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Effect of the Substitution of Pork Grease by Pre-Emulsion of Soy Isolate (*Glycine max*) with Palm Oil (*Elaeis guineensis*) on the Textural, Functional, Color and Organoleptic Properties of a Sticky Type Salicum Emulsion

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Abstract

Objective: The objective of this study was to analyze the effect of the substitution of pork dorsal fat by a pre-emulsion of soybean isolate and palm olein on the textural, functional, physicochemical, and sensory properties of a sausage. **Methods/ Analysis:** Four formulations were elaborated, only the fat substitution by pre-emulsion of soybean isolate and olein (1: 7: 7) varies as follows: T1: 25%, T2: 50%, T3: 75% and T4: 100%. Subsequently, they underwent: proximal analysis, Texture Profile Analysis (TPA), instrumental color, pH, Water Retention Capacity (CRA). **Findings:** The results show that there were significant differences (P≤0.05) in the proximal analysis with respect to the control and the treatments regarding the fat content, in the T4, there was a decrease of 74.46%. Regarding color, there were significant differences (P≤0.05) in the parameters L* and a* between samples. For the texture profile analysis the properties: cohesiveness, hardness, chewiness, gumminess and elasticity, the samples presented significant differences (P≤0.05). In the sensory characteristics, the T4 treatment presented greater acceptance. **Improvement:** It is possible to replace the pork dorsal fat with a pre-emulsion of soybean and palm olein in a sausage, without affecting the quality.

Keywords: Emulsion, Olein, Soybean, TPA, CRA

1. Introduction

The global tendency of healthy food consumption it's growing, because saturated fats and calories, cause the development of pathologies like obesity, cardiovascular diseases, high blood pressure and diabetes on consumers, this has led researches to develop formulations of low-fat meat products without affecting the organoleptic quality of the product and allowing it to have a good economic value[1]. The World Health Organization WHO (2015)[2], recommends consuming unsaturated fats (soy oil, sunflower, palm, canola and olive, among others) instead of consuming saturated ones (lard, coconut oil, among others) in order to reduce the risk of developing Non Communicable Diseases (NCDs), such as cardiovascular ones. In Colombia, cardiovascular disease is the leading cause of death, being one of the causes the abundant consumption of fats of animal origin and its derivatives. However, pork dorsal fat provides flavor, juiciness and texture in meat products. A current requirement is the

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quantity and quality of the fatty acids used in the preparation of meat derivatives, the reduction of fat of animal origin can be achieved either by the increase of the other raw materials (lean meat and/or water) or the addition of fat substitutes. The first method is not suitable for the formation of a stable emulsion, presenting problems of syneresis, texture and flavor. The second method is the most used and effective one. Many substances could be used to reduce fat in the meat emulsion such as proteins, micro particles, soybean paste, vegetable oils, and hydrocolloids, among others[3]. Soybean oil is rich in unsaturated fatty acids up to 82.5%, so, as with olive oil, it can also be incorporated into meat emulsions and helps counteract the harmful effects of saturated fats[4]. Different research are focused on reducing animal fat content in processed meat products and therefore regain the consumers' trust, they have included the use of vegetable oils such as avocado, sunflower and olive oils as a substitute for animal fat, resulting on new products with more favorable fatty acid profile, lower cholesterol level and greater oxidative stability compared to the traditional ones[5]. The objective of this study was to evaluate the effect of partial or total replacement of pork dorsal fat by a pre-emulsion of soy isolate (*Glycine max*) and palm oil (*Elaeis guineensis*) on the physicochemical, functional and sensory properties of a meat emulsion.

2. Materials and Methods

This study was carried out in the laboratories and pilot plants of the Food Engineering Program of the University of Cordoba, Berastegui campus, located in the district of Berastegui, Cienaga de Oro, Department of Cordoba. The independent variables were the replacement percentages of pork dorsal fat by pre-emulsion of soybean isolate and palm oil: 25%, 50%, 75% and 100%. On the other hand, the dependent variables were the proximal content, the Instrumental color, the Texture Profile analysis (TPA), functional properties (pH and CRA) and sensory characteristics (smell, color, flavor and texture).

For the preparation of the pre-emulsion, it was emulsified in a Felsinea cutter (1 liter capacity) performing 3 pre-tests (protein-fat-water ratios as follows: 1:7:7, 1:10:10, and 1:14:14), 1: 7:7 ratio presented the best texture conditions, the obtained pre-emulsion was packed in Styrofoam containers and stored (4°C/24h). Later the sausages were elaborated following the formulation that is observed in Table 1.

For the formulation, a calculation basis of 1.2 kg of meat mixture was used[6], as shown in Table 1; the factor that varied was the percentage of substitution of pork dorsal fat because of the pre-emulsion of soybean and palm oil isolate. Subsequently, the sausage characteristics Humidity; Fat and Protein were determined according to the methods described by AOAC 950.46, 954.02 and 940.25, 2012 respectively[7]. Dorsal pork fat (bacon), palm oil, soy and industrial beef were purchased in the local market located in the south of the city of Monteria, supplies were provided by a company specialized in additives and ingredients for the local meat industry. The formulas were evaluated using a spreadsheet to compare the link among protein, fat and water and also to verify compliance to the Colombian Technical Standard NTC 1325[8].

The meats were adapted, chopped, pre-salted and stored (4°C/24 h), then put through milling in a JAVAR 22 mill, using disk 6, once, according to the formulation, the

Table 1. Formulations of meat emulsions

INGREDIENTS	TREATMENTS (weight in Kg)				
	Control	T_1	T_2	T_3	T_4
Beef	0,720	0,720	0,720	0,720	0,720
Dorsal pork fat	0,144	0,0108	0,072	0,036	0
Pre-emulsion	0	0,036	0,072	0,108	0,144
Ice	0,246	0,246	0,246	0,246	0,246
Yucca starch	0,060	0,060	0,060	0,060	0,060
Condiments	0,018	0,018	0,018	0,018	0,018
Spices	0,0102	0,0102	0,0102	0,0102	0,0102
Polyphosphates	0,0036	0,0036	0,0036	0,0036	0,0036
Flavor enhancer	0,0006	0,0006	0,0006	0,0006	0,0006
Smoke flavor	0,0018	0,0018	0,0018	0,0018	0,0018

ingredients were weighed and then 5 samples were elaborated (control, T1, T2, T3 and T4) for which a FELSINEA cutter of 1, 2 capacity was used to obtain quality emulsified pastes, the order of addition of the ingredients was taken into account. Subsequently, the pastes of the different samples were stuffed using a Kramer stuffer, 28/30 caliber collagen casing was used and 10 cm portions were obtained. Later, the different samples were subjected to a heat treatment (scalding) temperature of the heating medium (70°C/30 min), until reaching the internal temperature of the product of 70°C, and then a thermal shock was carried out. Once the samples had cooled, they were vacuum packed in cryoback bags and stored (4°C).

The experimental units were subjected to a physicochemical characterization (humidity, protein and fat) to verify compliance to the NTC 1325[8] standard, determination of the TPA texture profile by using a texturometer TA-XT Plus, following the methodology proposed by[6], homogeneous cylindrical samples of approximately 2 cm in height and 2.5 cm in diameter were taken, and were compressed twice successively up to 25% of their original height with a plate of compression of 75 mm in diameter; in order to simulate human chewing. The textural analyzes were performed at room temperature. As for the instrumental color, this was measured using a Colorflex EZ colorimeter at room temperature. The results obtained were expressed according to the CIE system, determining the following coordinates L*, a* and b*. For the measurement of pH, the methodology proposed by[9] was followed using an Oakton potentiometer. On the other hand, to determine the Water Retention Capacity (CRA), the compression method proposed by[1] was implemented, with some modifications and sensory analysis to the final product. The sensory evaluation of the sausages was performed through a sensorial acceptance test with an untrained panel of 50 people, aged between 18 and 50 years old, of whom 10 were women and 40 were men, some of them belong to the fire brigade and others were parents and students of the mantis club of karate-do of the city of Monteria. The level of taste generated by the attributes was evaluated by: smell, color, taste and texture in the tasters, using a structured hedonic scale of 9 points equivalent to the hedonic terms 1: "I am extremely disgusted" and 9 "I like it extremely"[10].

For the statistical treatment of the data, a comparison of means with a single factor was implemented (percentage of substitution of pork dorsal fat by pre-emulsion of soy isolate and palm oil) and a control (100% pork fat). The substitution percentages of the emulsions were evaluated in four levels and the control sample, evaluating each of these with three repetitions for a total of 15 experimental units. For the analysis of data, an Analysis of Variance (ANOVA) was used. In the cases in which statistically significant differences were observed, the Tukey test ($p<0.05$) was used to compare means. All statistical analyzes were processed using the software Stat graphics Centurion XVI version 16.0.07.

3. Results and Discussion

3.1 Physicochemical Composition of Sausages

The results shown in Table 2 indicate that among humidity, fat and protein, only fat presents a statistically significant difference ($p <0.05$).

However, there were no significant differences ($P>0.05$) in the protein and humidity content between the experimental units. The fat content decreases as the amount of pre-emulsion of soy isolate and vegetable oil in the sausages increases. This may be because the pre-emulsion provides less fat than the pork dorsal fat. The T4 treatment, in which 100% of the pork dorsal fat was replaced by the pre-emulsion of soybean isolate and palm oil in the preparation of the sausages, presents a 5.71% of fat, not presenting significant differences with treatments T2 and T3. Besides, the fat content was reduced by 74.46% in the T4 treatment compared to the fat content in the control. Similar results were found by[11], who

Table 2. Physicochemical composition of the sausages (g/100g) *

	Control	T_1	T_2	T_3	T_4
Humidity	38,03^{a} ±1,56	37,96^{a}±0,17	39,49^{a}±0,25	38,24^{a}±0,78	37,92^{a}±0,90
Fat	22,36^{a}±4,65	17,90^{ab}±2,24	12,70^{abc}±6,9	7,61^{bc}±0,21	5,71^{c}±1,00
Protein	11,72^{a} ±0,40	14,27^{a} ±0,83	14,55^{a} ±4,22	14,71^{a} ±2,55	14,94^{a} ±2,61

The letters indicate statistically significant differences, Tukey test ($p<0.05$)

Table 3. Results of treatments on color and TPA texture profile analysis

Parameters	Control	T_1	T_2	T_3	T_4
L^*	63,46^{a}±0,83	65,36^{b}±0,22	67,63^{c}±0,54	67,26^{c}±0,58	67,26^{c}±0,58
a^*	12,72^{b}±0,19	12,35^{sb}±0,14	12,15^{ab}±0,15	12,41^{ab}±0,15	11,75^{a}±0,48
b^*	13,66^{a}±0,31	13,73^{ab}±0,22	14,06^{ab}±0,22	13,72^{ab}±0,07	14,45^{b}±0,41
Adhesiveness (g.s)	-1,08^{a} ±0,62	-1,92^{a} ±0,95	-2,74^{a} ±0,94	-1,75^{a} ±0,79	-2,12^{a}±0,66
Cohesiveness	0,81^{c} ±0,01	0,81^{c} ±0,00	0,79^{bc} ±0,01	0,78^{ab} ±0,00	0,77^{a}±0,01
Hardness (g)	3,64^{c} ±0,30	2,91^{b} ±0,22	2,71^{b} ±0,11	2,54^{ab} ±0,06	2,12^{a} ±0,09
Elasticity	0,95^{c} ±0,00	0,94^{b} ±0,00	0,93^{b}±0,00	0,92^{a} ±0,00	0,92^{a}±0,00
Gumminess (g)	2,94^{c} ±0,22	2,34^{b} ±0,19	2,15^{b} ±0,08	1,99^{ab} ±0,05	1,63^{a} ±0,07
Chewableness g	2,79^{d} ±0,21	2,19^{c} ±0,18	2,00^{bc} ±0,07	1,83^{ab} ±0,05	1,49^{a} ±0,07

The letters indicate statistically significant differences, Tukey test ($p<0.05$)

studied the effect of isolated soy protein on the quality characteristics of light pork sausages containing konjac gels. Equally, formulated low-fat bologna sausages using vegetable oil emulsion as a fat replacer[12]. In both studies, the incorporation of these ingredients as fat replacers provided favorable results on the quality of the products obtained, without drastic changes in physicochemical characteristics and texture. Another similar study was presented by, who replaced pork dorsal fat with soybean oil, finding a decrease in fat content and a better acceptance of the organoleptic characteristics of the product[13].

3.2 Instrumental Color and Texture

Table 3 shows the variations in color and texture characteristics of the sausages calculated by instrumental means.

Regarding color, the total substitution of pork dorsal fat for soybean and palm oil pre-emulsion shows significant differences ($p<0.05$) in brightness (L*) between control and treatments, while among T2, T3 and T4 treatments, didn't show significant differences ($p>0.05$). In the coordinate a* significant differences are observed ($p\leq0.05$) between the control and the T4 treatment, this is mainly because the tendency to red is diminished as the pre-emulsion of soybean and oil palm isolate is added to the sausages. Equally, in the b* coordinate in the T4 treatment there were significant differences compared to the control, while for the treatments T1, T2 and T3 there were no significant changes regarding the control ($p>0.05$). This is because the pork dorsal fat was replaced in its entirety by the pre-emulsion of soybean isolate and palm oil, dispersing the characteristic red color of the sausages and obtaining a more rosy shade. A similar study was presented by[12], who substituted pork dorsal fat for vegetable oil in sausages. The replacement levels of pork fat for linseed oil affected the parameters of the target color; this result may be due to whitish linseed oil. On the other hand, regarding the analysis of TPA, significant differences were observed ($p<0.05$) in the five properties, among all the treatments presented compared to the control. The treatment T4 was the one that obtained the lowest values in the results of the cohesiveness (0.77 ± 0.01), hardness (2.12 ± 0.09), chewiness (1.49 ± 0.07), gumminess (1,63 ± 0,07), elasticity (0,92 ± 0,00) and resistance (0,46 ± 0,01), which indicates that it is a sausage much softer on the palate and much juicier, which could be deformed easier in the mouth. Similar studies were presented by[14], who found a greater hardness and cohesiveness than those in which part of the fat was replaced by maltodextrin in a sausage formulation. In the results obtained by[6] it was observed that the hardness of the formulated sausages increased when quinoa flour was added in the formulation, compared to the control treatment.

Table 4. Results of CRA and pH of the sausages

Treatments	CRA	PH
Control	118,51^{a}±6,68	6,10^{a} ±0,03
T_1	125,77^{a} ±8,98	6,07^{a} ±0,05
T_2	129,95^{a} ±7,30	6,09^{a} ±0,02
T_3	127,74^{a} ±15,27	6,05^{a} ±0,04
T_4	133,88^{a} ±10,04	6,08^{a} ±0,02

The letters indicate statistically significant differences, Tukey test ($p<0.05$)

Table 5. Sensory analysis by attributes of the sausages

Treatments	Attributes			
	Color	Smell	Taste	Texture
Control	$6,88^{a}\pm1,29$	$6,56^{a}\pm1,46$	$6,56^{a}\pm1,98$	$6,40^{a}\pm1,66$
T_1	$6,60^{a}\pm1,32$	$6,42^{a}\pm1,83$	$6,38^{a}\pm2,22$	$6,86^{ab}\pm1,58$
T_2	$7,08^{a}\pm1,29$	$6,30^{a}\pm2,06$	$7,14^{ab}\pm1,46$	$6,92^{ab}\pm1,72$
T_3	$6,56^{a}\pm1,31$	$6,60^{a}\pm1,59$	$6,42^{a}\pm1,68$	$6,56^{ab}\pm2,06$
T_4	$6,48^{a}\pm1,80$	$6,50^{a}\pm2,06$	$7,64^{b}\pm1,24$	$7,38^{b}\pm1,47$

The letters indicate statistically significant differences, Tukey test ($p<0.05$)

3.3 Water Retention Capacity (CRA) and ph

As can be seen in Table 4, the CRA and the pH did not show significant differences ($p>0.05$) between the control and the treatments,

Similarly, we can observe that when replacing the pork dorsal fat partially or totally with soybean and palm oil isolate, the water retention capacity for the T4 treatment is of 133.88 compared to a study carried out by[15], in which they use a gel formulated with soy protein and carrageenan in the elaboration of blanched sausages, the inclusion of these favored the capacity of water retention.

3.4 Sensory Evaluation

The results presented in Table 5 show that the sausages treated with soybean oil and palm oil pre-emulsion didn't show statistically significant differences ($p>0.05$) in color and smell compared to the control, being on an average scale from "I like it lightly" to "I like it moderately".

When analyzing the values the flavor and texture attributes, it was observed that T4 treatment presented statistically significant differences ($p<0.05$) compared to the control. This could be because in this treatment a greater amount of pre-emulsion of soybean isolate and palm oil was used which could cause positive effects and therefore generate changes in the sensory characteristics of taste and texture, associated with the generation of a better flavor and a better texture to the palate, as well as what happened with the instrumental texture analysis where T4 treatment showed greater juiciness. For both the flavor and texture analysis, an average scale was found for T4 treatment of "I like moderately" to "I like it a lot".

Similar results were found by[16], who indicates that the use of non-meat proteins contributes to improve texture and improve sensory characteristics. Similarly[17], states that these types of ingredients help reduce some undesirable sensations in terms of the flavor of fat-free products, improving mouth feel and taste. Another similar study was carried out by[18], who replaced 75% of pork fat with vegetable oil and potato starch in the preparation of Frankfurt sausages, finding significant differences in taste acceptability by the tasters. On the other hand[14], when replacing malto-dextrina for pork fat in a sausage, found that the substitution directly affects the sensory acceptance. Having a higher level of acceptance the sample to which no substitution was made.

4. Conclusions

By completely replacing (T4 Treatment) the pork dorsal fat by a pre-emulsion of soybean isolate and palm oil, the fat content is reduced by 74.46%, hence the pre-emulsion can substitute the pork dorsal fat to obtain healthier and low fat products. The changes in L* and in a* in T4 are due to the replacement of pork fat. On the other hand, the replacement of pork fat by pre-emulsion in T4, improves the textural properties (hardness, chewability, cohesiveness, gumminess and elasticity) obtaining a product that is juicier, smoother and easier for the mechanical action of the mouth. Finally, the samples prepared with 100% of pre-emulsion, showed a higher acceptance according to the sensory evaluation performed, which allows the verification of the results obtained in the TPA analysis.

5. References

1. Mendez G, Garcia J, Santellano E, Chavez A, Duran L, Silva R, Quintero A. Fat reduction in the formulation of frankfurter sausages using inulin and pectin. Food Science and Technology. 2015; 35(1):25-31. https://doi.org/10.1590/1678-457X.6417
2. Organizacion Mundial de la Salud (OMS). Healthy diet. Fact sheet N° 394, (en linea). Available from: http://www.who.int/mediacentre/factsheets/fs394/en/

3. Rivera I. Reduccion de grasa y alternativas para su sustitucion en productos carnicos emulsionados, una revision. Nacameh. 2012; 6(1):1-14.
4. Alejandre M, Poyato C, Ansorena D, Astiasaran I. Linseed oil gelled emulsion: A successful fat replacer in dry fermented sausages. Meat Science. 2016; 121:107-13. https://doi.org/10.1016/j.meatsci.2016.05.010
5. Rodriguez J, Dorcuende D, Estevez M. Avocado. Sunflower and olive oils as replacers of pork back-fat in burger patties: Effect on lipid composition, oxidative stability and quality traits. Meat Science. 2012; 90:106-15. https://doi.org/10.1016/j.meatsci.2011.06.007
6. Albarracin W, Delgado N, Villegas C. Análisis de textura y color de salchichas elaboradas con adicion de harinas no convencionales. Agronomia Colombiana. 2016; 34(1):S1194-7.
7. AOAC International. Official Methods of Analysis of AOAC International. ed. 19. MD, USA: Editorial Gaithersburg; 2012. p. 3000
8. NTC 3967. Norma Tecnica Colombiana. Available from: http://web.mintransporte.gov.co/consultas/mercapeli/Reglamento/Anexos/NTC3967.pdf
9. Ramos D, San Martin V, Rebatta M, Arbaiza T, Salva B, Caro I, Mateo J. Caracteristicas fisicoquimicas de la salchicha de cerdo del departamento de Tumbes, Peru. Salud y Tecnologia Veterinaria. 2014; 2(2);120-8. https://doi.org/10.20453/stv.2014.2249 https://doi.org/10.20453/stv.v2i2.2249
10. Ramirez J. Analisis sensorial: Pruebas orientadas al consumidor. Reciteia. 2012; 12(1):83-102.
11. Akesowan A. Effect of soy protein isolate on quality of light pork sausages containing konjac flour. African Journal of Biotechnology. 2008; 7(24):4586-90.
12. Ferreira-Ignacio AK, Rodrigues-Pollonio MA. Reducing Animal Fat in Bologna sausage using pre-emulsified linseed oil: Technological and sensory properties. Journal of Food Quality. 2015; 38(3):201–12. https://doi.org/10.1111/jfq.12136
13. Beauvois, S. Sustitucion de la grasa dorsal de cerdo por aceite de soja en la elaboracion de chorizo tipo antioqueno [Tesis Zootecnista, Universidad de la Salle, Bogota]; 2016. p. 1-90.
14. Bravo-Yacuma A, Coral-Ruiz M, Abarracin W. Analisis de textura en salchichas tipo Frankfurt empleando maltodextrina como sustituto parcial de la grasa. Investigacion y Desarrollo en Ciencia y Tecnologia de Alimentos. 2017; 2:353-6.
15. Pietrasik Z, Duda Z. Effect of fat content soy protein/carrageenan mix on the quality characteristics of comminuted, scalded sausages. Meat Science. 2000; 56(2):181-8. https://doi.org/10.1016/S0309-1740(00)00038-3
16. Serdaroglu M. Improving low fat meatball characteristics by adding whey powder. Journal Meat Science. 2006; 72(1):155-63. https://doi.org/10.1016/j.meatsci.2005.06.012
17. Cury K, Martinez A, Aguas Y, Olivero R. Caracterizacion de carne de conejo y produccion de salchicha. Revista Colombiana Ciencia Animal. 2011; 3(2):275-9.
18. Banda D. El efecto de la sustitucion de la grasa animal (cerdo) por grasa vegetal (Danfat FRI -1333) en la formulacion y elaboracion de salchichas Frankfurt [Tesis: Ingeniero de Alimentos, Universidad Tecnica de Ambato, Ecuador]; 2010. p. 33-5.