# Evaluation of pumpkin flour (*Cucurbita moschata* Duch.) added as a meat extender in Frankfurt-type sausages

## Evaluación de la harina de zapallo (*Cucurbita moschata* Duch.) adicionada como extensor cárnico en salchichas tipo Frankfurt

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### Abstract

The objective of this study was to evaluate the physicochemical properties of Frankfurt sausages made with pumpkin flour (*Cucurbita moschata* Duch.) (PF), as an extender substance and a partial replacement for wheat flour (*Triticum aestivum* L.) (WF). Three formulations with PF substitutions were evaluated: 10, 20 and 30%, along with a control formulation without substitution. The measured parameters included proximal composition, emulsion stability, water activity, water holding capacity, cooking loss, color and texture profile. Results showed that emulsion stability was not affected when substitution reached 20%, while the water holding capacity of the sausages increased by 3.81% when the 10% PF substitution was tested. Water activity, pH and cooking losses did not vary when the addition was 20% PF. The highest protein values were measured on the 20% substitution. Results showed that up to 20% WF replacement with PF guaranteed good quality sausages, resulting in a new possible development for the meat industry.

**Keywords**
Meat extender • meat products • proximal composition • sausage • texture profile

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**Resumen**

El objetivo de este estudio fue evaluar las propiedades fisicoquímicas de salchichas de tipo Frankfurt elaboradas con harina de zapallo (*Cucurbita moschata* Duch.) (PF) como elemento extensor en sustitución parcial de harina de trigo (*Triticum aestivum* L.) (WF). Se evaluaron tres formulaciones con sustitución de PF de la siguiente manera: 10, 20 y 30% y una formulación control, sin sustitución de WF por PF. Los parámetros de medición fueron composición proximal, estabilidad de la emulsión, pH, actividad de agua, pérdidas de cocción, color y perfil de textura. Los resultados mostraron que la estabilidad de la emulsión no se afecta hasta con una sustitución del 20%, mientras que la capacidad de retención de agua en la salchicha aumenta en 3,81% cuando se reemplaza hasta con 10% de PF. El pH, la actividad de agua y las pérdidas de cocción no presentaron variación al adicionar hasta 20% de PF. La salchicha con adición de PF que presentó un mayor valor de proteína fue del 20%. Los resultados mostraron que un reemplazo de hasta el 20% de WF por PF garantiza una salchicha de buena calidad, lo que plantea una nueva posibilidad para el desarrollo de la industria cárnica.

**Palabras clave**
extensor cárnico • productos cárnicos • composición proximal • salchicha • perfil de textura

## Introduction

Exponential population growth has led to an urgent need for new protein-rich alternatives (14, 18, 22) in human nutrition. According to data provided by the Ministry of Health of Colombia (2018), protein intake increased by 36% between 2010 and 2015, meaning that the recommended daily intake of 0.91 g/kg of weight was not satisfied in most of the domestic population. This is a consequence of the high cost and low availability of protein-rich alternatives throughout the year, which is much more evident in low income communities (49.7%) and rural areas (48.5%) (3). In order to minimize this problem and satisfy this demand, alternative substances have been used, generally plant-based with good nutritional and functional properties. Meat extenders are added to meat, reducing production costs without affecting the quality of the final products (6, 17, 30, 36, 37). They also fulfill important functions such as improving water holding capacity and lipid absorption, promoting fat emulsification and protein gelation, and increasing yield (23). These substances play a functional role because of their protein and carbohydrate contents (31). However, these extenders do not replace meat protein or the nutrients associated with it (6), and should be used in quantities that do not alter the quality and acceptability of the final products (29).

Pumpkin (*Cucurbita moschata*) is economically important worldwide and, in Colombia. It is rich in nutrients, such as carbohydrates, vitamins A and C, carotenes and essential amino acids (26, 27). In addition, it acts as an antioxidant (9, 12, 19) and included in the elaboration of multiple processed foods. No research has established the use of pumpkin flour as an extender in meat products yet. However, the use of this plant in the production of emulsified sausages and Frankfurt-type sausages is an important alternative for the development of meat products thanks to its carbohydrate and protein content. Therefore, the objective of this research was to evaluate the physicochemical properties, the color coordinates and the texture profile of Frankfurt sausages with pumpkin flour added as a meat extender.

## Materials and methods

### Preparation of the pumpkin flour

The PF was developed in the Unit Operations Laboratory of the Universidad Nacional de Colombia -Palmira. 8 kg of *Cucurbita moschata* pumpkins, all in the same maturation stage, were purchased from a local market in the city of Palmira, Valle del Cauca, Colombia. The pumpkins were washed and disinfected using a sodium hypochlorite solution at a concentration of 700ppm (70 mg/L) at a temperature of 10 ± 1°C. Subsequently, they were peeled by manually removing the husks and seeds, and then chopped, also manually, into small slices, approximately 2 mm thick, using a sharp stainless steel knife. The shopped pumpkin was dehydrated in a tray dryer (Armfield®, model UOP8 Ringwood, England). Dehydration was carried out at dry and wet bulb temperatures of 80 and 42°C, respectively with an average air circulation speed of 0.48 m/s. These values were defined in previous experiments. Once the pumpkin was dry, it was ground in a mill (IKA® M20-S3, USA) until 95% of the particles passed through a 12-mesh sieve, which is equivalent to a particle diameter 0f 102 microns. The flour was packed in polyethylene bags using a vacuum baler (EGAR-VAC®SCP Basic B, Vacarisses, Barcelona Spain) and kept in a dry and dark chamber at a temperature of 24 ± 2°C. The bags with the PF were covered with foil sheets to avoid interaction with light, which can alter the physicochemical, color and texture of the PF. Pumpkin pulp yield (after removing skin and seeds) in relation to fresh fruit was 88.26%, while pumpkin flour yields in relation to fruit, pulp was 6.62%. These data reflected a total of 0.47 kg of pumpkin flour, which was used to manufacture the different batches of sausages developed in the present research.

### Preparation of the sausage

The sausages were prepared in the Meat Technology Laboratory of the Universidad Nacional de Colombia - Palmira with a formulation previously developed at the University (table 1) (16). For this research, three samples were developed, in which wheat flour (WF) was replaced by pumpkin flour at 10, 20 and 30% along with a control sample without any

**Table 1.** Samples for processed sausages.

**Tabla 1.** Muestras para las salchichas procesadas.

| Ingredients | % | $T_0$ (Control) 0% | $T_1$ 10% | $T_2$ 20% | $T_3$ 30% |
|---|---|---|---|---|---|
| | | g | g | g | g |
| Beef | 24.940 | 1247.00 | 1247.00 | 1247.00 | 1247.00 |
| Pork | 21.994 | 1099.70 | 1099.70 | 1099.70 | 1099.70 |
| Pork back fat | 14.888 | 744.40 | 744.40 | 744.40 | 744.40 |
| Soy plant protein | 2.248 | 112.40 | 112.40 | 112.40 | 112.40 |
| Ice | 25.280 | 1264.00 | 1264.00 | 1264.00 | 1264.00 |
| Salt | 1.592 | 79.60 | 79.60 | 79.60 | 79.60 |
| Nitrates and Nitrites | 0.380 | 19.00 | 19.00 | 19.00 | 19.00 |
| Sausage seasoning | 1.012 | 50.60 | 50.60 | 50.60 | 50.60 |
| Polyphosphates | 0.422 | 21.10 | 21.10 | 21.10 | 21.10 |
| Ascorbic acid | 0.252 | 12.60 | 12.60 | 12.60 | 12.60 |
| Monosodium glutamate | 0.116 | 5.80 | 5.80 | 5.80 | 5.80 |
| Liquid smoke | 0.252 | 12.60 | 12.60 | 12.60 | 12.60 |
| Onion powder | 0.252 | 12.60 | 12.60 | 12.60 | 12.60 |
| Garlic powder | 0.252 | 12.60 | 12.60 | 12.60 | 12.60 |
| Pumpkin flour | 6.120 | 0.00 | 30.60 | 61.20 | 91.80 |
| Wheat flour | | 306.00 | 275.40 | 244.80 | 214.20 |
| TOTAL | 100.00 | 5000.00 | 5000.00 | 5000.00 | 5000.00 |

PF addition.

The sausages were made with a mixture of beef (pH 6.2) and pork (pH 6.3) without any connective or adipose tissue, purchased at a supermarket in the city of Palmira, Valle del Cauca, Colombia. The meat and pork back fat were cut manually with a stainless steel knife and subsequently ground using a meat grinder (Torrey® M-12-SF, Mexico). The emulsion was prepared in a food cutter (SHARFEN® TC-1, Germany), adding the ingredients in table 1, and following the appropriate procedures, which consisted of, firstly adding the meats together with the fat, secondly, adding salt and polyphosphates in order to break the actomyosin complex and extract the myofibrillar protein. The other ingredients and additives were then included, followed by wheat and pumpkin flours. The temperature of the emulsion in the cutter did not exceed 12°C throughout the process. Each sample was handled independently by adding the stipulated amount of pumpkin flour and wheat flour. The sausages in each sample were introduced into Amicel® synthetic casings with a diameter of 23 mm using a stuffing machine (Javar® EM 30, Colombia) and tied manually with a special thread at 12 cm, with an average weight of 60 g. The sausages were subjected to thermal treatment in a scalding tank with water at 80 ± 2°C until they reached an internal temperature of 72 ± 1°C, measured with a needle thermometer (Chektemp® H19850, England). A 350 liter, gas-powered, stainless steel, rectangular scalding tank, was used, to which clean drinking water was added. The sausages were subsequently transferred to a tank cold water crushed ice to cool for approximately 15 min. They were packed in vacuum polyethylene bags in a baler (EGARVAC® SCP Basic B, Vacarisses, Barcelona, Spain), labeled for identification according to each sample, refrigerated, and stored at 4 ± 1°C for 48 h. Each processed sausage had an approximate weight of 60 g, and, according to the formulation used (table 1, page 397), the total processed sausages for each sample, including the control sample, were approximately, 80 m units.

**Determination of proximal composition**

For each of the samples, the following characteristics were measured: dry material content according to AOAC (1990), method 934.06, protein content according to method AOAC Kjeldahl (1990), (method 31-1.22), ash content according to AOAC (1990), method 942.05, and carbohydrates, using the difference of proximal analysis (5). All measurements were taken threefold.

**Emulsion stability**

To determine the emulsion stability in each sample, a sample of the meat emulsion of approximately 25 g was taken directly from the cutter. Suspensions were prepared in distilled water with 6 g of the respective samples, which were introduced into previously weighed 15 ml falcon tubes. The tubes were heated for 30 min in a water bath at 75 ± 1°C and placed in centrifuge containers, at 3600 rpm for 5 min, which resulted in the detachment of the lipid layer, which was drained (10, 39). The stability of the emulsion was calculated using the following equation:

$$\%Es = \frac{Weight\ of\ the\ meat\ mass\ in\ the\ tube\ after\ drainage\ of\ the\ lipid\ layer}{Weight\ of\ the\ meat\ mass\ in\ the\ tube\ before\ heating}\ x\ 100$$

**pH measurements and water activity**

The pH was measured in each sample according to the methodology proposed by Dzudie *et al*. (2002) using a digital pH meter (MP 230, Metter Toledo, Switzerland) with a 10% (w/v) buffer solution of distilled water that was previously homogenized in a mixer (T25-B, IKA, Malaysia) at 1800 rpm for 1 min. According to the method proposed by Abbey *et al*. (2017), water activity (Aw) was determined using a Hygrolab C1 (Rotronic Instrument Corp., NY, USA) with a 5 ± 1 g sample placed in the container at room temperature (24 ± 2°C). Each measurement was taken three times.

**Water Holding Capacity (WHC)**

The methodology proposed by Dzudie *et al*. (2002), with the modifications described by Rosero-Chasoy *et al*. (2018), was used. A 0.5 g sample of the meat emulsion was taken and placed on grade 1 filter paper, which was then pressed between two plates at a pressure of 1 kg for 20 min. With the help of ImageJ (ImageJ® 1.40f, Wayne Rasband, National Institutes of Health, USA), the area of the pressed meat and the released liquid, were determined. The WHC was calculated with the following equations:

$$Released\ water = \frac{(Total\ area - Meat\ layer\ area)cm\ x\ 61.1\ x\ 100}{Total\ humidity\ of\ the\ meat\ sample}$$

$$WRC\ (\%) = 100 - (\%)\ released\ water$$

**Determination of cooking loss**

Cooking loss for each sample was measured by calculating the difference between the weight of the sausages before and after the thermal treatment, divided by the weight of the sausages before the thermal treatment, expressed as percentages. All measurements were taken three times and averaged for statistical analysis.

**Color measurement**

Color measurement of the samples was carried out with a colorimeter (Konica Minolta CHROMA METTER CR-400, Japan), evaluating the CIELab parameters of the International Commission on Illumination. Illuminant D65 and 2° observer were used (equipment calibrated with a white ceramic plate with reference values Y = 89.5, x = 0.3176, and y = 0.3340). Three measurements were assessed, and taken internally. With the coordinates a* and b*, the parameters C (saturation index) and h (hue) were calculated using the following equations:

$$C = (a*^2 + b*^2)^{1/2}$$

$$h = (arctang \frac{b*}{a*})$$

**Texture profile analysis**

The texture profile analysis was carried out using a texturometer (Shimadzu Tester EXTestEX-S, Japan). For each of the samples, three parallel measurements were made from 1.5 cm thick samples, which were allowed to stand for one hour at room temperature inside a closed polyethylene bag. Double compression was used at a tension of 75% at a speed of 60 mm/min, with a recess time of 5 seconds between compressions. Hardness (N), cohesiveness, elasticity, chewiness (N.mm) and adhesiveness (N.mm) (35) were analyzed.

**Statistical analysis**

SAS was used for statistical analysis (SAS Institute, Inc, USA). A completely randomized design with two repetitions was proposed, while the response variables were evaluated three times. The data were analyzed with one-way ANOVA. Significant differences between the samples and statistical significance were given a 5% probability level ($p<0.05$). The Tukey multiple range test was used to compare the mean values of the samples.

## RESULTS AND DISCUSSION

**Proximal composition of the sausages**

Average values of the sausages for each sample are shown in table 2 (page 400). They dry material increased significantly ($p<0.05$) compared to the control, when PF was added, with the highest increase being $T_1$ sample, at approximately 12%. The results presented by Choe *et al*. (2013) with chicken sausages with oat bran added agree with those in this research, achieving a significant increase in dry material content. Protein content decreased significantly ($p<0.05$) approximately by 11.5% in all samples, as compared to the control sausage. These values are consistent with those presented by Rosero-Chasoy *et al*. (2018), who worked with Frankfurt-type sausages with yacon flour (*Smallanthus sonchifolius*) added, and whit those presented by Dzudie *et al*. (2002), who introduced common bean flour as an extender in sausages. Contrarily, the study by Savadkoohi *et al*. (2014) showed an increase in protein content when adding tomato bagasse to beef sausages. Ash content was not significantly affected ($p<0.05$) by adding PF to the sausages in any of the samples, which agrees with hat reported by Choe *et al*. (2018) and Yetin *et al*. (2006), who made sausages with a mixture of pork skin, wheat fiber and liquid whey added respectively. Finally, for carbohydrates, a significant increase was observed ($p<0.05$), approximately 61% when adding PF at a concentration of 30% ($T_3$), as compared to the control sample. This can be explained by the greater content of carbohydrates in pumpkins, the raw material from which the PF was obtained (4, 15, 22).

PF: Pumpkin flour, [a-c] Averages with different superscripts in the same column are significantly different (p<0.05).

PF: Harina de zapallo, [a-c] Promedios con diferentes superíndices en la misma columna son significativamente diferentes (p<0,05).

**Table 2.** Effect of addition of PF on the proximal composition of sausages (Means ± SD).

**Tabla 2.** Efecto de la adición de PF sobre la composición proximal de las salchichas (Medias ± DS).

| Sample | Mean value ± SD (%) | | | |
|---|---|---|---|---|
| | **Dry material** | **Protein** | **Ash** | **Carbohydrates** |
| Control, 0% | $39.28 \pm 0.53^c$ | $34.55 \pm 0.08^a$ | $8.82 \pm 0.21^a$ | $0.24 \pm 0.02^c$ |
| $T_1$, 10% | $44.67 \pm 0.20^a$ | $30.84 \pm 0.19^b$ | $8.28 \pm 0.09^a$ | $0.38 \pm 0.02^b$ |
| $T_2$, 20(%) | $43.98 \pm 0.35^a$ | $31.04 \pm 0.44^b$ | $8.91 \pm 0.24^a$ | $0.57 \pm 0.04^b$ |
| $T_3$, 30(%) | $43.06 \pm 0.12^b$ | $29.88 \pm 0.46^c$ | $8.63 \pm 0.39^a$ | $0.61 \pm 0.06^b$ |

According to Colombian Standard NTC 1325 meat sausage must include a value that does not exceed 3% carbohydrates, which was met by the three sausage samples developed in this research. Savadkoohi *et al*. (2014) reported a significant increase in the carbohydrate content of sausage with 7% /weight of added tomato bagasse.

**Emulsion stability, ph, water activity, Water Holding Capacity (WHC) and cooking loss**

The results of the analysis of the emulsion stability, pH, water activity, water holding capacity and cooking loss are shown in table 3.

[a–c] Averages with different superscripts in the same row are significantly different (p<0.05).

[a–c] Promedios con diferentes superíndices en la misma fila son significativamente diferentes (p<0,05).

**Table 3.** Emulsion stability, pH, water activity (Aw), water holding capacity (WHC) and cooking loss for the sausages (Means ± SD).

**Tabla 3.** Estabilidad de la emulsión, pH, actividad de agua (Aw), capacidad de retención de agua (CRA) y pérdidas de cocción para las salchichas (Medias ± DS).

| Analyzed parameter | Sample | | | |
|---|---|---|---|---|
| | **Control, 0%** | **$T_1$, 10%** | **$T_2$, 20%** | **$T_3$, 30%** |
| Emulsion stability, % | $96.24 \pm 1.12^a$ | $94.03 \pm 0.89^a$ | $91.56 \pm 1.41^a$ | $91.77 \pm 0.97^b$ |
| pH | $6.57 \pm 0.02^a$ | $6.52 \pm 0.03^a$ | $6.51 \pm 0.02^a$ | $6.47 \pm 0.02^a$ |
| Water activity, (Aw) | $0.974 \pm 0.21^a$ | $0.976 \pm 0.16^a$ | $0.967 \pm 0.18^a$ | $0.972 \pm 0.22^a$ |
| Water Holding Capacity, (WHC) | $76.88 \pm 0.88^a$ | $79.93 \pm 1.02^b$ | $77.51 \pm 0.97^b$ | $74.62 \pm 1.06^c$ |
| Cooking loss, % | $23.63 \pm 0.34^a$ | $25.48 \pm 0.66^a$ | $26.12 \pm 1.02^a$ | $29.18 \pm 0.98^b$ |

For the emulsion stability, no significant differences (p<0.05) were observed when comparing samples $T_1$ (10% replacement of WF with PF) and $T_2$ (20% substitution of WF with TF), as compared to the control sample. However, the greater $T_3$ substitution (30%) showed a significant decrease (p<0.05), which could have been due to the protein content of the flours: 0.60 - 0.70% for the pumpkin flour (wet basis) (27, 28) and 10 - 14% for the wheat flour (dry basis) (11, 24, 32). Based on this data, it can be concluded that it is possible to replace WF with PF by up to 20% without affecting emulsion stability in Frankfurt-type sausages.

The pH values in the different samples did not show significant differences from the control sample, which means that pH does not directly affect the production of Frankfurt-type sausages at the PF concentrations used for WF replacement. Similar results were found by Marti-Quijal *et al*. (2019), who developed fresh pork sausages with partial replacement using different vegetable sources, whey and microalgae proteins, as well as by Choe *et al*. (2013), who worked with sausages with a mixture of pork skin and wheat fiber added as extender element.

A similar situation was obtained in the measurements of the water activity (Aw) in the different samples, in which there were no significant differences (p<0.05) between the samples and the control. These results are consistent with those presented by Souza *et al*. (2015), who also found no statistically significant differences in hamburger samples with by-products obtained from the transformation of chia (*Salvia hispanica* L.).

Water holding capacity (WHC) in the different samples showed significant differences between the control sample and the samples with the addition of PF. However, the $T_3$ sample (30% substitution of WF with pF) also presented a significant difference from the $T_1$ and $T_2$ samples. The WHC of meat products is important since the juiciness of the final product partially depends on it, as does the texture, and it also adds economic benefits (36).

The higher the percentage of water released, the lower the moisture content of the sausage and, therefore, the drier it will be, which can affect the texture and acceptability of the final product (29). With the increase in the PF concentration added to the sausages, there was an increase of 3.8% in the WHC for $T_1$ and 0.81 for $T_2$ ($p<0.05$), as compared to the control sample, which can be explained by the greater presence of dietary fiber in PF than in WF (8). This confirms the idea that the PF can be used as an extender component, at up to 20%, in the manufacture of Frankfurt sausage since, thanks to the high content of dietary fiber, it has a great capacity to bind the water in the meat matrix and, thus, increase yields improving economic benefits (25).

Finally, the cooking losses showed a small, statistically non-significant variation ($p<0.05$) between samples $T_1$ and $T_2$, as compared to the control sample. The substitution of WF with PF greater than 20%, had a significant variation. Cooking loss measures the ability of a system to bind water and fat after protein denaturation and aggregation during cooking (15). The lack of variation in this parameter in concentrations lower than 20% substitution of WF with PF means that there was no moisture loss during the cooking process, which guarantees quality in terms of texture.

**Color measurement**

The values obtained for the color parameters are shown in table 4. It can be seen at the samples with the addition of PF did no show, significant differences from the control sausages for the L* values ($p<0.05$) because the PF presented a dark tone when diluted in water, which is very similar to the that of the meat emulsion.

**Table 4.** Color parameters for sausages (Means ± SD).

**Tabla 4.** Parámetros de color de las salchichas (Medias ± DS).

| **Analyzed parameter** | **Sample** | | | |
|---|---|---|---|---|
| | Control, 0% | $T_1$, 10% | $T_2$, 20% | $T_3$, 30% |
| L* | 61.07 ± 0.67$^a$ | 61.83 ± 0.92$^a$ | 60.33 ± 0.88$^a$ | 60.15 ± 0.62$^a$ |
| a* | 10.84 ± 1.01$^a$ | 13.49 ± 0.77$^b$ | 14.04 ± 0.84$^b$ | 14.57 ± 0.51$^c$ |
| b* | 19.06 ± 0.99$^a$ | 23.44 ± 1.79$^b$ | 23.99 ± 1.53$^b$ | 23.73 ± 1.48$^b$ |
| Hue angle (*h*) | 60.37 ± 2.11$^a$ | 60.07 ± 2.03$^b$ | 59.66 ± 1.98$^b$ | 58.45 ± 2.15$^b$ |
| Saturation index (C) | 21.92 ± 0.66$^a$ | 27.04 ± 0.89$^b$ | 27.79 ± 0.75$^b$ | 27.84 ± 0. 62$^b$ |

L*: 0 = black and 100 = white; a*: -60 = green and +60 = red; b*: -60 = blue and +60 = yellow; hue Angle: 90° = yellow, 180° = green and 0° = red; Saturation index: distance from the coordinates at the origin to the determined color point; $^{a\text{-}c}$ Averages in the same row with different superscripts are significantly different ($p<0.05$).

L*: 0 = negro y 100 = blanco; a*: -60 = verde y +60 = rojo; b*: -60 = azul y +60 = amarillo; Ángulo de tono: 90° = amarillo, 180° = verde y 0° = rojo; Índice de saturación: distancia desde las coordenadas en el origen hasta el punto de color determinado; $^{a\text{-}c}$ Promedios en la misma fila con diferentes superíndices son significativamente diferentes ($p<0,05$).

According to Savadkoohi *et al.* (2014), parameters L* and a* (red-green coordinate) are the most important parameters for color changes in Frankfurt-type sausages. For the a* coordinate, a significant difference was observed from the control sample, however, for samples $T_1$ and $T_2$, no significant differences were observed, which indicates that a substitution of up to 20% of WF with PF does not influence the red-green coloration, but the greater substitution in $T_3$ (30%) presented a significant difference ($p<0.05$) from the control sample and $T_1$ and $T_2$. These results are consistent with those presented by Choe *et al.* (2013), who worked with Frankfurt-type sausages with a mixture of pork skin and wheat fiber added, as well as those reported by Sariçoban *et al.* (2008) who worked with meat emulsions with different levels of lemon albedo added. On the contrary, the data obtained in this study differ from those presented by Rosero-Chasoy *et al.* (2018), who obtained a statistically significant decrease ($p<0.05$) in sausages with yacon peels added, and by Sanjeewa *et al.* (2010), who added 5% chickpea flour to bologna-type mortadella. On the contrary Calvo *et al.* (2008) who worked with sausages enriched with lycopene obtained from tomato skin, observed higher values for the a* coordinate. The data obtained by different authors leads to the conclusion that the value of the a* coordinate influences sausage coloration, depending on the components in the different extenders used in its elaboration. The b* coordinate showed no statistically significant variations ($p<0.05$) for any of the samples. However, it did show an increase of 23% in relation to the control sample, which is explained by the greater presence of carotenoid-like dyes in the PF. Sausages with PF added showed a decrease in the hue angle in relation to the control sample, of between 0.50 and 3.28%, but showed no statistically significant differences between the three samples, which indicates a greater value of yellow in the sample. All samples, unlike the control, had a greater red color. The saturation index showed a similar stability recorder for the hue angle. Consequently, variations in the color parameters when substituting WF with PF, up to 20%, did not affect the acceptance of the processed sausages, which is a quality parameter in processed products, as confirmed by Afoakwah *et al*. (2015).

### Profile texture

The texture profile parameters: hardness (N), cohesiveness, elasticity, chewiness (N.mm) and adhesiveness (N.mm) are shown in table 5. The hardness of the sausages in samples $T_1$ and $T_2$ did not show significant differences ($p<0.05$); however, when compared to the control sample, there was less hardness in these two samples, but greater hardness than in $T_3$, which had a higher inclusion of PF. These data are consistent with these presented by Rosero-Chasoy *et al*. (2018) who worked with sausages with yacon peels flour added, and those presented by Torres *et al*. (2016), who compared a sausage with lentil flour added as an extender and a commercial sausage. In contrast, Choe *et al*. (2013) showed an increase in the hardness of sausages by increasing the concentration of a mixture of pork skin and wheat fiber used as an extender. Similarly, Savadkoohi *et al*. (2014) obtained an increase in hardness in beef sausages by increasing the concentration of tomato bagasse. This increase is explained by the greater presence of acid detergent fiber and protein in these meat extenders, unlike PF, which has a relatively low content, leading to greater hardness in sausages. Chewiness, had a significant increase ($p<0.05$) for the three samples in relation to the control, which is consistent with the data presented by Choe *et al*. (2013). For the parameters cohesiveness, elasticity and adhesiveness, there were no significant differences ($p<0.05$) in any of the samples, including the control.

**Table 5.** Analyses of the texture profile for the sausages (Means ± SD).

**Tabla 5.** Análisis del perfil de textura de las salchichas (Medias ± DS).

| Analyzed parameter | Sample | | | |
|---|---|---|---|---|
| | Control, 0% | $T_1$, 10% | $T_2$, 20% | $T_3$, 30% |
| Hardness (N) | 33.82 ± 0.98$^a$ | 30.97 ± 1.14$^b$ | 28.02 ± 1.23$^c$ | 25.67 ± 0.95$^c$ |
| Cohesiveness | 0.37 ± 0.07$^b$ | 0.33 ± 0.03$^b$ | 0.32 ± 0.03$^b$ | 0.31 ± 0.02$^b$ |
| Elasticity | 0.36 ± 0.03$^a$ | 0.39 ± 0.02$^a$ | 0.42 ± 0.03$^a$ | 0.40 ± 0.02$^a$ |
| Chewiness (N.mm) | 3.36 ± 0.77$^a$ | 3.69 ± 0.21$^b$ | 3.98 ±0.80$^b$ | 4.06 ± 0.34$^b$ |
| Adhesiveness (N.mm) | -0.59 ± 0.07$^a$ | -0.51 ± 0.06$^a$ | -0.48 ± 0.09$^a$ | -0.43 ± 0.05$^a$ |

$^{a-c}$ Averages in the same row with different superscripts are significantly different ($p<0.05$).

$^{a-c}$ Promedios en la misma fila con diferentes superíndices son significativamente diferentes ($p<0,05$).

## Conclusion

The inclusion of pumpkin flour as a partial substitute for wheat flour in Frankfurt-type sausages made with a mixture of pork and beef was analyzed. It was concluded that it is possible to replace up to 20% of wheat flour without affecting the characteristics of the emulsion or its stability, as well as some of the physicochemical, color and texture properties of the final product. A sausage with a good water holding capacity and low cooking losses was obtained, which has positive effects from the technical and economic point of view. This, in turn, is reflected in the good quality of the processed sausage and good acceptance of the final product. This research opens doors for new developments in the production of Frankfurt-type sausages, such as the use of pumpkin flour as a meat extender, which has implications and economic benefits for the meat industry.

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