Preparation and physico-chemical characterization of mutton mortadella supplemented with yacón meal

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RESUMEN

La harina de patata yacon, viene siendo utilizada como suplemento en diversos productos. Entre los componentes funcionales presentes en la patata yacon, se destacan los frutanos, del tipo inulina, fruto-oligosacáridos y compuestos fenólicos, siendo considerados agentes promotores de beneficios a la salud. La utilización de carne ovina en la producción de mortadelas también ha sido empleada, siendo viable debido a su calidad nutricional y sensorial. Este estudio tuvo como objetivo la elaboración y caracterización físico-química de diferentes formulaciones de mortadelas a base de carne ovina, suplementadas con diferentes concentraciones de harina de patata yacon y con contenidos reducidos de lípidos y cloruro de sodio. Se prepararon cuatro formulaciones de mortadelas que contenían carne ovina, grasa porcina, harina de patata yacon, sales NaCl, KCl y CaCl2, nitrito de sodio, eritrocitos de sodio, azúcar y agua. Los análisis físico-químicos realizados fueron: humedad, cenizas, proteínas, lípidos, color, pH y Aw. Los valores de humedad variaron entre 61,2 a 59,7%, cenizas de 2,5 a 2,9%, proteínas de 16,6 a 18,7% y lípidos del 19,1 al 14,3%. Todas las cuatro formulaciones cumplieron las exigencias mínimas, en relación a los parámetros físico-químicos, establecidos en la legislación brasileña para el procesamiento de mortadelas. Los parámetros pH y Aw mantuvieron la uniformidad y en el parámetro coloración hubo variación entre las diferentes formulaciones, pudiéndose inferir que la introducción de diferentes niveles de harina de la patata yacon y grasa porcina interfirieron en la coloración de las mortadelas. Se ha comprobado que la utilización de nuevas materias primas e ingredientes que contienen componentes funcionales son una alternativa prometedora en el contexto de la elaboración de productos cárnicos más saludables.
Yacón meal has been used as supplement in several food products. Functional components of yacón meal include fructans such as inulin, fructooligosaccharides, and phenolic compounds with proved benefits to human health. Mutton has become a viable alternative in mortadella production due to its nutritional and sensory attributes. This study describes the preparation and analysis of mortadella formulations prepared with mutton and supplemented with different amounts of yacón meal and reduced contents of sodium chloride and lipids. Four formulations were prepared with mutton, pork fat, yacón meal, NaCl, KCl, CaCl₂, sodium erythorbate, sugar, and water. Moisture, ash, protein, and lipid contents were analyzed, as well as pH, color, and Aw. Moisture, ash, protein, lipid contents varied within the ranges of 59.7% - 61.2%, 2.5% - 2.9%, 16.6% - 18.7%, 14.3% - 19.1%, respectively. All formulations met the minimum physico-chemical standards established by the Brazilian legislation for mortadella production. pH and Aw did not vary significantly across formulations, though color may have been affected by the addition of yacón meal and pork fat. New raw materials and ingredients containing functional components stand as a promising alternative in the healthier meat products.

Key words: functional components | mortadella | mutton | *Smallanthus sonchifolius*
interesting alternative in the supplementation of skin-encased foods with functional components.

Mortadella is one of the skin-encased meat products most consumed in Brazil. Due to its good nutritional and sensory attributes, mutton is used in the production of mortadella. Several studies have described the production of this food item using sheep meat (Guerra et al., 2011; Leite et al., 2015).

One of the main concerns in the production of healthy foods is the reduction of sodium chloride (NaCl) levels, mainly in skin-encased products. High NaCl contents in foods play a direct role in arterial hypertension. Studies have investigated alternatives to reduce sodium levels in skin-encased products based on the use of sodium-free salts like potassium chloride (KCl) and calcium chloride (CaCl₂) (Aliño et al., 2010; Horita et al., 2011).

In this context, the present study describes the physico-chemical characterization of mortadella formulations prepared with mutton and supplemented with various concentrations of yacón meal and lower contents of lipids and NaCl.

MATERIALS AND METHODS

Study location and raw materials

The mortadella formulations used were prepared in the Laboratório de Processamento de Carnes, while the physico-chemical analyses of the products were carried out in the Laboratório de Química Aplicada, Instituto Federal do Espírito Santo (IFES), Campus de Alegre, municipality of Alegre, state of Espírito Santo, Brazil.

Mutton shoulders frozen at -18ºC were purchased from an export company (Caltes SA) located in the municipality of Paso de los Toros, Uruguay and transported under identical conditions to IFES, Campus de Alegre, where the meat was stored at the same temperature. All mutton cuts were slowly thawed under controlled temperature (2ºC to 4ºC).

Yacón meal was purchased from a wholefood shop (P.C. Campos Produtos Naturais, Rio de Janeiro, state of Rio de Janeiro, Brazil). The other ingredients and additives used in formulations were bought at local specialized shops.

Preparation of mortadella formulations

Based on preliminary assays and a literature review (Brasil, 2000; Guerra et al., 2011), four mortadella formulations were prepared using different amounts of mutton, pork fat, yacón meal, NaCl, KCl, CaCl₂, sodium nitrite (NaNO₂), sodium erythorbate, sugar, and water (Table 1). Approximately 4 kg of mortadella were prepared using each formulation.
Table 1 - Mortadella formulations shown as percent contents of raw materials and additives (%)

<table>
<thead>
<tr>
<th>Raw materials and additives</th>
<th>Control</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutton</td>
<td>76.66</td>
<td>76.66</td>
<td>76.66</td>
<td>76.66</td>
</tr>
<tr>
<td>Pork fat</td>
<td>20.00</td>
<td>18.00</td>
<td>16.00</td>
<td>14.00</td>
</tr>
<tr>
<td>NaCl</td>
<td>2.20</td>
<td>1.65</td>
<td>1.65</td>
<td>1.65</td>
</tr>
<tr>
<td>KCl</td>
<td>0.00</td>
<td>0.275</td>
<td>0.275</td>
<td>0.275</td>
</tr>
<tr>
<td>CaCl2</td>
<td>0.00</td>
<td>0.275</td>
<td>0.275</td>
<td>0.275</td>
</tr>
<tr>
<td>Sugar</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Water</td>
<td>1.00</td>
<td>2.00</td>
<td>3.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Yacón meal</td>
<td>0.00</td>
<td>1.00</td>
<td>2.00</td>
<td>3.00</td>
</tr>
<tr>
<td>NaNO2</td>
<td>0.015</td>
<td>0.015</td>
<td>0.015</td>
<td>0.015</td>
</tr>
<tr>
<td>Sodium erythorbate</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
</tr>
</tbody>
</table>

1 Kitchen salt, Cisne®
2 Analytical grade, Merck®
3 Muscovado sugar, União®
4 Yacón meal, Flor da Mata®
5 Curing salt, Kura K007 Doremus®
6 Antioxidant, Griffith®

Initially, mutton was manually mixed with scalded diced pork fat. Next, the different predefined amounts of NaCl, KCl, CaCl2, NaNO2 and the other additives were manually added and mixed to formulations. Then, yacón meal was added and mixed to mortadella preparations, also manually. Subsequently, formulations were put in stainless steel molds and cooked in a double bath at 80°C until the temperature in the center of mortadellas reached 74°C. Cooked mortadellas were then vacuum-packaged made of the nylon and pomade of nylon and polyethylene layers, labeled, and kept at 4°C upon analysis.

Physico-chemical characterization

Moisture content was analyzed by direct drying in a stove at 105°C. Ash levels were assessed based on the amount of incineration bottom, while protein concentrations were established according to the classic Kjeldahl method. Lipid levels were analyzed according to the method described by AOAC (2000).

Water activity (Aw) was determined by direct reading in a specific meter device (Aqualab TE, Decagon Devices Inc.). Samples were washed,
homogenized, and analyzed. pH was assessed using a pH meter (Schott Handylab).

Color analyses were carried out using a portable spectrometer (MiniScan EZ-Hunterlab) and D65 as illuminant at a 10° observation angle according to the CIELab system. The results were shown as angular coordinates, in which the L* axis reflects the lightness of a color (L* = 0 represents absolute black, L* = 100 represent absolute white), the a* axis represents the green shades (-80 < a* < 0 denotes green, 0 < a* < 100 denotes red), and the b* axis is for the color yellow (-100 < b* < 0 represents blue, 0 < b* < +70 represents yellow).

Statistical analyses

The results of the physico-chemical analyses were compared using a complete randomized design with four treatments and three repeats for each mortadella formulation (control, F1, F2, and F3). The results were submitted to an analysis of variance (ANOVA), and means of treatments were compared using the Tukey test at 5% probability. The analyses were carried out in the Statistical Analysis System (SAS, version 9.2).

RESULTS AND DISCUSSION

Table 2 shows the results of the physico-chemical analyses of mortadella formulations as means and standard deviations, and the reference values listed by the Regulamento Técnico de Identidade e Qualidade de Mortadella (RTQI).

Table 2 - Physico-chemical parameters (mean and standard deviation) of mortadella formulations and reference values (RTQI).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Formulations</th>
<th>Control</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>RTQI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>61.2±0.1 a</td>
<td>60.9±0.1 a</td>
<td>60.3±0.2 a</td>
<td>59.7±0.2 a</td>
<td>Max.65%</td>
<td></td>
</tr>
<tr>
<td>Ash (%)</td>
<td>2.5±0.0 a</td>
<td>2.6±0.1 a</td>
<td>2.6±0.0 a</td>
<td>2.9±0.0 a</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Proteins (%)</td>
<td>16.6±0.3 a</td>
<td>18.3±0.1 a</td>
<td>18.8±0.2 a</td>
<td>18.7±0.2 a</td>
<td>Min.12%</td>
<td></td>
</tr>
<tr>
<td>Lipids (%)</td>
<td>19.1±0.1 a</td>
<td>17.0±0.0 b</td>
<td>15.6±0.1 c</td>
<td>14.3±0.1 d</td>
<td>Max.30%</td>
<td></td>
</tr>
<tr>
<td>Aw</td>
<td>0.97±0.0 a</td>
<td>0.97±0.0 a</td>
<td>0.97±0.0 a</td>
<td>0.97±0.0 a</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.3±0.2 a</td>
<td>6.3±0.2 a</td>
<td>6.4±0.2 a</td>
<td>6.5±0.3 a</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td>52.7±1.8 a</td>
<td>53.5±1.5 a</td>
<td>53.0±1.8 a</td>
<td>50.7±2.1 b</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>a*</td>
<td>5.4±0.9 a</td>
<td>3.4±0.4 b</td>
<td>3.3±0.4 b</td>
<td>2.8±0.5 b</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>b*</td>
<td>10.5±0.4 a</td>
<td>10.6±0.3 a</td>
<td>10.5±0.4 a</td>
<td>10.7±0.4 a</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Values on the same line followed by different lowercase letters differ statistically (P < 0.05, Tukey test).
Moisture, ash, protein, and lipid contents in the mortadella formulations analyzed varied within the ranges of 59.7% - 61.2%, 2.5% - 2.9%, 16.6% - 18.7%, and 14.3% - 19.1%, respectively. It should be noted that the amounts of lipids added to each formulation were carefully controlled. The results obtained are similar to the findings published by other authors in studies about skin-encased mutton products. Abdullah (2004) evaluated the physico-chemical parameters of mortadella prepared with mutton and reported moisture, ash, protein, and lipid contents of 62.7%, 2.87%, 13.4%, and 20.7%, respectively. In turn, Guerra et al. (2011) evaluated mortadella formulations prepared with mutton and different amounts of pork fat (10%, 20%, and 30%). Moisture contents varied between 55% and 68%, ash levels were 2.7%, and contents of proteins and lipids were in the ranges of 12% - 17% and 10% - 30%, respectively. In a recent investigation, Leite et al. (2015) assessed the physico-chemical characteristics of wieners prepared with mutton and different pork fat contents (0%, 10%, and 30%). Moisture, ash, protein, and lipid contents were within the ranges of 58% - 67%, 3.7% - 4.3%, 14% - 18%, and 0% - 30%, in that order.

In the present study, mean moisture content, Aw, and pH of mortadella formulations did not differ significantly (P > 0.05). For Guerra et al. (2011), moisture content, Aw, and pH are very important parameters in boiled skin-encased products, since high values indicate the existence of favorable conditions to the development of undesired microorganisms, while low values of these parameters affect texture and flavor of these products.

The results of the present study show that the increasing amounts of yacón meal and lower levels of fat produced mortadella formulations with lower moisture content, but without differ statistically. Leite et al. (2015) also reported that moisture content in wieners increased with the addition of lower levels of fat to formulations. Lorenzo & Franco (2012) observed a similar relationship between moisture and fat contents in various kinds of skin-encased meat products. All mortadella formulations analyzed in the present study met the moisture content standard levels established by the Brazilian regulations, which define a maximum limit of 65% moisture for these products (Brasil, 2000).

An important aspect regarding moisture contents in the mortadella formulations analyzed is that even though increasing amounts of water were used in the preparation of formulations F1, F2, and F3, moisture contents in the products did not increase. This may have been due to the high water-holding capacity of yacón meal.

Lipid contents varied significantly between the mortadella formulations prepared and analyzed in the present study (P < 0.05). This result was expected, since the incorporation of pork fat was controlled and diminished from the control to formulations F1, F2, and F3. Yet, it should be emphasized that all formulations met the maximum limit of 30% fat established by Brazilian regulations (Brasil, 2000). For Guerra et al. (2011), lipid content
plays a very important role in the sensory attributes of in mortadella, directly affecting texture and flavor.

Differently, no statistically significant difference was observed in protein and ash contents between treatments (P > 0.05). It should be emphasized that protein content of all formulations was above the minimum value established by Brazilian regulations, 12% (Brasil, 2000). Importantly, proteins work as stabilizers in emulsified products, reducing the tension in the lipid-water interface and eventually helping both blend and preventing the coalescence and loss of lipids. In addition, the essential role of proteins in the preparation of emulsified skin-encased products with acceptable sensory attributes has been described (Guerra et al., 2011).

The objective evaluation of color is carried out based on the values of L*, a*, and b*. The formulations F1, F2, and control had L* values between 52.7 and 53.5, with no statistically significant difference (P > 0.05). Only formulation F3 differed from the other formulations in L* value, which was 50.7 (P < 0.05). The lower L* value indicates that F3 was of a darker color, compared to the other formulations.

The a* values between 2.8 and 5.4 indicate that the mortadella formulations analyzed were of intense red color (0 < a* < +100). Statistically significant difference was observed between the control formulation and the three mortadella formulations investigated (P < 0.05), when the control formulation was of the showed most intense red (5.4). In turn, b* values varied between 10.5 and 10.7, indicating intense yellow (0 < b* < +70), with no statistically significant difference (P > 0.05). It is possible that color of the mortadella formulations varied due to the use of yacón meal, which is of a dark hue. However, the addition of different contents of fat, which is of a lighter hue, may also explain the color of the mortadella formulations investigated. Sánchez-Rodríguez & Santos (2001) claim that water and lipid contents may considerably influence L* values, as observed in the present study.

As a rule, consumers prefer foods that are healthy, safe, of high sensory quality and quick to prepare. Research has discussed the advantages of supplementing foods with meal obtained from plant species. These studies had challenging aims, such as the development of new products and the search for technological alternatives as a means to boost the availability of functional components in these plant species concerning foods consumed daily. In this sense, several foods have been supplemented with yacón meal, like ham, yogurt, sweets containing various jellification agents, cakes, and bread (Maldonado & Singh, 2008; Rosa et al., 2009; Rolim et al., 2010). It should be noted that the production of yacón meal by dehydration is interesting not only because it affords longer shelf life of the product, but also because it makes easier to incorporate it to cakes, cookies, sweets, skin-encased products, juices, and other food items.
The advantage of using mutton to produce mortadella lies in the fact that this meat is widely consumed in various countries and due to its high nutritional value, compared with other red meats. Furthermore, mutton is not banned for religious reasons, like beef and pork. Mutton is rich in protein of biological value containing all essential amino acids, in addition to its low fat contents, ideal fatty acid levels, high iron concentrations, and attractive color and texture. The chemical composition of mutton may vary mainly with factors associated with nutrition, genetics, farming system, gender, age, and live weight at slaughter (Santos et al., 2009).

Mutton has been used in the production of skin-encased meat products due to its nutritional value (Pelegrini et al., 2008; Osório et al., 2009). With lower percent contents of fat, compared with other kinds of meat, mutton is a promising alternative in the production of skin-encased products with appropriate fat contents. In addition, some countries face the need to make use of the meat from culled animals, whose market value is low but nevertheless may still be used in the production of processed foods, adding value to an otherwise undesired kind of meat and enlarging the product mix that may be offered to customers (Abdullah, 2004; François et al., 2007).

Importantly, the addition of the salts did not affect the physico-chemical characteristics of the mortadella formulations analyzed. In this sense, studies have proposed the replacement of NaCl by sodium-free salts as a means to produce healthier skin-encased meat products (Ruusunem et al., 2003; Desmond, 2006; Aliño et al., 2010; Maia Júnior et al., 2013). NaCl plays an important role in the processing of meat products, improving texture, flavor, and smell. The salt is also known to affect protein solubilization, in addition to its bacteriostatic effect and its potential to enhance preservatives that in turn define a product’s shelf life (Ruusunem et al., 2003). KCl is today the preferred substitute for NaCl in meat products designed with low sodium contents, though it lends saltier, bitter, and metallic taste to them. But researchers like Desmond (2006) claim that such bitter taste may be attenuated using masking agents such as sugar. Recently CaCl$_2$ has also been used as a substitute for NaCl in meat products. Aliño et al. (2010) reported that the replacement of 50% of NaCl% by 25% of CaCl$_2$ and 25% of KCl did not affect color, appearance, and smell of meat products.

CONCLUSION

The results of the present study show that new raw materials and ingredients containing functional components are a promising alternative in the production of healthier meat products. The inclusion of various amounts of yacón meal in mutton mortadella formulations afforded to reduce lipid contents and use sodium-free salts. Physico-chemical parameters of the mortadella formulations analyzed met the standards defined by the Brazilian legislation.

Partnerships between research centers and the food industry play an important role in the search for innovations aiming to meet customer demands
and produce healthier foods on commercial scale and legal physico-chemical requirements.

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REFERENCES


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