

Assessment of Chemical, Physico-Chemical and Sensorial Properties of Frankfurters-Type Sausages Added with Roselle (*Hibiscus sabdariffa* L.), Extracts [†]

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Abstract: Frankfurters are the most widespread type of emulsified meat product in the world. However, it could be considered unhealthy due to the high-fat content (15–30%). The meat industry wishes to change the perception of these products reformulating them. One strategy is increased the content of compounds considered beneficial for human health. Thus, the aim of this study was determined the chemical, physico-chemical and sensorial properties of frankfurters-type sausages added with roselle (*Hibiscus sabdariffa* L.), extracts. Frankfurt-type sausages were made following traditional formula. Three different formulations were prepared: the original mixture was used as control sample (CS). The other samples were formulated added roselle extract at 4.08% (FRE4) and 8.17% (FRE8). For proximate analysis, no statistical differences were found between FRE4 and FRE8 and CS. However, the residual nitrite levels decreased from 88.41 mg NaNO₂/kg in CS to 86.31 and 69.82 mg NaNO₂/kg in FRE4 and FRE8, respectively. Regarding the sensory analysis of the frankfurters, CS and FRE4 samples generally scored significantly higher than FRE8 for all the parameters considered. This study suggests that the reformulation of Frankfurt-type sausages using roselle extracts is feasible and represents a viable alternative to improve the safety and the nutritional composition of the product.

Keywords: Frankfurt sausage; roselle; nitrite; sensorial; emulsion stability

1. Introduction

Changes in eating habits arising from the development of society in recent decades have led people to search for affordable and healthier foods with satisfactory taste and pleasant appearance. Thus, the food industry continually seeks to adapt and develop new formulations designed to increase shelf life and to improve quality and food safety [1]. Following increased consumer demand for fast food, many efforts have been made to improve the quality and stability of Frankfurt sausages or burgers [2,3]. In an attempt to make healthier these products, meat industry have added functional ingredients in the meat formulations. However, the challenge for them is not easy due to this type of products should maintain traditional quality and an accessible cost, so that consumers can continue to enjoy them regularly [4]. Plant material, fruits, vegetables, flowers, and their co-products are the most studied substrates for the obtention of these functional ingredients due to in their composition

it is possible to find several bioactive compounds that shown different nutritional and technological properties derived from their structure, composition, and solubility. Roselle (*Hibiscus sabdariffa* L.), an herb that belongs to *malvaceae* family, is widely used to prepared cold and hot beverages in many countries. Moreover, roselle extracts are currently marketed as supplements due to their apparent potential health benefit [5]. In this sense, roselle extracts have been incorporated into patties [4], chicken sausages [6], and marinades [7] where the biggest challenge has been to maintain the quality characteristics of the products. However, it should be borne in mind that the incorporation of unusual ingredients in the meat formulation could affect the physico-chemical, sensory, and nutritional quality of the new product. Therefore, the aim of this study was to determine the effect of roselle (*Hibiscus sabdariffa* L.) extracts addition on the chemical, physico-chemical and sensorial properties of frankfurters-type sausages.

2. Material and Methods

2.1. Preparation of Roselle Extracts and Frankfurters Sausges

Roselle (*Hibiscus sabdariffa* L.) was obtained from the local market and the extract was prepared by adding 15 g of dried roselle petals to 100 mL of water at 87 °C and stirred 10 min, cooled overnight (4 °C), filtered through a Buchner funnel frozen at −18 °C. Frankfurters were manufactured according to a traditional formula: This original mixture was used as control sample, and the others Frankfurt sausages (two formulations) were prepared as shown in Table 1.

Table 1. Ingredients of emulsion Frankfurter sausages.

Ingredients (g/100 g)	CS	FRE4	FRE8
Lean Pork Trim	57.17	57.17	57.17
Pork backfat	24.50	24.50	24.50
Ice	12.25	8.17	4.08
Roselle extract	---	4.08	8.17
Salt	2.04	2.04	2.04
Corn starch	1.23	1.23	1.23
Potato peel flour	1.23	1.23	1.23
Caseinate	1.23	1.23	1.23
Smoke	0.080	0.080	0.080
Sodium ascorbate	0.025	0.025	0.025
Sodium Tripolyphosphate	0.020	0.020	0.020
Sodium nitrite	0.015	0.015	0.015
White pepper powder	0.16	0.16	0.16
Nutmeg powder	0.04	0.04	0.04

The products were prepared in the Miguel Hernández University Pilot Plant following an industrial processing protocol. Briefly, meat ingredients were ground in a cutter (1094-Homogenizer, Tekator, Höganäs, Sweden) and mixed with the sodium chloride and the rest of the ingredients for 2 min (temperature below 8 °C). After homogenization, the resulting meat batter was stuffed using a piston stuffer EM-12 (Mainca, Barcelona, Spain) into 20 mm diameter cellulose casings (Fibran, Girona, Spain). Samples were hand linked and cooked in a water bath (90 °C) to an internal temperature of 72 °C using a thermocouple probe (Omega Engineering, Inc., Stamford, CT) positioned in the geometric centre of one sample. When the endpoint temperature was achieved, the sausages were immediately chilled in ice for 5 min. Then, they were peeled by hand and vacuum packed (vacuum machine: Egarvac, Barcelona, Spain) in plastic bags. All samples were stored immediately after packing at 4 ±1 °C under darkness conditions.

2.2. Proximate Composition

The proximate composition was calculated according to the Association of Official Agricultural Chemists (AOAC) official methods [8]. 950.46 to determine moisture, 981.10 to determine crude protein, 920.153 to determine ash and 991.36 to determine crude fat. Residual nitrite content (mg NaNO₂/kg sample) was determined according to standards ISO/DIS 2918.26 [9].

2.3. Physico-Chemical Properties

The pH of frankfurters was measured directly using a Crison combination electrode probe (Cat. No. 52) connected to a pH-meter (model 507 Crison, Barcelona, Spain). The measurement was taken three times, changing the location of electrode insertion. Water activity (aw) was measured at 25 °C using an electrolytic hygrometer (Novasina TH-500, Novasina, Axair Ltd., Pfaeffikon, Switzerland). The procedure of Hughes, Cofrades and Troy [10] was followed to assess emulsion stability.

2.4. Sensory Evaluation

A 40-member sensory panel (15 males and 23 females) aged 18–55 years and with no specific training in the sensory analysis of frankfurter, were recruited from the staff and students of the Miguel Hernández University. Protocols for sensory analysis were approved by the Project Evaluation Office of the Miguel Hernández University (OEP, UMH, Elche, Alicante, Spain). This analysis was performed under white fluorescent lights in individual booths. Pieces of approximately 2.0 cm (3 pieces, one from each bath) were cut from the frankfurter and served at room temperature. Unsalted crackers and mineral water (room temperature) were provided to clean the palate between samples. The hedonic scale consisted of 7 levels (7 = highly acceptable; 1 = highly unacceptable), in which the panellists evaluated the following attributes: colour, brightness, smoke smell, salty flavour, potato flavour, roselle flavour, sausage flavour, granularity, juiciness, hardness and general acceptability.

2.5. Statistical Assay

The results in the tables are expressed as mean values and standard deviation. One-way analysis of variance (ANOVA) was performed to evaluate the statistical significance ($p \leq 0.05$) of the effect of sample formulation (product characterization) using the SPSS program v. 27 for Windows (IBM, Chicago, IL, USA). Tukey's post hoc test was applied for comparison.

3. Results and Discussion

3.1. Chemical Composition

Table 2 showed the chemical composition of the control sausages, and the added treatments with roselle extract at 4 and 8%, it was observed that the moisture, ash, and fat content did not present a significant difference ($p > 0.05$) between the evaluated treatments. Only the protein content showed a slight reduction ($p < 0.05$) which can be due to the protein content in the initial meat batch.

Table 2. Chemical composition of Frankfurt sausage added with roselle extract.

	Moisture	Ash	Proteins	Fat
CS	64.34 ± 1.13 ^a	2.39 ± 0.01 ^a	17.97 ± 0.27 ^{ab}	13.28 ± 1.56 ^a
FRE4	61.70 ± 0.83 ^a	2.35 ± 0.02 ^a	18.07 ± 0.27 ^a	14.29 ± 0.75 ^a
FRE8	63.01 ± 0.96 ^a	2.41 ± 0.10 ^a	17.08 ± 0.02 ^b	13.61 ± 0.76 ^a

All data are presented as means ± standard error. Values expressed as g/100 g sample. CS: Control sample, FRE4: frankfurter +4% roselle extract; FRE8: frankfurter +8% roselle extract. Means with different letters in the same column are significantly different ($p \leq 0.05$).

Residual nitrite content corresponds to nitrite that has not reacted with myoglobin and it is available for other reactions in the organism. The rate of reduction is dependent upon numerous factors such as pH, original nitrite content, the temperature during process and storage temperatures, and/or meat-to-water ratio [11]. Figure 1 showed the residual nitrite content present on frankfurters-type sausages added with roselle extracts at 4% and 8%. The addition of roselle extract had a significant impact on residual nitrite content. Thus, the results showed that the incorporation of roselle extract decreases the residual nitrite content and it did a concentration-dependent manner. For FRE4 the reduction was 2.37% while for FRE8 the reduction achieved was 20.91%. It is important to notice that all the residual nitrites values are within the established norms, which indicate that the maximum is 100 mg NaNO₂/kg sample [12].

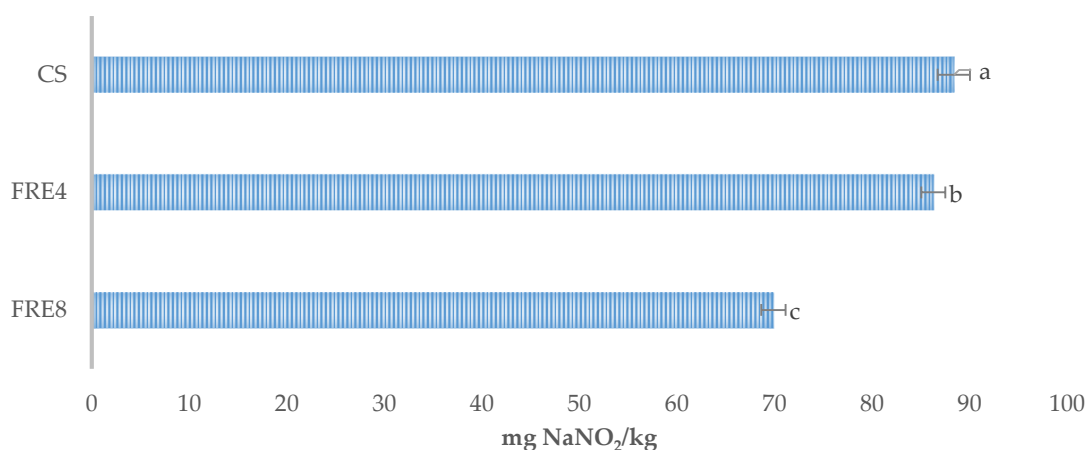


Figure 1. Residual nitrite content of frankfurters added with roselle extracts. CS: control sample; FRE4: frankfurter + 4% roselle extract; FRE8: frankfurter + 8% roselle extract. Bars with different letters in the same column are significantly different ($p < 0.05$).

There are numerous studies where a reduction in nitrite content in cooked meat products such as frankfurter-type sausages or paté added with plant extracts was obtained [3,13]. This reduction could be caused by the reaction between nitrite and bioactive compounds, mainly polyphenols, present in these plant extracts.

3.2. Physico-Chemical Properties

The physico-chemical properties of Frankfurt sausage added with roselle extract at 4 and 8% are shown in Table 3. The emulsions stability among treatments was not significant ($p > 0.05$) and all values showed that they possess excellent emulsifying stability. This property is related to fat and water retention capacity as well as the pH of the meat matrix. Thus, despite the fact that the roselle extract had an acidic pH, it did not influence either the ability to form the meat emulsion or its stability.

Table 3. Physic-chemical properties of Frankfurt sausage added with roselle extract.

	Emulsion Stability	pH	Aw
CS	98.18 ± 0.45 a	6.04 ± 0.01 a	0.97 ± 0.00 a
FRE4	99.28 ± 0.34 a	5.83 ± 0.03 b	0.96 ± 0.00 a
FRE8	99.28 ± 0.44 a	5.71 ± 0.02 c	0.96 ± 0.00 a

Aw: water activity. All data are presented as means ± standard. CS: control sample, FRE4: frankfurter + 4% roselle extract; FRE8: frankfurter + 8% roselle extract. Means with different letters in the same column are significantly different ($p < 0.05$).

For water activity, no statistical differences ($p > 0.05$) were found between CS and the samples added with roselle extracts at 4 and 8%. The values obtained in this work for water activity are typical for this type of cooked meat product. The pH was deeply affected ($p < 0.05$) by the addition of roselle extract and it occurs in a concentration-dependent manner. The control treatment had a pH of 6.04 and decreased until 5.83 and 5.70 in the treatments with 4 and 8%. This behavior is similar to reported by Karabacak and Bozkurt [14] in Turkish dry-fermented sausage or Pérez-Báez et al. [4] in burger patties where a reduction in pH values was observed. This reduction could be due to the naturally low pH value of roselle extracts.

3.3. Sensorial Analysis

Figure 2 showed the results obtained for the sensorial analysis carried out in Frankfurt sausages formulated with roselle extracts at 4 and 8% FRE4 and FRE8, respectively. For visual and olfactory attributes, FRE8 showed the lowest ($p < 0.05$) scores for colour and brightness while CS had the highest values. These results are very important due to they indicated that the panellists detected a change of colour and brightness caused by the incorporation of the roselle extract in the sausages. For smoke smell were no differences ($p > 0.05$) with FRE4 and control sample.

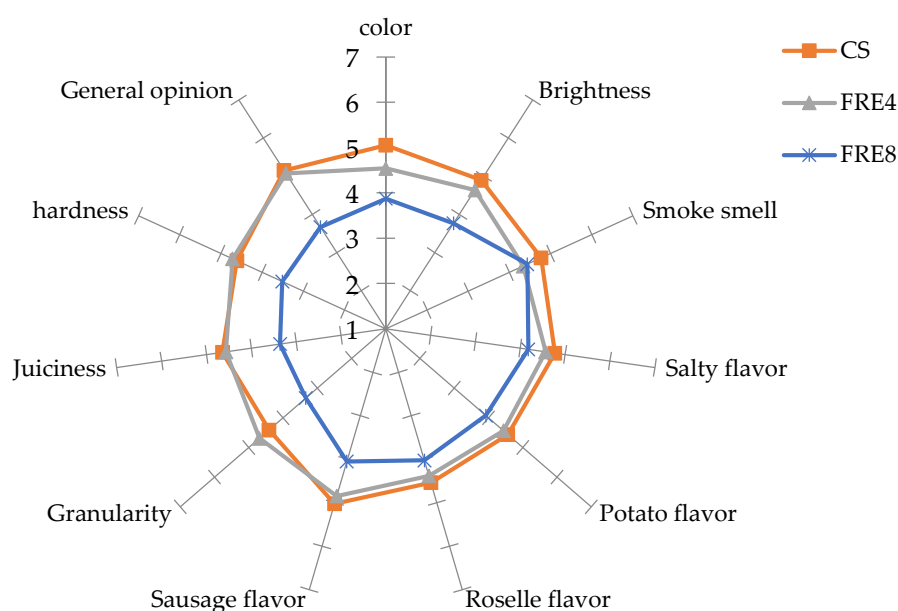


Figure 2. Sensory evaluation of frankfurters added with roselle extracts. CS: control sample; FRE4: frankfurter + 4% roselle extract; FRE8: frankfurter + 8% roselle extract.

As regards taste attributes again FRE8 had, the lowest ($p < 0.05$) scores for salty flavour, potato flavour, roselle flavour and sausage flavour. On the other hand, no statistical differences were found ($p > 0.05$) between CS and FRE4 for these parameters. It is important that the roselle flavour be not detected in the FRE4, because its flavour is related to very acidic or earthy flavours that sometimes are not acceptable for the consumer. As regards touch attributes (granularity, juiciness and hardness), no statistical differences ($p > 0.05$) were found between CS and FRE4. FRE8 scored worse for all touch attributes. Finally, as regard general, acceptance the lowest ($p < 0.05$) values were obtained for FRE8 while the most acceptable sample ($p < 0.05$) were FRE4 and the control sample, with no statistical differences ($p > 0.05$) between them.

4. Conclusions

This study suggests that the reformulation of Frankfurt-type sausages using roselle extracts is feasible and represents a viable alternative to improve the safety and the nutritional composition of the final product without adversely affecting the technological properties.

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