Effect of inulin and pectin on physicochemical characteristics and emulsion stability of meat batters

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ABSTRACT

The aim of this study was to investigate levels of inulin and pectin replacing pork back fat in meat batter (MB) formulation. Six treatments were evaluated: T1, control MB (100% pork back fat); T2, MB + 70% pork back fat (low fat); T3, MB + 85% pork back fat + 15% inulin; T4, MB + 70% pork back fat + 30% inulin; T5, MB + 85% pork back fat + 7.5% inulin + 7.5% pectin; and T6, MB + 70% pork back fat + 15% inulin + 15% pectin. T6 reduced pH, maintained brightness (L*), increased redness (a*), yellowness (b*), Chroma, and browning index (BI); T4 decreased a*, b*, L*, and water holding capacity but increased the total color change (ΔE), cooking loss, and total expressive fluid. The addition of 15% inulin and 15% pectin can be used to replace fat without affecting the physical properties of MB.

1. Introduction

Fat content of emulsified meat products provides stability to its meat batters (MBs) (St.Clair Henning, Tshalibe, & Hoffman, 2016; Youssef & Barbut, 2011). Additionally, the processed meat products are important protein sources with high biological value, energy, vitamins (B6 and B12), and minerals (Fe and Zn) (Schmiele, Mascarenhas, da Silva, & Rodrigues, 2015). According to Choi et al. (2009), fats are of vital importance as a source of energy and essential fatty acids. However, obesity and cardiovascular diseases are changing food consumption habits (Méndez-Zamora et al., 2015). These health risks associated with intake of foods high in fat content have prompted researchers to develop products with healthier dietary ingredients (Choi et al., 2014; Schmiele et al., 2015). Food technologists and nutritionists have been making great efforts to develop novel meat products with low fat and low sodium contents, containing natural antioxidants and antimicrobials, and enriched with dietary fiber (DF), and ω-3 and ω-6 fatty acids (Hygreeva, Pandey, & Radhakrishna, 2014). An alternative to the design of novel meat products is the substitution of meat fat with other ingredients, such as DFs. DFs are functional ingredients that have been used to replace fat, resulting in increased water-binding capacity, decreased cooking loss (CL), and improved texture of meat products (Rodriguez Furlán, Pérez Padilla, & Campderrós, 2014). DFs consist of polysaccharides such as cellulose, pectin, and inulin obtained from plants, vegetables, and fruits. These DFs are resistant to hydrolysis by animal digestive enzymes but are hydrolyzed and fermented by colon microbiota (Raninenn, Lappi, Mykkänen, & Poutanen, 2011).

Inulin is produced from chicory, a bi-annual plant belonging to the Asteraceae family. During the first year of growth, chicory plants persist in the vegetative phase and form only leaves, taproots, and fibrous roots. It is during this vegetative phase inulin is stored in the collection of the raw tap root. Inulin harvest goes through two stages; the first phase involves extraction and the initial collection of the raw syrop. The raw syrup is further refined during second phase of processing to produce the commercial product, with above 99.5% purity (Shoaib et al., 2016).

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RESUMEN

El objetivo de este estudio fue investigar niveles de inulina y pectina remplazando la grasa dorsal en la formulación de pasteas cárnicas (PC) de salchichas Frankfurt. Seis tratamientos fueron evaluados: T1, control PC (100% grasa dorsal); T2, PC + 70% grasa dorsal (bajo en grasa); T3, PC + 85% grasa dorsal + 15% inulina; T4, PC + 70% grasa dorsal + 30% inulina; T5, PC + 85% grasa dorsal + 7,5% inulina; T6, PC + 70% grasa dorsal + 15% inulina + 15% pectina. T6 disminuyó el pH, mantuvo la luminosidad (L*), incrementó la tendencia al color rojo (a*), tendencia al amarillo, Chroma, e índice de coloración (IC); T4 redujo a*, b*, IC y la capacidad de retención de agua pero incrementó el cambio de color total (CCT), pérdida de cocido y el fluido total expulsado. La adición de 15% inulina y 15% pectina pueden ser usados para remplazar la grasa sin afectar las propiedades físicas de las pastas cárnicas.

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1. Introduction

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Inulin is produced from chicory, a bi-annual plant belonging to the Asteraceae family. During the first year of growth, chicory plants persist in the vegetative phase and form only leaves, taproots, and fibrous roots. It is during this vegetative phase inulin is stored in the collection of the raw tap root. Inulin harvest goes through two stages; the first phase involves extraction and the initial collection of the raw syrop. The raw syrup is further refined during second phase of processing to produce the commercial product, with above 99.5% purity (Shoaib et al., 2016).
Pectin, another plant-derived DF functional ingredient, is a well-known food additive which is mainly used for its gelling and stabilizing abilities. This DF is extracted from the plant cell wall, especially from citrus peels, apple pomace, and sugar beet pulps (Leroux, Langendorff, Schick, Vaishnav, & Mazoyer, 2003; May, 1990). According to Pagán, Ibarz, Llorca, Pagán, and Barbosa-Cánovas (2001), pectin extraction is a multiple-stage physicochemical process in which hydrolysis and extraction of the pectin macromolecules from plant tissue and their solubilization takes place under the influence of different factors, mainly temperature, pH, and time.

DFs studied as fat replacers and stabilizers in MBs include citrus pectin (Sançoban et al., 2008), rice bran (Álvarez, Xiong, Castillo, Payne, & Garrido, 2012; Choe, Kim, Lee, Kim, & Kim, 2013), makgeolli lees (Choi et al., 2013, 2014), inulin (Álvarez & Barbut, 2013; Rodríguez Furlán et al., 2014), Z-Trim® cellulose (Schmiele et al., 2015), and sugarcane bagasse (Zhuang et al., 2016). Inulin and pectin exhibit similar qualities and may be able to replace animal fat in batters. Inulin is a water-soluble fructooligosaccharide, or fructan, that contains β-fructose units bound by β-2-1 glycosidic linkages (Lattanzio, Kroon, Linsalata, & Cardinali, 2009). The inulin fructans are a mixture of oligomers and polymers that are best characterized by the degree of polymerization (DP), either as the average (DPav) or the maximum (Dpmax) value (Roberfroid, 2007). Chicory inulin moderately dissolves in water (nearly 10% at 25°C) which enables its addition in aqueous medium without precipitation; water at 50–100°C is recommended to make inulin solution (Shoaib et al., 2016). Pectin is a polysaccharide composed of galacturonic acid chains, is soluble in hot water, forms gels upon cooling, and is used as a thickening agent in food (Buttriss & Stokes, 2008). However, few studies have been conducted on the use of inulin and pectin as fat substitutes to improve MB stability (Álvarez & Barbut, 2013). Although Méndez-Zamora et al. (2015) reported the use of inulin and pectin as fat substitutes in frankfurter sausages and effects on chemical composition, texture, and sensory acceptance, it would be important to research the effect of these DFs on MB stability.

The aim of this study was to evaluate different levels of inulin and pectin replacing pork back fat in frankfurter sausage MBs and to evaluate their effect on the physicochemical variables and chemical stability.

2. Materials and methods

2.1. Ingredients

The ingredients tested were inulin powder (92% inulin, 10% sweetness level, high dispersibility, average DP ≥10; Beneo Orafti® Inulin, Megafarma S.A. de C.V., Mexico City, Mexico) and low methoxyl pectin (degree of esterification (DE) 30%; Grindsted™ Pectin LA-410, Dannova Chemical S.A. de C.V., Mexico City, Mexico). These ingredients were used in this study due to results obtained by Méndez-Zamora et al. (2015) on physicochemical properties, texture, and sensorial evaluation of sausages; however, the evaluation of inulin and pectin during MB performance before sausage manufacture could give information on emulsion stability such as its pH, CL, and expressible fluids can be considered. The formulations and experimental design for preparation of MBs and treatments were the same as those used by Méndez-Zamora et al. (2015) (Table 1).

### Table 1. Formulation of meat batters prepared with inulin and pectin.

| Ingredients (%) | T1 | T2 | T3 | T4 | T5 | T6 |
|-----------------|----|----|----|----|----|----|
| Beef meat       | 10.98 | 10.98 | 10.98 | 10.98 | 10.98 | 10.98 |
| Pork meat       | 41.93 | 41.93 | 41.93 | 41.93 | 41.93 | 41.93 |
| Pork back fat (BF) | 19.47 | 13.63 | 16.55 | 13.65 | 16.55 | 13.63 |
| Ice/water       | 20.37 | 20.37 | 20.37 | 20.37 | 20.37 | 20.37 |
| Inulin          | 0.0 | 0.0 | 2.92 | 5.84 | 1.46 | 2.92 |
| Pectin          | 0.0 | 0.0 | 0.0 | 0.0 | 1.46 | 2.92 |
| Corn starch     | 4.39 | 4.39 | 4.39 | 4.39 | 4.39 | 4.39 |
| Salt            | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 |
| Polysphosphates | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Nitrites        | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 |
| Sodium ascorbate| 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| Sausage condiment | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |

*Meat batters (MB) treatments: T1, control MB (100% pork back fat); T2, MB + 70% pork back fat (low fat); T3, MB + 85% pork back fat + 15% inulin; T4, MB + 70% pork back fat + 30% inulin; T5, MB + 85% pork back fat + 7.5% inulin + 7.5% pectin; and T6, MB + 70% pork back fat + 15% pectin + 15% inulin. 

†Tratamientos de pastas cárnicas (PC): T1, control PC (100% grasa dorsal); T2, PC + 70% grasa dorsal (bajo en grasa); T3, PC + 85% grasa dorsal + 15% inulina; T4, PC + 70% grasa dorsal + 30% inulina; T5, PC + 85% grasa dorsal + 7.5% inulina + 7.5% pectina; T6, PC + 70% grasa dorsal + 15% inulina + 15% pectina.

2.2. Treatments

Six treatments (MB) were conducted to test the replacement of pork back fat with 15 and 30% inulin and 7.5 and 15% pectin in the formulations: T1, control MB (100% pork back fat); T2, MB + 70% pork back fat (low fat); T3, MB + 85% pork back fat + 15% inulin; T4, MB + 70% pork back fat + 30% inulin; T5, MB + 85% pork back fat + 7.5% inulin + 7.5% pectin; and T6, MB + 70% pork back fat + 15% inulin + 15% pectin. The experimental units were 1.5 kg, in triplicate, and at three different time periods (three lots).

2.3. pH and color measurement

MB pH was measured (Orion 3 Star Puncture Portable pH meter, Thermo Fisher Scientific, Waltham, MA, USA) at 24 h in triplicate in each MB. After 24 h, the color of each MB treatment was determined directly using a Minolta Chroma Meter 2002 (CR-400/410, Konica Minolta Holdings, Inc., Tokyo, Japan), based on the CIE-Lab L* (lightness), a* (redness), and b* (yellowness) system; furthermore, Hue angle and Chroma were considered. Total color change (ΔE; Equation (1)) and browning index (BI; Equations (2) and (3)) were calculated using Chroma Meter L*, a, and b values according to the following equations (Ledesma, Laca, Rendueles, & Díaz, 2016):

\[
\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}
\]

\[
BI = \left[\frac{100 \times (x - 0.31)}{0.17}\right]
\]
where
\[ L^*_0 = 94.18; \quad a^*_0 = -0.43; \quad b^*_0 = 3.98 \]
\[ x = \frac{\text{final sample weight}}{\text{initial sample weight}} \]
\[ \text{WHC} = \frac{\text{final sample weight}}{\text{initial sample weight}} \]

A higher WHC (g H₂O absorbed per g meat) indicates that more water was bound to the batter.

### 2.5. CL and emulsion stability

CL of MB was evaluated according to the method of Álvarez et al. (2011). CL was calculated using the following Equation (5):

\[ \text{CL} = \frac{\text{raw weight} - \text{cooked weight}}{\text{raw weight}} \times 100 \]

Emulsion stability of MB was determined according to the method of Lin and Huang (2003). Assessment of emulsion stability was carried out in triplicate. The values of emulsion stability were estimated according to the volume of total expressible fluid (% TEF; Equation (6)) and percentage of fat exuded (% TEF₉₅; Equation (7)).

\[ \% \text{TEF} = \frac{\text{(weight of centrifuge tube and sample)} - \text{(weight of centrifuge tube and pellet)}}{\text{original sample weight}} \times 100 \]

\[ \% \text{TEF}_{95} = \frac{\text{(weight of crucible with dried supernatant) - (weight of empty crucible)}}{\text{TEF}} \times 100 \]

### 2.6. Statistical analysis

The data analysis was performed using a design randomized complete block with the GLM procedure (SAS, 2006), with the following statistical model:

\[ y_{ij} = \mu + T_i + \beta_j + e_{ij}; \]

where: \( y_{ij} \) = dependent variables; \( \mu \) = mean of treatments; \( T_i \) = effect of \( i \)th treatment (T1-T6); \( \beta_j \) = effect of \( j \)th block (lots); \( e_{ij} \) = random error (normal distribution with zero mean and variance \( \sigma^2 \)). A probability of type I error (\( p < 0.05 \)) was established to demonstrate the effect of treatments, and treatment means were compared using Tukey test.

### 3. Results and discussion

#### 3.1. pH and color

The pH of MB was influenced by the dietary ingredients (\( p < 0.05; \) Table 2). T6 containing 15% inulin and 15% pectin had the lowest pH while T1 control treatment had the highest. These differences may be due to the incorporation of the 15% pectin which leads to dissociation of carboxyl groups (–COOH) (Sriamornsak, 2003), increasing the hydrogen potential. In contrast, inulin has a pH near neutrality (Franck, 2002) which would modify the pH of MB, being that the medium is alkaline. On the other hand, Sarçoban et al. (2008) found similar low pH results in MB after incorporating different amounts of citrus pectin (2.5, 5.0, 7.5, and 10%) with a pH of 4.08. Choi et al. (2014) and Sarçoban et al. (2008) found that MB pH decreased due to the pH of added makgeolli lees fiber (pH = 4.76) and citrus pectin, respectively. These authors stated that the pH values of the emulsions could be due to the presence of some organic acids in the pectin. Similar performances may be associated with the –COOH dissociation accompanying the pectin tested in the current study.

The values \( L^* \), \( a^* \), \( b^* \), Hue angle, Chroma, total change color (\( \Delta E \)), and BI were affected by the addition of inulin and pectin in the MB (\( p < 0.05; \) Table 2). Treatment T1 control presented the highest \( L^* \) while T3 the lowest. T6 had the highest \( L^* \) among the treated samples, possibly due to the ability of inulin and pectin to retain water. In contrast, Choe et al. (2013) observed \( L^* \) (71.73 ± 0.99) and \( b^* \) values higher (>17.60), but similar \( a^* \) (4.78 ± 0.25) values in the control treatment to the current study with 30% inulin (T4). According to Serdaroglu and Deniz (2004), the addition of

### Table 2. Influence of inulin and pectin on pH and color of low-fat Frankfurter meat batters.

| Treatments (meat batters) | pH | \( L^* \) | \( a^* \) | \( b^* \) | Hue angle | Chroma | \( \Delta E \) | BI |
|--------------------------|----|---------|---------|---------|----------|--------|----------|-----|
| T1                       | 6.03<sup>a</sup> | 66.07<sup>d</sup> | 4.62<sup>a</sup> | 15.44<sup>bc</sup> | 72.73<sup>b</sup> | 16.21<sup>a</sup> | 30.85<sup>b</sup> | 31.48<sup>b</sup> |
| T2                       | 5.89<sup>bc</sup> | 65.52<sup>bcd</sup> | 5.07<sup>ab</sup> | 15.95<sup>ab</sup> | 71.95<sup>ab</sup> | 16.79<sup>ab</sup> | 31.59<sup>ab</sup> | 33.32<sup>ab</sup> |
| T3                       | 6.01<sup>b</sup> | 63.82<sup>a</sup> | 5.32<sup>ab</sup> | 15.53<sup>ab</sup> | 70.63<sup>ab</sup> | 16.51<sup>ab</sup> | 33.08<sup>b</sup> | 33.70<sup>ab</sup> |
| T4                       | 5.95<sup>c</sup> | 64.40<sup>ab</sup> | 4.77<sup>ab</sup> | 14.93<sup>c</sup> | 71.59<sup>bc</sup> | 15.77<sup>ab</sup> | 32.23<sup>c</sup> | 31.58<sup>c</sup> |
| T5                       | 5.98<sup>c</sup> | 64.64<sup>bc</sup> | 5.34<sup>b</sup> | 15.09<sup>a</sup> | 69.77<sup>a</sup> | 16.16<sup>a</sup> | 32.18<sup>ac</sup> | 32.31<sup>c</sup> |
| T6                       | 5.64<sup>c</sup> | 65.75<sup>cd</sup> | 5.95<sup>c</sup> | 16.41<sup>b</sup> | 69.75<sup>b</sup> | 17.54<sup>b</sup> | 31.74<sup>bc</sup> | 34.99<sup>c</sup> |
| SE                       | 0.03 | 0.32 | 0.16 | 0.25 | 0.54 | 0.26 | 0.32 | 0.62 |

\(<p>0.05)

Means (n = 9) in the same column with different letters are different (\( p < 0.05 \)); SE: Standard error.

1 Meat batters (MB) treatments: T1, control MB (100% pork back fat); T2, MB + 70% pork back fat (low fat); T3, MB + 85% pork back fat + 15% inulin; T4, MB + 70% pork back fat + 30% inulin; T5, MB + 85% pork back fat + 7.5% inulin + 7.5% pectin; and T6, MB + 70% pork back fat + 15% inulin + 15% pectin.

2 Lightness (\( L^* \)-value), redness (\( a^* \)-value), and yellowness (\( b^* \)-value), \( \Delta E \): total color change; BI: browning index; **Means (n = 9) in the same column with different letters are different (\( p < 0.05 \)); SE: Standard error.

3 Treatamientos de pastas cárnica (PC); T1, control PC (100% grasa dorsal); T2, PC + 70% grasa dorsal (bajo en grasa); T3, PC + 85% grasa dorsal + 15% inulin; T4, PC + 70% grasa dorsal + 30% inulin; T5, PC + 85% grasa dorsal + 7.5% inulin + 7.5% pectina; T6, PC + 70% grasa dorsal + 15% inulin + 15% pectina.

4 Luminosidad (valor CIE \( L^* \)), tendencia a color rojo (valor CIE \( a^* \)), tendencia al color amarillo (valor CIE \( b^* \)).

5 CT: cambio de color total; IC: índice de coloración; **Medias (n = 9) en la misma columna con diferente letra son diferentes (\( p < 0.05 \)); EE: error estándar.
inulin and pectin to the MBs diluted the myoglobin in the meat and, therefore, increased the lightness of the MB. Likewise, statistically T6 was not different from T1 and T2, but was different from T3 and T4, possibly the addition of 15% inulin + 15% pectin increased the lightness. Álvarez et al. (2011) indicated that the color differences may be due to the fat and ingredient (2.5% rice bran) distribution within the protein matrix in low-fat frankfurter MBs. Therefore, in the current study, the low-fat treatments were less luminous (T3–T5) in respect to control (T1) (p < 0.05), corroborated by the higher ΔE obtained of T2 to T6. These results indicated that incorporation of DFs affect the color change of MB. In a*, b*, Chroma, and BI, T6 showed the highest value while T4 with 30% inulin had the lowest in b*, Hue angle, and BI (Table 2). The increase in a* and b* with 7.5% inulin + 7.5% pectin (T5) and 15% inulin + 15% pectin (T6) in the batters is consistent with the findings of Sarçoban et al. (2008) who saw that an increase in carotenoid concentrations increased a* in MBs, although these authors obtained the DF directly from the raw material, which may conserve the pigments by another process. Likewise, T4 with 30% inulin displayed low values of a*, b*, and BI, because inulin is a white powder that is soluble in water.

### 3.2. Water holding capacity

The treatment T4 containing 30% inulin presented the lowest WHC value when compared to all other treatments (p < 0.05; Table 3). According to Franck (2002), the batter is physically stable when large amounts of water are immobilized, and Nair, Kharb, and Thompkinson (2010) indicated that, when thoroughly mixed with water or another aqueous liquid, inulin forms a particle gel network resulting in a white creamy structure with a short spreadable nature and has very good physical stability, which is attributed to its ability to immobilize large amounts of water. On the other hand, the added pectin likely increased the negative charges on the myofibrillar proteins, allowing water to bind (T5 and T6, 0.21). Therefore, pectin decreased the batter pH, causing water molecules to be absorbed. In relation to pectin, the DE is one of the properties influencing pectin application as it determines the gelling nature of pectin. Percentages of DE above 50% are classified as high methyl ester (HM) pectin, while those less than 50% are known as low methyl ester (LM) pectin (Joye & Luzio, 2000; Liew, Chin, & Yusof, 2014).

Other authors have studied the WHC with inulin (Rodríguez Furlán et al., 2014) and cellulose fiber (Schmiele et al., 2015) as a fat replacement, establishing that the fibers contribute to the integrity of the emulsion and improve the binding capacity. Thus, inulin + pectin (T5 and T6) increased water binding and improved the stability of the batter during the emulsification process.

### 3.3. CL and meat emulsion stability

The addition of inulin and pectin affected the CL of the MB (p < 0.05; Table 3). The treatment with 30% inulin (T4) had the highest CL, while the T1 control and T5 containing 7.5% pectin were the lowest. These results could indicate that the ability of inulin to retain bound water decreases during heat treatment, but the addition of 7.5 and 15.0% pectin improve the CL (T5 and T6). Choi et al. (2010) showed that the CL is affected by cooking, the fat type, and the content of the meat. Choi et al. (2009) mentioned that the DF in batters improves CL when the fat concentration is decreased and the amount of fiber is increased. In the current study, T5 could be stabilizing the protein matrix in the presence of high temperatures. In contrast, Álvarez and Barbut (2013) observed low CL values with the addition of 6% inulin powder. This low level of inulin may not be sufficient to modify the CL. Choe et al. (2013) and Choi et al. (2014) obtained a reduction of CL with 20% wheat fiber and 2% makgeolli lees fiber, respectively. These authors noted that the fibers have the ability to bind water which may have occurred in T5 when 7.5% inulin and 7.5% pectin were added to the MB.

The treatments had an effect on TEF and TEF\(_{\text{Fat}}\) (p < 0.05; Table 2). Total expressive fluid was higher in T4 and lower in T5. In contrast, T5 had the highest TEF\(_{\text{Fat}}\) while T6 with 15% inulin and 15% pectin exuded less fat. Miklos, Xu, and Lametsch (2011) reported that the TEF consists of a mixture of gel and fat that is not retained in the protein network during heat treatment, and water loss is related to the stability of the protein matrix. In the current study, the evaluated ingredients affected the expulsion of water and fat. T4 containing 30% inulin increased the expressive fluids while T6 reduced the TEF. According to Youssef and Barbut (2011), a high level of protein forms a strong network during cooking which causes the release of fat globules. The TEF was increased when inulin was used, and it is possible that a higher amount of protein was required to increase the bond between the fat and the polysaccharides. Álvarez et al. (2011) associated the increase in fat exuded with the interaction between the fiber and the fat–protein bonds during emulsification and cooking, and the TEF\(_{\text{Fat}}\) measured in T3 (15% inulin), T4 (30% inulin), and T5 (15% inulin and 15% pectin) confirm this. Álvarez and Barbut (2013) indicated that thermal treatment may affect the

| Treatments | WHC (%) | CL (%) | TEF (%) | TEF\(_{\text{Fat}}\) (%) |
|------------|---------|--------|---------|----------------------|
| T1         | 0.20\(^b\) | 3.91\(^a\) | 4.35\(^a\) | 7.21\(^b\)          |
| T2         | 0.20\(^b\) | 4.87\(^b\) | 4.43\(^b\) | 9.40\(^c\)          |
| T3         | 0.20\(^b\) | 6.16\(^c\) | 4.81\(^b\) | 11.69\(^d\)         |
| T4         | 0.19\(^a\) | 7.48\(^d\) | 5.32\(^b\) | 12.23\(^e\)         |
| T5         | 0.21\(^b\) | 3.90\(^a\) | 4.12\(^a\) | 13.85\(^a\)         |
| T6         | 0.21\(^b\) | 6.99\(^d\) | 4.63\(^b\) | 2.94\(^a\)          |
| SE         | 0.0004 | 0.0001 | 0.0013 | 0.0001              |

\(^a-b\) Means in the same column with different letters are different (p < 0.05); SE: Standard error.

\(^1\)Meat batters (MB) treatments: T1, control MB (100% pork back fat); T2, MB + 70% pork back fat (low fat); T3, MB + 85% pork back fat; T4, MB + 70% pork back fat + 30% inulin; T5, MB + 85% pork back fat + 7.5% inulin + 7.5% pectin; and T6, MB + 70% pork back fat + 15% inulin + 15% pectin; \(^2\)WHC: water holding capacity (g H\(_2\)O absorbed per g meat); CL: cooking loss; TEF: total expressive fluid; TEF\(_{\text{Fat}}\): total expressive fluid fat; \(^*\)Means (n = 9) in the same column with different letters are different (p < 0.05); SE: Standard error.

### Table 3. Effect of inulin and pectin on the emulsion stability of low-fat Frankfurter meat batters.

###Tabla 3. Efecto de la inulina y pectina sobre la estabilidad de la emulsión de pastas cárnicas Frankfurt bajas en grasa.
structure of carbohydrate chains and the stability of the batter. Choi et al. (2014) found that the fat separation of 20% fat-free fiber was high but that it decreased when the fat levels were decreased (10%) and the fiber was increased (2%). However, TEF was lower with 30% fat without fiber. In the current research, the high exudates could be due to the high levels of inulin (15%; T3) in the batters.

4. Conclusion

The results of this study suggest that the combination of 15% inulin with 15% pectin could be used to replace pork back fat and help to maintain the emulsion stability of the MBs. In conclusion, animal fat could be replaced with functional ingredients as a strategy for producing stable, more health-friendly MBs. Furthermore, inulin and pectin can be used in the preparation of low fat meat products obtaining products to improve physicochemical stability.

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Disclosure statement

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