±1.50&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>45.95±0.21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>48.00±0.37&lt;sup&gt;b&lt;/sup&gt;</td>
<td>24.11±1.52&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means of three repetitions±standard deviation; <sup>1</sup>values expressed in dry basis; <sup>2</sup>calculated by difference (100-fat-ash-protein-total starch-total dietary fiber); <sup>3</sup>calculated by conversion factor of nitrogen content of 5.7 for wheat flour and 6.25 for roots or tubers flours; means with different letters in the same column indicate statistically significant differences between samples by Scott-Knott test (P<0.05).

Table 2 – Technological parameters of instant noodles

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fat content (g.100g&lt;sup&gt;1&lt;/sup&gt;)</th>
<th>Fat loss (g.100g&lt;sup&gt;1&lt;/sup&gt;)</th>
<th>Weight gain (g.100g&lt;sup&gt;2&lt;/sup&gt;)</th>
<th>Solid loss (g.100g&lt;sup&gt;2&lt;/sup&gt;)</th>
<th>Firmness (N&lt;sup&gt;c&lt;/sup&gt;)</th>
<th>Adhesiveness (N.s)&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>WF</td>
<td>23.85±0.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>34.69±1.07&lt;sup&gt;c&lt;/sup&gt;</td>
<td>151.69±4.46&lt;sup&gt;e&lt;/sup&gt;</td>
<td>11.20±0.24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.28±0.15&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.055±0.011&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>B5</td>
<td>22.05±0.33&lt;sup&gt;d&lt;/sup&gt;</td>
<td>21.16±0.77&lt;sup&gt;f&lt;/sup&gt;</td>
<td>127.09±11.57&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.35±0.90&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.26±0.09&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.058±0.013&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>B10</td>
<td>26.06±0.64&lt;sup&gt;a&lt;/sup&gt;</td>
<td>35.48±1.13&lt;sup&gt;c&lt;/sup&gt;</td>
<td>154.16±8.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.11±0.96&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.97±0.16&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.070±0.007&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>PSP5</td>
<td>22.01±1.49&lt;sup&gt;d&lt;/sup&gt;</td>
<td>42.21±1.83&lt;sup&gt;a&lt;/sup&gt;</td>
<td>133.68±4.58&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.77±1.17&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.21±0.15&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.067±0.010&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>PSP10</td>
<td>23.26±0.32&lt;sup&gt;c&lt;/sup&gt;</td>
<td>43.68±0.74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>129.86±6.68&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>11.75±0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.47±0.11&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.099±0.013&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>C5</td>
<td>24.37±1.18&lt;sup&gt;b&lt;/sup&gt;</td>
<td>28.93±1.31&lt;sup&gt;d&lt;/sup&gt;</td>
<td>132.15±10.53&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.32±0.42&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.18±0.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.061±0.014&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>C10</td>
<td>23.98±0.76&lt;sup&gt;b&lt;/sup&gt;</td>
<td>39.17±0.79&lt;sup&gt;b&lt;/sup&gt;</td>
<td>138.96±7.07&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>11.64±1.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.20±0.18&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.068±0.014&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>T1</td>
<td>21.90±0.58&lt;sup&gt;d&lt;/sup&gt;</td>
<td>25.59±0.89&lt;sup&gt;e&lt;/sup&gt;</td>
<td>151.11±7.24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.56±1.27&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.01±0.11&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.033±0.008&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>T2</td>
<td>21.92±0.52&lt;sup&gt;d&lt;/sup&gt;</td>
<td>36.27±0.80&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>136.64±1.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.51±1.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.31±0.12&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.066±0.016&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>p-value&lt;sup&gt;3&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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</table>

<sup>1</sup>Means of three repetitions±standard deviation; <sup>2</sup>means of eight repetitions±standard deviation; <sup>3</sup>p-value of the analysis of variance.

For the firmness was observed a decrease for PSP10 and no difference was observed between the others roots and tubers wholemeal use with the higher levels in relation to the standard sample.
Besides that, the noodles with lower firmness resulted in highest adhesiveness, as a result from the solids leaching, favoring the stickiness (Schmiele et al. 2013). These results promote the use of the roots and tubers in the highest levels, favoring the presence of bioactive compounds with health benefits.

The antioxidant capacity was higher for ORAC in the hydrophilic extracts and for ABTS in the lipophilic extracts (Fig 1). The highest antioxidant capacity in the hydrophilic ORAC was observed for PSP10, followed by T2, and the other samples showed no difference between them. In the hydrophilic ABTS method, only in B10 and PSP10 was observed an antioxidant capacity, and PSP10 was the largest one.

Figure 1 – Antioxidant capacity for the ORAC and ABTS methods for hydrophilic and lipophilic extracts (i) and in vitro starch hydrolysis curve and glycemic index (ii).

The ABTS method in the lipophilic extracts showed the highest values to PSP10, followed by WF and no difference was observed between B10, C10 and T2. In the ORAC method, the highest antioxidant capacity was observed in T2, and no difference between the others. Moreover, the
hydrophilic extracts showed greater antioxidant capacity for ORAC in relation to ABTS, but it is important to explain that the mechanism of the ORAC and ABTS methods are different.

The bioactive compounds ferulic, sinapic and para-coumaric acids found in the wheat (Rosa et al., 2013) are water soluble components and it explains the considerable antioxidant capacity of hydrophilic extracts in comparison with lipophilic extracts. Betalains (mainly betacyanins) are water-soluble nitrogen-containing pigments with elevated stability to pH and temperature variations and might contribute to protection from age-related diseases due to his antioxidant capacity (Ravichandran et al., 2013). However, between the samples, B10 showed the lowest antioxidant capacity. Kano et al. (2005) identified 8 types of anthocyanins (mainly cyanidin or peonidin) in PSP with different solubility and more stables on account of the acylated form with phenolic acids (Xu et al., 2015), which probably explain the great performance obtained of PSP10 IN in the antioxidant capacity evaluation. Regarding C10 IN, the thermal processing can improve β-carotene bioaccessibility and bioavailability, but with a decrease of antioxidant capacity due to the molecule isomerisation (Knockaert et al., 2012). On the other hand, T2 IN has shown a high antioxidant capacity. This result is probably by virtue of the curcuminoids found in turmerics, such as curcumin (77%) with accentuated hydrophobicity, demethoxycurcumin (17%), and bisdemethoxycurcumin (3%) with lower hydrophobicity. These compounds have shown considerable antioxidant, anticancer, hypoglycemic and anti-inflammatory effects (Prassad et al., 2014).

The INs presented a low glycemic index, mainly when compared to white bread crumb. Besides that, the use of PSP and C showed the lowest glycemic index between the samples, probably because of the low digestible starch presents in PSP and the lofty dietary fiber content in C.

Foods with low glycemic indexes reflect in a better satiety (Brand-Miller and Gilbertson, 2002) and feedback of cholecystokinin and glucagon hormones responsible for fullness sense (Lemos et al., 2002). Besides that, diets with reduced glycemic indexes can cooperate with the weight control and appetite due to the stabilization of blood sugar levels, preventing diseases, such as type 2 diabetes and heart diseases.

### 4. CONCLUSION

The use of roots and tuber, manly purple sweet potato, beet, carrot and turmeric wholemeal in replacement of wheat flour in instant noodles manufacture showed promise results. The highest levels used in our work showed the best result, regarding cooking properties and instrumental texture. In addition, the use of this roots and tuber promote a final product with antioxidant capacity and low glycemic index, and can promote the wellness and wellbeing of the consumers, besides being a healthier diet.

### 5. ACKNOWLEDGMENTS

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### 6. REFERENCES


