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Study of textural properties Frankfurter's sausages modified with candelilla wax oleogel

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ABSTRACT

Objective: to evaluate the characteristics of Frankfurt-type sausages formulated with soybean and canola oleogel structured with candelilla wax (CW).

Design/methodology/approach: evaluated the physicochemical properties and textural attributes through storage time (1 and 21 days) after a partial or total substitution of the fat phase in the meat emulsion (50% and 100%) in two comercial edible oil [soybean oil (SO) and canola oil (CO)].

Results: the physicochemical characterization showed that retained higher moisture as the animal fat was displaced in the formulation, being 100% SO and 100% CO (43.46% and 40.64% respectively) those that conserved higher humidity, as well as fat and protein values. Additionally, the samples responded incrementally in 50% SO and 100% SO than in CO, after storage this in hardness, elasticity, cohesiveness, stickiness and chewiness profiles. Besides 100% SO and 100% CO were the ones that developed the greater hardness over time.

Limitations on study/implications: limitations in the manufacture of sausages, which implied a longer maturation time of the meat matrix in order to obtain a stable emulsion.

Findings/conclusions: these results are promising to establish processing parameters in order to design an attractive final product for the consumer, helping to reduce the consumption of saturated fats and trans fats.

Keywords: Oleogels, Vegetable wax, edible oil, Frankfurt Sausages, Saturated fat.

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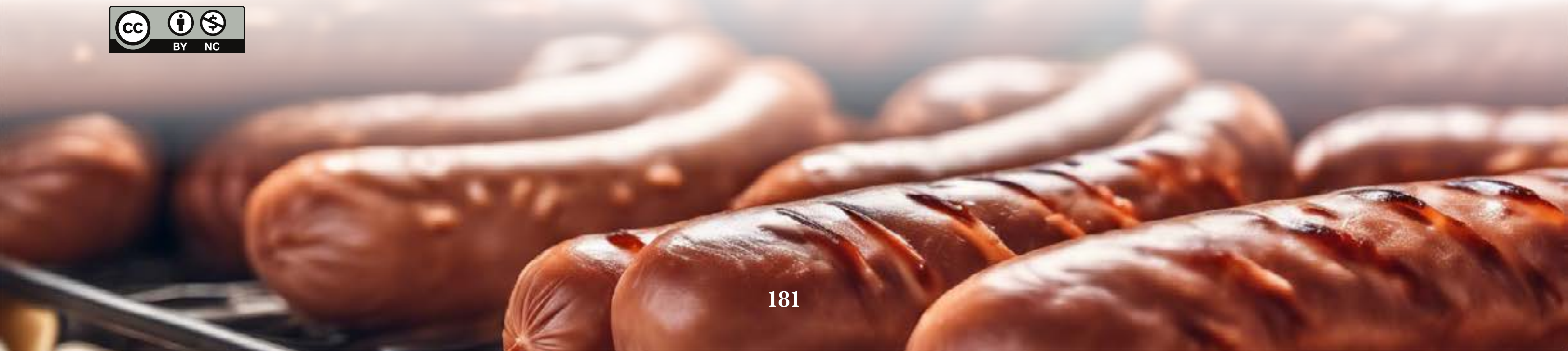
INTRODUCTION

The saturated fats provide functional characteristics in formulation food, however there is evidence of consuming fatty acid saturated are causing of metabolic diseases such as insulin resistance, diabetes, weight gain, adiposity and coronary heart disease [1,3]. This is added to the fact that to produced is necessary to consume or transform inputs as assets and services for example food, medicines, vaccines, direct labor and indirect production costs [4], that increase the cost of production of any meat products, although, animal fat, provide taste and textural properties in meat products, however saturated fatty acids and cholesterol in animal fats are some of the reasons why consumers have avoided meat and meat products [5].



Recently as a strategy to reduce the consumption of saturated fats is increasing the intake of mono and polyunsaturated fatty acid present in edible oils offer advantages such as lower bad cholesterol, as well as reduce the level of triglycerides and control the blood sugar [4,6]. Currently the effort to obtain structured materials without saturated fat or animal fat use, will be translated into oleogels implementation, this strategy provided solid systems, increasing melting point, hardness and chewiness in food and emulsifier food products [7,8]. The oleogels are semisolid system with a continuous phase made of a hydrophobic liquid (vegetable oil), where a self-assembled network, formed by a structuring agent, is responsible for the physical entrapment of the liquid [9], that could provide nutritional benefits and organoleptic attributes, it is required a gelling molecules that can structure the edible oils that contributed to non-covalent interactions such as candelilla wax. Candelilla wax (CW) is obtained from the leaves of a small shrub native to northern Mexico and the southwestern United States, *Euphorbia cerifera* and *Euphorbia antisyphilitica*, from the family Euphorbiaceae. CW is a globally recognized food additive approved by the FDA, can be used as a substitute for carnauba wax and beeswax in different food systems. Reports on the general CW composition indicates the presence of 49-50% n-alkanes with 29 to 33 carbons, 20-9% esters of acids and alcohols with even-numbered carbon chains (C28 to C34), 12-14% alcohols and sterols, and 7-9% free acids. These characteristics are to which its gelling capacity is attributed, in addition to being a great promise to create fat-like materials, using concentrations ranging from 1-4% (w/w) [10]. The study of new alternatives that promote the consumption of polyunsaturated fatty acids is undoubtedly an important advance in this type of materials, after the implementation of cheap and food-grade materials. The objective of this work is to characterize the impact of the partial or total substitution of saturated fat by soybean and canola oleogels structured with candelilla wax (CW) on the production of frankfurter type sausages.

MATERIALS Y METHODS

Oleogel Preparation

The oleogels were made by heating canola oil (Aceites, Grasas y Derivados, SA, Guadalajara - Jalisco, Mexico) and 2.5% CW (p/p) (Alkento Ingredientes, Monterrey - N. L., México), on a grill heating with constant stirring at 100 °C, for a period of 20 min, stored for at least five days at 4 °C covered with aluminum foil, to promote complete crystallization of the resulting oleogel, as previously reported (Wolfer *et al*., 2018).

Preparation of the Frankfurter type sausage

The pork leg muscle (the initial chemical composition of the meat was 70% moisture, 1% ash, 6.6% fat and 20.3% protein, determined on a dry base) was obtained from the Frigorifico de la Cuenca del Papaloapan SA de CV (Tierra Blanca-Veracruz, Mexico), removing the superficial fat, connective tissue and subcutaneous skin for subsequent grinding in a mill, MGB-120 with 280 W of power (Zimtown, Dayton-NJ, USA), and packed in hermetic bags of 1 kg each, frozen for processing. As stated [11], formulations substituting 50 and 100% of the fat phase were realized with help of a food processor

Cuisinard Model CFP-800 (Corporación Milenium, S. de R.L. de C.V. ("Conair Mexico"), processing the meat with the condiments, adding half of the crushed ice and half of the fat phase, to add the other half afterwards leaving ∼3 min of time of processing between proportions and denominating them as canola (CO or soy (SO) according to the nature of the oil. Once the emulsion was obtained, it was covered by sticky paper and stored to 4 °C for a 24 h period before the stuffing process. The sausages were made in synthetic casing, to then have a blanching process in hot water of 70-75 °C, for a period of 15 min, after which it is cooled down to 4 °C for 24 h before the vacuum packing process. The already packed samples are stored refrigerated until their subsequent analysis.

Proximal chemical analysis

They were determined on days 1 and 21 after their elaboration, the determination of proteins was carried out by the modified Biuret method with a pre-digestion of the sample in a 50/50 mixture of 10% NaOH and distilled water, after which the sample was homogenized and centrifuged (Centrificient IV, CRM Globe Int, CDMX, Mexico) for 20 min at 4000 rpm. After separation, the supernatant is decanted and is brought to a 1:10 solution for its preparation according to the method. Additionally, NMX-F-083 was used for moisture determination in food products, NMX-F-066-S-1978 for ash determination and NMX-F-089-S for determination of ethereal extract in food. All samples were analyzed in duplicate.

Mechanical evaluation

TPA tests are a well-established method for textural analysis. For these tests, 2.0 cm long samples were placed in a texture analyzer (TA. XTPlus, Stable Micro Systems, UK) at room temperature (T=22 °C). The texture parameters were obtained by means of double compression in order to simulate human chewing at 50% deformation and a speed of 2 mm/s with a 100 mm diameter stainless steel compression plate, 10 replicates were evaluated of each formulation to carry out the tests, where the force/time curve was obtained. The average of their measurements is reported.

Statistical analysis

The experiments were randomized, and the evaluations were taken 1 and 21 days after their preparation. For the statistical analysis, the Statistica V10 software (StatSoft, Inc. (2011) was used. Performing a one-line ANOVA with a 95% confidence level, the graphs indicate the standard error.

RESULTS AND DISSCUSION

The physicochemical characterization of the samples from day 1 are expressed in Table 1, where the effect on the humidity parameter is observed with respect to the formulation, with the 50% CO sample being the one with the lowest humidity, and 100% SO. the one that presented the highest humidity of all the samples analyzed, this probably due to the greater structural affinity of the emulsion, when 50% of the pork fat is replaced than when 100% fat is replaced, which could influence the results texture parameters.

Table 1. Means for effect of treatment on moisture, lipid, protein and ashes.

Treatment	Humidity	Ashes	Protein	Lipid
50% CO	37.48 [a]	2.82 [a]	14.43 [a]	26.42 [a]
50% SO	40.48 [b]	2.49 [b]	21.55 [b]	28.98 [a]
100% CO	40.64 [b]	2.78 [a]	23.60 [c]	39.97 [b]
100% SO	43.46 [c]	2.56 [c]	18.05 [d]	43.25 [b]
S. E. M	0.220	0.033	0.285	1.086

S.E.M.: standard error of mean
Mean values within a column with different letters are significantly different ($P \leq 0.05$).

Additionally, and according to the NMX-F-065-1984 standard, said products should not exceed the limit of 30% added fat, which is complied with according to the characterization by observing that the meat presented 6.6±0.43% fat since in the samples of 50% CO and 50% SO they presented values of 26.42% and 28.98% respectively, however, a considerable increase was observed in 100% SO and 100% CO, this due to the mathematical impossibility of obtaining the same moisture and fat content due to the use of lipid sources of different composition [12], coupled with the effect of the composition of the wax, since being mainly composed of alkanes, these are more similar to the polarity of the extraction solvent, so there is a greater dragging capacity, increasing the value of the ethereal extract at a higher concentration of oleogel. In the sausage, which in turn can explain the moisture content since in products with a higher fat-protein ratio moisture is lower (50% SO and 50% CO), on the contrary in products where it was present had higher fat content with a lower proportion of protein the moisture is higher (100% SO and 100% CO), due to the hydrophobic nature of the fat [13], which would directly impact the shelf life, as well as the texture of the products.

Effect of fat replacement on the textural properties of sausage

In the analysis of texture (Table 2), showed the effect of storage time in the sausage's hardness, observing in every case an increase in this parameter, which suggests a good balance between the forces that contribute to hardness, product of the interaction between canola oil oleogel and soybean oil-candelilla wax and protein. It is observed that sausages formulated with 50% of the animal fat replacement obtained less hardness depending on the type oil, in addition the sausages with higher hardness contained 100% of oleogel in both oils., being the formulation of oleogel of soybean oil-candelilla wax resulting in higher hardness of all the segment that was consistent to the 21 days of storage which is demonstrated in other studies [12, 28, 29] to replace from a 20% of animal fat by vegetable oil or oleogels, which are attributable to the specific properties of each oil, incorporation systems used and differences in product formulation, processing, composition and the proportion of animal fat replaced by the oleogel system [17], as well as the formation of small fat globules that shown to have greater resistance to compression [18].

Furthermore, the sausages not presented differences in adhesiveness, cohesiveness and elasticity and resilience, indicating that there is no effect of the type oil, concentration of oleogel and storage time on these attributes, the same reported by other authors [15, 32].

Table 2. Effect of fat replacement of texture profile analysis parameters of Frankfurt sausage containing oleogel bean soy oil (SO) and oleogel canola oil (CO).

Treatment	Hardness (g)	Adhesiveness (g*s)	Springiness	Cohesiveness	Gumminess (g)	Chewiness (g)	Resilence
			Day 1				
50%SO	1009.24^{c}	−32.78^{d}	0.77^{b}	0.55^{b}	566.78^{c}	436.92^{d}	0.26^{b}
50% CO	1124.36^{c}	−15.14^{b}	0.78^{b}	0.59^{b}	675.07^{b}	531.69^{c}	0.28^{b}
100% CO	1586.15^{b}	−9.48^{a}	0.84^{a}	0.69^{a}	1085.76^{a}	914.31^{b}	0.33^{a}
100%SO	1702.23^{a}	−24.99^{c}	0.86^{a}	0.69^{a}	1199.31^{a}	1029.41^{a}	0.33^{a}
S. E. M	56.35	12.55	0.01	0.01	24.91	20.54	0.01
			Day 21				
50%SO	1799.97^{b}	−29.05^{b}	0.80^{b}	0.57^{b}	1035.70^{c}	825.73^{c}	0.27^{b}
50% CO	1522.15^{c}	−19.27^{a}	0.80^{b}	0.59^{b}	900.62^{d}	721.57^{d}	0.28^{b}
100% CO	1827.00^{b}	−28.75^{b}	0.85^{a}	0.67^{a}	1222.93^{b}	1041.86^{b}	0.32^{a}
100%SO	2435.04^{a}	−26.28^{b}	0.86^{a}	0.65^{a}	1587.90^{a}	1364.82^{a}	0.30^{a}
S. E. M	40.38	6.15	0.01	0.01	33.33	36.32	0.01

S.E.M.: standard error of mean.
Mean values within a column with different letters are significantly different ($P \leq 0.05$)

However, gumminess and chewiness are affected by time and concentration, especially in soybean oil, observing a greater effect in the substitution of 100% SO with candelilla wax that the 100% CO, since when the proportion of saturated fat replaced is increased, it causes an increase in the chewiness referred to the energy required to chew a solid and disintegrate it until it can be swallowed as a product of hardness*elasticity*cohesiveness, therefore, by decreasing the proportion of oleogel in the meat emulsion, softer products can be generated and therefore with less chewiness, as well as the composition of the oil itself due to the fact that a greater number of unsaturation's present impacts the hardness of the organogels, as well as of the formulated products [21], which could allow the design of products with the desired composition and texture profile.

CONCLUSION

The potential of oleogels to provide an alternative to saturated fat (animal fat) in meat products without high production costs, contributing to enrichment in polyunsaturated fatty acids using edible vegetable oils, which would imply that the consumption of this type of products could prevent the development of chronic degenerative diseases. Soybean oil oleogels had a greater impact on the textural properties of the formulated sausage than canola oil, which would allow the design of the final product with the desired nutritional characteristics. The use of candelilla wax as a structuring agent for oleogels in meat matrices resulted in an economical and food grade alternative to replace animal fat present in formulated sausages, providing better opportunities in the development of meat products, showing physicochemical and textural characteristics similar to the products available in the market, same that were modified by refrigerated storage, however evaluating acceptability of the final product is necessary to evaluate the sensory characteristics of products obtained therefore being able to modify parameters in formulation.

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