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# Effect of the partial replacement of wheat flour with turmeric flour (*Curcuma longa*) on the physicochemical and sensory properties of a common chorizo

José Igor Hleap-Zapata, Luiza Romero-Quintana, Jheny Botina-Cárdenas, Carlos Andrés Martínez-Martínez, Yenifer Valenciano-Pulido & Karen Higuita-Diaz

*Facultad de Ingeniería y Administración, Universidad Nacional de Colombia – Sede Palmira, Colombia,*
*jihleapz@unal.edu.co, ljromeroq@unal.edu.co, jzbotinac@unal.edu.co, canmartinez@unal.edu.co, yvalencianop@unal.edu.co, kghiguitad@unal.edu.co*

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**Abstract**
The effect of partial replacement of wheat flour with turmeric flour (*Curcuma longa*) on the physicochemical and sensory properties of chorizo made with pork was evaluated. Three levels of turmeric flour substitution were proposed 0.8%, 1.4% and 2.1%, corresponding to a substitution of a 19.04%, 33.33% and 50,00%, respectively, along with a control chorizo without the addition of said flour. The pH, water holding capacity, color, texture and sensory evaluation were measured. The pH tended towards acidity in the treatment with the greatest inclusion of uremic flour. The sensory evaluation was carried out with to untrained panelists who determined the chorizo with the highest acceptability. For the sensory parameters, there were no significant differences, except for color. Therefore, turmeric flour can be used as a partial substitute for wheat flour in the production of common chorizo without affecting physicochemical and sensory properties.

*Keywords*: color; meat; meat industry; protein content; sensory evaluation; texture.

# Efecto del remplazo parcial de harina de trigo por harina de cúrcuma (*Curcuma longa*) sobre las propiedades fisicoquimicas y sensoriales de un chorizo común

**Resumen**
Se evaluó el Efecto del remplazo parcial de la harina de trigo por harina de cúrcuma (*Curcuma longa*) sobre las propiedades fisicoquímicas y sensoriales de chorizos hechos con carne de cerdo. Se propusieron tres niveles de sustitución de harina de cúrcuma 0,8%, 1,4% y 2,1%, correspondientes a una sustitución de 19,04%, 31,33% y 50,00%. Respectivamente y un chorizo control sin adición de dicha harina. Se midieron el pH, la capacidad de retención de humedad, el color, la textura y la evaluación sensorial. El pH mostró una tendencia a la acidez en el tratamiento con una mayor inclusión de harina de cúrcuma. La evaluación sensorial se trabajó con 70 panelistas no entrenados que determinaron el chorizo con la mayor aceptabilidad. En cuanto, a los parámetros sensoriales, no hubo diferencias significativas, excepto para el color. Por lo tanto, se puede concluir que la harina de cúrcuma se puede usar como un sustituto parcial de la harina de trigo en la producción de chorizo común, sin afectar sus propiedades fisicoquímicas y sensoriales.

*Palabras clave*: color; carne; industria cárnica; contenido proteico; evaluación sensorial; textura.

## 1. Introduction

The expectations and needs of consumers, in terms of diet, have changed in recent years. Currently, foods with a low fat content, nutraceuticals and foods that help maintain the proper physiological functions of organs and that favor the well-being and health of consumers are preferred [1-3].

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Increases in food-related illnesses, such as coronary blockage related to a high intake of red meat, processed meats and fast foods, among other food rich in saturated fatty acids, have led to a gradual rejection of these types of food [4]. The World Health Organization, in its 2018 report, recognized, chronic diseases that are related to food intake and issue recommendations for good eating habits in order to reduce these diseases [5]. In addition, in a recent pronouncement, the WHO warned against the consumption of fresh and processed meat since it has been classified under group 2A, i.e., probably carcinogenic to humans [6].

Consequently, the food industry is currently betting on new ingredients that have a selective effect on certain body functions [7]. In particular, the meat industry has been developing alternatives that decrease the risks associated with meat consumption [8-12]. To achieve this, the inclusion of cereals and legumes that act as binders or extension agents has been studied thanks to their ability to bind water and fat [12-14]. The most commonly used include wheat, corn, potato and cassava flours because they contain gluten, which has very good viscoelastic properties and contributes a small protein content [15,16]. However, the consumption of gluten can cause allergies and gastric difficulties that lead to the development of the so-called celiac disease, for which the only solution is to eliminate the consumption of gluten in the daily diet.

Antioxidants are natural compounds that have been widely studied thanks to their ability to eliminate free radicals that are generated in the body's natural oxidation processes, preventing the onset of degenerative diseases [17-19]. A dietary antioxidant is a substance that is part of everyday foods and can prevent the aforementioned adverse effects [20].

Chorizo is a raw meat product of Spanish origin that is found and accepted throughout the world, generally made with pork, beef, chicken or mixtures thereof [21]. According to Colombian Technical Standard NTC 1325 [22], chorizo is a fresh, raw, processed meat product, obtained by grinding or chopping cooked and matured meat, along with fat and other permitted substances. Multiple formulations with different ingredients with very different flavors and aromas are known. However, manufacturing requires preservatives such as nitrates and nitrites that guarantee the microbiological safety of products since storage is not done under refrigeration or freezing conditions. In addition, adding curative substances provides certain characteristics of color, flavor and aroma that are important for the acceptance of the final product. However, the presence of these compounds has been widely criticized because of their possibly carcinogenic effects [23,24]. In response, research has been carried out to explore alternatives that minimize the negative effects of these nitrates and nitrites on meat products using, among others, extenders agents from plant substances that have antioxidant properties [12, 25-27].

Turmeric (Curcuma *longa*) is a plant native to Southeast Asia, distributed in the tropical and subtropical regions of the planet and used in the food industry, in the cosmetics industry and in the pharmaceutical industry [28,29]. Because of its antioxidants properties [30-33] and its content of dietary fiber and protein, it has potential for use in meat industry in order to minimize the negative effects caused by the oxidation of fats, the addition of nitrates and nitrites and the presence of gluten in sausage-type meat products. However, studies on the use of turmeric as an extender in the production of such products are not referenced in the scientific literature. Therefore, the objective of this study was to evaluate the effect of partial substitution of wheat flour (WF)with turmeric flour (TF) on the physicochemical and sensory properties of pork common chorizo.

## 2. Materials and methods

The chorizos were made in the Meat Technology Laboratory of the National University of Colombia – Palmira headquarters. The formulations used is shown in Table 1. Lean pork (pH 6,7) was used with a small content of connective tissue and pork back fat, purchased from a meat supermarket in the city of Palmira, Valle del Cauca Departament, Colombia and maintained at -20°C ± 1°Cfor 24 hours before use. The TF was obtained directly from Biovalle plant located in the municipality of Ginebra, Departament of Valle del Cauca, Colombia. The other ingredients were purchased in a supermarket and in store specializing in the sale of supplies for the food industry.

For this experiment, three formulations with different levels of WF substitutions with TF and a control formulation were used (Table 1). For each proposed treatment, three 4 kg batches were prepared. Thawed pork back fat and meat were manually chopped into pieces, approximately 5 cm on each side, using a stainless steel knife and subsequently ground with an 8 mm grinder (Javar® MC22-16 2F, Bogotá, Colombia). All the ingredients, weighed according to each treatment, were mixed with the ground meat and fat using a mixer (Javar® MZ 100 3F 100 LT, Bogotá, Colombia) for 15 minutes. The mixture was placed in a stuffer (Javar® EN 30, Bogotá, Colombia), and, using natural casings 3 cm in diameter, the chorizos were stuffed. Subsequently, the chorizo was hung on a metal hanger for the drying process, at room temperature (24°C) for 48 hours, after which the respective analyses were carried out.

Table 1
Formulations of processed chorizo samples

| Ingredients | Treatment, (%) | | | |
|---|---|---|---|---|
| | Control | $T_1$ | $T_2$ | $T_3$ |
| Meat pork | 41.94 | 41.94 | 41.94 | 41.94 |
| Pork back fat | 27.92 | 27.92 | 27.92 | 27.92 |
| Soy isolate | 3.50 | 3.50 | 3.50 | 3.50 |
| Ice | 15.35 | 15.35 | 15.35 | 15.35 |
| Garlic power | 0.14 | 0.14 | 0.14 | 0.14 |
| Polyphosphates | 0.20 | 0.20 | 0.20 | 0.20 |
| Ascorbic acid | 0.17 | 0.17 | 0.17 | 0.17 |
| Monosodium glutamate | 0.03 | 0.03 | 0.03 | 0.03 |
| Chorizo seasoning | 0.69 | 0.69 | 0.69 | 0.69 |
| Long green onion (*Allium fistulosum* L.) | 4.19 | 4.19 | 4.19 | 4.19 |
| Wheat flour (WF) | 4.20 | 3.40 | 2.80 | 2.10 |
| Turmeric flour (TF) | 0.00 | 0.80 | 1.40 | 2.10 |
| Salt | 0.83 | 0.83 | 0.83 | 0.83 |
| Curing salt | 0.21 | 0.21 | 0.21 | 0.21 |
| Cumin | 0.28 | 0.28 | 0.28 | 0.28 |
| Liquid smoke | 0.35 | 0.35 | 0.35 | 0.35 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 |

Source: The Authors.

### 2.1. Chemical composition, water holding capacity, pH and color measurement

Using the standard methods of the AOAC, the chemical composition of the different chorizo samples was determined [34]. The water holding capacity (WHC) was determined following the methodology described by Braña *et al*., [35], for which 5 g chorizo samples were taken. Mixed using a spatula with 8 ml of a 0.6 M NaCl solution and placed in centrifuge tubes, which were left in a cold water bath for 30 min. Afterwards, the samples were shaken for 1 min and placed in a centrifuge at 10000 rpm for 15 min. Finally, the samples were removed, the supernatant was removed and the volume of the separated liquid was measured. The WHC was defined using equation (1).

$$\%WHC = \left(\frac{(V1 - V2)}{W}\right) x\ 100 \quad (1)$$

Were, $V_1$ = ml of NaCl solution added, $V_2$ = ml of separated liquid supernatant, W = g of chorizo sample.

A potentiometer-type pH meter (Schott pH meter CG482, Germany) was used to determine the pH of the chorizo. 5 g of the sample were mixed with 20 ml of distilled water for one minute using a homogenizer, and the measurement was taken. With the aid of a colorimeter (Konica, Minolta Chroma Meter CR400, Japan), with D65 illuminant and 2° observer (equipment calibrated with a standard plate with reference values Y = 89.5, x = 0.3176 and y = 0.3340), the color coordinates were determined. The measurements were expressed in terms of luminosity L*and the chromaticity parameters a* and b*, and finally, the coordinates C* (chroma) and h* tone were calculated using equations (2) and (3), respectively. Each measurement was taken in triplicate.

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

$$h = \arctan(b^{*}/\,a^{*}) \quad (3)$$

### 2.2. Texture profile analysis

The texture parameters: hardness (N), gumminess (N), elasticity, adhesiveness (N.mm) and cohesiveness were determined according to Szczesniak [36]. A Shimadzu Universal Tester Texturometer (EXTestEZ-S, Japan) was used, and slices of 2-cm-long chorizo were cut for measurements and placed in a polyethylene bag for one hour at room temperature. Double compression was performed at 75% deformation and a speed of 60 mm/min, with a 5 second pause between each compression. Three repetitions per sample were carried out.

### 2.3. Sensory analysis

The qualitative characteristics of color, smell, taste, texture and acceptance established the sensory evaluation of the processed chorizos, which used pieces approximately 1.5 cm long, softened in neutral vegetable oil and labeled with random three-digit numbers for each of the evaluated samples. The samples were offered to 70 untrained evaluators between the ages of 21 and 60, of both sexes and from different social classes. Said evaluation was applied between 2:00 P.M. and 5:00 P.M. in order to minimize the possible effects caused by hunger or satiety. A survey was applied with a hedonic scale of seven points (1 = I like very much and 7 = I dislike it a lot), according to the methodology proposed by Duizer and Walker [37].

### 2.4. Statistical analysis

A completely randomized design was applied for the following parameters: proximal chemical composition, water holding capacity (WHC), pH, color measurement and texture profile analysis, followed by one-way ANOVA. The results are presented as the average and standard deviation of three repetitions. For the sensory analysis, the results were subjected to statistical analysis based on descriptive statics, analysis of variance (ANOVA) and comparison of averages using the Tukey test, with a probability for significant differences of $p < 0.05$. The statistical analysis was carried out with the help of SPSSW Statics 19, 2020.

## 3. Results and discussion

The results of the chemical composition of the processed chorizo showed significant differences ($p < 0.05$) for moisture and lipids in the three analyzed treatments (Table 2). A directly proportional relationship was observed between the moisture and fat contents in relation to the TF concentration ($p< 0.05$). These results agree with those presented by Rosero-Chasoy *et al*., [12] and Choe *et al*., [38], who worked with pork sausage and different plant materials as extenders, and by Bhosale *et al*., [39], who used raw ground carrots and mashed potatoes in chicken nuggets. Finally, the proteins, ash and neutral detergent fiber did not show significant differences ($p < 0.05$) in the three analyzed treatments.

The water holding capacity (WHC), defined as the amount of moisture retained in the sample in relation to the initial moisture, revealed that, as the TF content increased, the WHC decreased because of the lower water holding capacity that TF has (Table 2). There was also a decrease in the WHC of 1.86%, 13.53% and 28.59%, respectively for treatments $T_1$, $T_2$ and $T_3$, in comparison with the WHC of the control sausage, which showed a statistically significant decrease ($p < 0.05$). However, when analyzing the behavior of the WHC in the different treatments, there were no statistically significant differences ($p < 0.05$). This may have been due to the proximal composition of both types of flour (WF and TF), where TF has a higher content of dietary fiber (22.7%) [28], (29.6%) [40] and (34.47%) [41], in relation to WF (9.82%) [42]. Dietary fiber easily joins with water, so, thanks to this characteristics, TF is an alternative for the production of sausage, increasing its antioxidant capacity and improving yield.

Table 2 shows that the pH value had a statistically significant decrease ($p < 0.05$) as the TF content in the chorizo samples increased in the $T_1$ treatment, as compared to the $T_2$

and $T_3$ treatments. However, when compared with the control chorizo, a higher pH was observed, probably because of the fact that TF had a lower pH value that caused the pH to decrease in the analyzed samples. These results agree with those presented by Shilling *et al*., [43], who worked with fresh pork sausage that had extracts of rosemary and green tea added. On the other hand, the results presented by Balzan *et al*., [44], who worked with raw and cocked fresh pork sausages with phenols added, did not show significant differences in the pH variations.

The color coordinates for the different chorizos showed that the lowest luminosity value (L*) was seen in the control sample ($p < 0.05$), which indicated that the higher the TF, the grater the luminosity in the products (Table 3). Similar results were presented by Savadkoohi *et al*., [45] for sausage with 7% tomato bagasse added. The progressive decrease in the a* coordinate seen in the treatments was due to the yellow tone of the TF, while the b* coordinate (blue-yellow) did not show statistically significant differences in the different treatments although it had slightly higher values than the control sausage. These data agree with the results obtained by Sanjeewa *et al*., [46], who added 5% chickpea flour to bologna-type mortadella. The a* and b* values varied with the increase in the TF concentration; however, this variation did not present statistically significant values ($p < 0.05$), which led to the conclusion that adding TF did not influence the color of the chorizo.

The results for the texture profile analysis parameters hardness, gumminess, elasticity, adhesiveness and cohesiveness are shown in Table 4. For the elasticity, adhesiveness and cohesiveness parameters, there were no significant differences

Table 2.
Chemical composition, WHC, and pH, of the chorizo

| Parameter | Treatment | | | |
|---|---|---|---|---|
| | Control | $T_1$ | $T_2$ | $T_3$ |
| | 0.00% | 0.80% | 1.40% | 2.10% |
| Moisture, % | $42.19 \pm 1.03^a$ | $41.68 \pm 1.54^b$ | $42.27 \pm 0.99^c$ | $42.43 \pm 1.23^d$ |
| Protein, % | $20.45 \pm 0.98^a$ | $20.12 \pm 1.24^a$ | $20.43 \pm 1.12^a$ | $21.61 \pm 1.51^a$ |
| Lipids, % | $28.35 \pm 1.14^a$ | $26.37 \pm 1.47^b$ | $26.48 \pm 1.40^c$ | $26.58 \pm 1.39^d$ |
| Ash, % | $3.98 \pm 0.45^a$ | $6.25 \pm 0.71^a$ | $6.36 \pm 0.68^a$ | $5.59 \pm 0.99^a$ |
| Neutral detergent fibre, % | $5.03 \pm 0.78^a$ | $5.58 \pm 0.86^a$ | $4.46 \pm 1.02^a$ | $3.79 \pm 0.94^a$ |
| WHC, % | $14.48 \pm 0.12^a$ | $14.21 \pm 0.14^b$ | $12.52 \pm 0.19^b$ | $10.34 \pm 0.22^b$ |
| pH | $5.06 \pm 0.42^a$ | $5.52 \pm 0.23^b$ | $5.43 \pm 0.17^c$ | $5.38 \pm 0.11^c$ |

Al values are the means ± standard deviation of three repetitions
a-d Averages within rows with different letters are significantly different ($p < 0.05$).
Source: The Authors.

Table 3.
Color coordinates of the chorizo

| Parameter | Treatment | | | |
|---|---|---|---|---|
| | Control | $T_1$ | $T_2$ | $T_3$ |
| | 0.00% | 0.80% | 1.40% | 2.10% |
| L* | $61.87 \pm 0.18^a$ | $62.52 \pm 0.20^b$ | $63.72 \pm 0.19^b$ | $64.62 \pm 0.17^b$ |
| a* | $6.01 \pm 0.36^a$ | $5.67 \pm 0.24^a$ | $3.93 \pm 0.21^a$ | $2.97 \pm 0.21^a$ |
| b* | $44.02 \pm 0.19^a$ | $43.76 \pm 0.11^b$ | $43.15 \pm 0.13^b$ | $42.55 \pm 0.11^b$ |
| C* | $44.43 \pm 0.22^a$ | $44.13 \pm 0.25^a$ | $43.33 \pm 0.24^a$ | $42.65 \pm 0.20^a$ |
| h* | $82.23 \pm 0.32^b$ | $82.62 \pm 0.36^b$ | $84.80 \pm 0.38^b$ | $86.01 \pm 0.33^b$ |

L*: 0 = black and 100 = white; a*: -60 = green and +60 = red; b*: -60 = blue and +60 = yellow; h – tone: 90° = yellow, 180° = green and 0° = red; C* - chroma: distance from the coordinates at the origin to the determined color point
All values are the means ± standard deviation of three repetitions.
a-b Averages within rows with different letters are significantly different ($p < 0.05$).
Source: The Authors.

Table 4.
Texture profile of the chorizo

| Parameter | Treatment | | | |
|---|---|---|---|---|
| | Control | $T_1$ | $T_2$ | $T_3$ |
| | 0.00% | 0.80% | 1.40% | 2.10% |
| Hardness (N) | $8.56 \pm 0.98^a$ | $9.97 \pm 1.05^b$ | $10.67 \pm 0.99^b$ | $12.79 \pm 0.95^b$ |
| Gumminess (N) | $9.76 \pm 1.31^a$ | $9.32 \pm 1.16^b$ | $9.21 \pm 1.22^b$ | $9.28 \pm 1.20^b$ |
| Elasticity | $0.50 \pm 0.04^a$ | $0.55 \pm 0.05^a$ | $0.62 \pm 0.07^a$ | $0.57 \pm 0.08^a$ |
| Adhesiveness (N.mm) | $-0.94 \pm 0.09^b$ | $-0.88 \pm 0.11^b$ | $-0.79 \pm 0.21^b$ | $-0.75 \pm 0.18^b$ |
| Cohesiveness | $0.52 \pm 0.09^c$ | $0.42 \pm 0.08^c$ | $0.49 \pm 0.06^c$ | $0.44 \pm 0.08^c$ |

All values are the means ± standard deviation of three repetitions.
a-c Averages within rows with different letters are significantly different ($p < 0.05$).
Source: The Authors.

($p < 0.05$) for the partial substitution of WF with TF in the chorizo. However, the lowest hardness value was observed in the control sample, without TF; when the concentration increased, hardness increased although there were no significant differences ($p < 0.05$) between the three treatments. These data agree with those reported by Savadkoohi *et al*., [45] and Calvo *et al*., [47], who worked with pork sausage with bagasse and tomato peels added, respectively, and who attributed the results to the presence of acid detergent fiber and protein in these added substances, which led to hardening of the final product. This study's results also agree with those of Martinez *et al*., [48], who worked on meat products (loin and salted pork bacon) with commercial liquid smoke added, and Choe *et al*., [38], who produced pork sausage with a partial replacement with a mixture of pork skin and wheat flour, observing an increase in the hardness of the products as the concentration of the added substances increased. On the other hand, Rosero-Chasoy *et al*., [12] observed a decrease in hardness as the concentration of yacon flour that was added to sausage increased. For gumminess, treatments $T_1$, $T_2$ and $T_3$ did no show statistically significant differences ($p < 0.05$); however, the control sausage had a lower value, probably because of a greater presence of insoluble fiber in the chemical composition of the TF.

The results of the sensory analysis can be seen in Fig. 1. For the five analyzed parameters: color, smell, taste, texture and acceptance, no statistically significant differences were found ($p < 0.05$) between the three treatments. The taste was not influenced by the addition of TF at levels up to 1.40% substitution. A greater addition of TF led to acidification of the product, which caused rejection by the consumers. This allowed the conclusion that the addition of this flour, at the percentage indicated, did not affect the acceptance of the final product. The same result was seen for the parameters smell and acceptance ($p < 0.05$). However, the color evaluation of the three treatments ($T_1 = 3.30 \pm 0.42^a$, $T_2 = 3.55 \pm 0.46^a$, $T_3 = 3.25 \pm 0.51^a$), when compared with the control chorizo ($2.28 \pm 0.63^b$), presented higher values on the hedonic scale, with statistically significant differences ($p < 0.05$), which manifested as a non-traditional yellowish color in the meat product caused by the natural color of turmeric. These results agree with those presented by Choe *et al*., [38], who made pork sausages with a mixture of pork skin and wheat flour added. The texture of the three treatments ($T_1 = 3.40 \pm 0.21^a$, $T_2 = 3.20 \pm 0.26^a$, $T_3 = 3.20 \pm 0.25^a$) also presented significant differences ($p < 0.05$) from the control chorizo ($2.86 \pm 0.6767^b$), which had the lowest texture value, presenting a point in favor of chorizo with TF added since this parameter is an important quality attribute in chorizo. This confirm, that the addition of turmeric flour at a concentration of up to 2.10% in relation to wheat flour (4.20% in chorizo formulations = 50% substitution) does not affect sensory properties, which was corroborated with the statistical analysis since the greatest frequency expressed by the panelists fluctuated between "I like it a lot" and "I like a little", grades 2 and 3 on the hedonic scale.

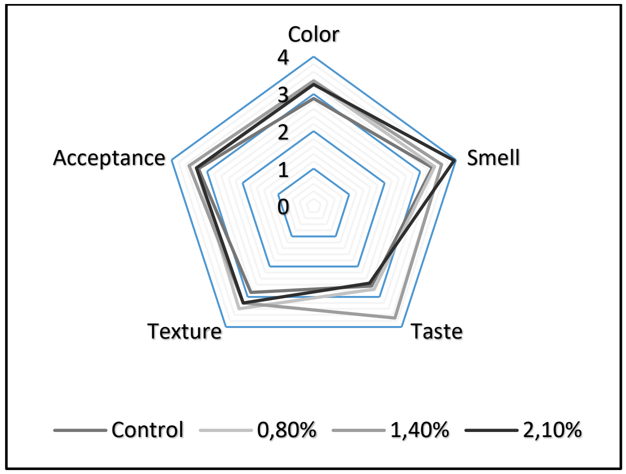


Figure 1. Sensory analysis parameters of the chorizo
Source: The Authors.

## 4. Conclusion

The physicochemical properties and chemical composition of the processed sausages were not affected by the inclusion of turmeric flour up to a level of 1.40%, corresponding to a 33.3% substitution of wheat flour. From the sensory point of view, adding turmeric flour to the sausages did not affect the sensory characteristics, except for color, which turned a little more yellow because of the natural color of the turmeric. A higher concentration of turmeric flour caused an acid taste, which was not well accepted by the consumers. The sample with 1.40% substitution of wheat flour with turmeric flour produced a firm chorizo with good water holding capacity (WHC) and good textural properties. This led to the conclusion that this substitution is an alternative for meat products, using it as a partial extender, since it improves the quality characteristics of chorizo and confers some functional properties, such as antioxidants that are typical in turmeric.

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**J.I. Hleap-Zapata,** is PhD. in Food Engineering from Astrakhan State Technical University, Russia. His research interests include: animal food engineering, meat industry, fish industry, aquaculture. Currently, he is an associate professor in the Department of Engineering, Faculty of Engineering and Administration, at the Universidad Nacional de Colombia, Palmira campus. Author of 36 articles published in national and international scientific magazines and three book chapters. Participation in 10 research and extension projects. Speaker at 57 national and international events. National and international consultant for the fishing and meat industries. Evaluator of research projects and evaluator of scientific articles in national and international scientific journals.
ORCID: 0000-0001-9692-5443

**L. Romero-Quintana,** is BSc. Eng. in Agroindustrial Engineer. Research in Group on Management and Agroindustrialization of Products of Biological Origin. Engineering Department, Faculty of Engineering and Administration, Universidad Nacional de Colombia – Palmira campus.
ORCID: 0000-0003-3234-3406

**J.Z. Botina–Cárdenas,** is BSc. Eng. in Agroindustrial Engineer. Research Group on Management and Agroindustrialization of Products of Biological Origin. Engineering Department, Faculty of Engineering and Administration, Universidad Nacional de Colombia – Palmira campus.
ORCID: 0000-0003-3170-2593

**C.A. Martínez-Martínez,** is BSc. Eng. in Agroindustrial Engineer. Research Group on Management and Agroindustrialization of Products of Biological Origin. Engineering Department, Faculty of Engineering and Administration, Universidad Nacional de Colombia – Palmira campus.
ORCID: 0000-0001-7421-7470

**Y. Valenciano-Pulido,** is BSc. Eng. in Agroindustrial Engineer. Research Group on Management and Agroindustrialization of Products of Biological Origin. Engineering Department, Faculty of Engineering and Administration, Universidad Nacional de Colombia – Palmira campus.
ORCID: 0000-0002-8201-0370

**K.G. Higuita-Diaz,** is BSc. Eng. in Agroindustrial Engineer. Research Group on Management and Agroindustrialization of Products of Biological Origin. Engineering Department, Faculty of Engineering and Administration, Universidad Nacional de Colombia – Palmira campus.
ORCID: 0000-0002-8780-1112