REDUCING SODIUM IN A MEAT EMULSION MODEL SYSTEM PREPARED WITH MECHANICALLY RECOVERED CHICKEN MEAT

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Abstract – Consumers are increasingly aware of the relationship between sodium intake and hypertension. Therefore, the aim of the present study was to investigate the technological impacts of sodium (sodium chloride) reduction and KCl (potassium chloride)/phosphate addition in model meat emulsions prepared with mechanically recovered chicken meat (MRCM). The optimization process was performed using the Central Composite Design based on Response Surface Methodology, and consisted of 20 trials with six replicates at the center point. The emulsion stability and shear force were used as independent variables. In the joint evaluation of the responses, the best contents of phosphate (0.4%) and KCl (0.46%) were found for a sodium-reduced meat emulsion model system.

Key Words – Sodium, Phosphate, potassium chloride

I. INTRODUCTION

Excessive consumption of sodium is linked to hypertension and consequently increased risk of stroke and death from vascular diseases. Sodium intake by industrialized countries population exceeds the nutritional recommendations and in the UK, it is estimated that around 75% of sodium intake is derived from processed food. About 5% of the remaining sodium is usually found in the food and 20% is added as flavoring during cooking [1].

Besides its use as a condiment, salt also helps to solubilize the myofibrillar proteins, transforming the native state into solubilized protein, and when heated, this solubilized protein is fixed as a network structure, immobilizing water, giving this paste a gel-like consistency and consequently improving the texture of sausages [2]. In the production of sodium-reduced products, it must be considered the effects that salt reduction may have on technological functions. Since there is not an isolate ingredient that can be used to replace salt in meat products, combinations of functional ingredients must be developed and /or optimized [3].

The preference for chicken cuts led to the need to find better use chicken backs, necks and bones resulting from the boning process, since 24% of these parts are edible [4]. According to the Ministry of Agriculture, Livestock and Supply [5] in Brazil, mechanically recovered chicken meat (MRCM) refers to the meat obtained from mechanical grinding and bone separation to produce specific meat products. Those are immediately frozen in fast or ultra-fast processes, when they are not consumed immediately.

The objective of this study was to investigate the impacts of technological reduction of sodium contents, with the addition of phosphate and potassium chloride to meat emulsion type models containing MRCM in their composition. Thus, different ways to reduce the sodium contents in industrial meat mixture might be achieved.

II. MATERIALS AND METHODS

The experiment was carried out in a model system and the batter were obtained in a cutter with all ingredients usually used to make sausage with varying contents of phosphate (Abastol 452®), sodium chloride (NaCl) and potassium chloride (Nu-Tek Salt Potassium Chloride®). For the optimization process, it was used a factorial design with central composite rotational design (DCCR) based on Response Surface Methodology [6]. The independent variables are listed in Table 1. The design consisted of 20 experiments including six replicates in the central composite, which were performed at random sequence, according to the design matrix shown in Table 2.

Table 1. Codified and real values for the variables of the experimental design.

Variable	-α	-1	0	+1	+α
Phosphate	0.00	0.10	0.25	0.40	0.50
[NaCl]	1.00	1.30	1.75	2.20	2.50
[KCl]	0.20	0.46	0.85	1.24	1.50

Table 2. Experimental design (DCCR) for three variables with six repetitions at the central composite.

Trial	Phosphate	[NaCl]	[KCl]
1	0.10	1.30	0.46
2	0.40	1.30	0.46
3	0.10	2.20	0.46
4	0.40	2.20	0.46
5	0.10	1.30	1.24
6	0.40	1.30	1.24
7	0.10	2.20	1.24
8	0.40	2.20	1.24
9	0.00	1.75	0.85
10	0.50	1.75	0.85
11	0.25	1.00	0.85
12	0.25	2.50	0.85
13	0.25	1.75	0.20
14	0.25	1.75	1.50
15	0.25	1.75	0.85
16	0.25	1.75	0.85
17	0.25	1.75	0.85
18	0.25	1.75	0.85
19	0.25	1.75	0.85
20	0.25	1.75	0.85

The emulsion stability was performed by Parks et al. methodology [7]. That was expressed as a liquid loss percentage of packed emulsion treated for 60 minutes in water bath at 70ºC.
The shear force was determined in an emulsion samples cut into 2.0 cm length in a texturometer TA-XT 2i (Texture Technologies Corp. / Stable Micro Systems, UK) equipped with a Warner-Bratzler blade set (3-mm thick), moving at a constant speed 0.8 mm/s.
The physical-chemical composition of each treatment was performed according to Horwitz [8]. The amounts of phosphates, sodium chloride and potassium chloride varied among the emulsion treatments formulations as shown on Table 2, the water percentage was adjusted in the formulation to achieve 100%.

The emulsions were formulated with MRCM (60%),water (27.82% to 29.8%), texturized soy protein (3,0%), cassava starch (2.0%), isolated soy protein (1.2%), antioxidant (0.05%), sodium nitrite (0.02%), spices (0.25%), yeast extract (0.75%), sodium lactate (1.0%) and liquid smoke (0.07).
The statistical analysis was conducted using the STATISTICA software (StatSoft, Poland), with effects assessment and significance level 5% probability ($p < 0.05$).

III. RESULTS AND DISCUSSION

Table 3 shows the physical-chemical parameters of the raw MRCM and the average chemical composition of the 20 trials of sausage emulsions.
The results obtained for the MRCM composition are within the technical regulations established for this type of raw material [5]. The minimum protein required is equal to 12% and the maximum fat amount allowed is 30%. There is no limit established for the ash content. Chemical composition of emulsions did not change among treatments since the amount of the ingredients (except for NaCl, phosphate and KCl) were the same for all 20 trials.

Table 3. Physical-chemical characteristics of the MRCM and meat emulsions with MRCM.

	Moisture[1]	Total Fat[1]	Ash[1]	Protein[1]	pH
CMRM	73.88 (0.06)	4.16 (0.24)	1.36 (0.07)	20.32 (0.41)	6.45 (0.01)
Emulsion	73.54 (0.73)	2.29 (0.16)	3.85 (0.48)	15.48 (0.41)	6.33 (0.05)

Means (standard error).
[1]grams/100 grams.

The results of emulsion stability and shear force provided the equation templates including parameters statistically significant ($p < 0.05$), with a percentage of variance explained (R^2) 81.09% and 70.72%, respectively, expressed by:

$$\text{Emulsion stability} = 15.93 - 19.52\ \text{Phosphate} - 9.82\ \text{NaCl} + 2.49\ \text{NaCl}^2 - 3.01\ \text{KCl}^2$$

$$\text{Shear force} = 1.03 + 0.09\ \text{Phosphate} - 0.14\ \text{Phosphate}^2 + 0.03\ \text{NaCl} - 0.13\ \text{NaCl}^2 + 0.03\ \text{KCl} - 0.10\ \text{KCl}^2 - 0.07\ \text{Phosphate} * \text{NaCl}$$

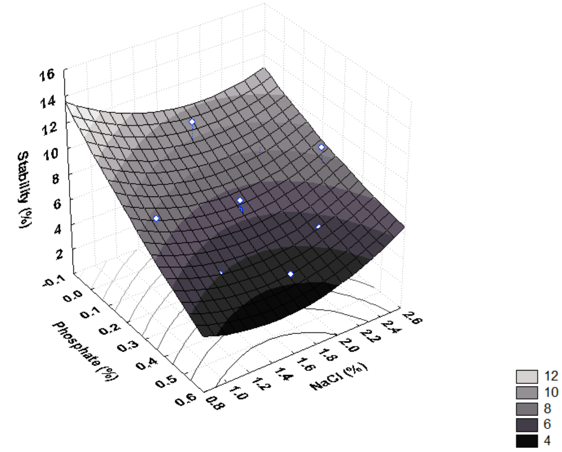
This study did not aim to determine the best sodium contents, since its importance in technological characteristics for an emulsion meat mixture is well known. It was investigated the best phosphate and KCl contents in a system to reduce sodium content. The Table 4 shows the stability of emulsion and shear force data.

Table 4. Stability of emulsion and shear force.

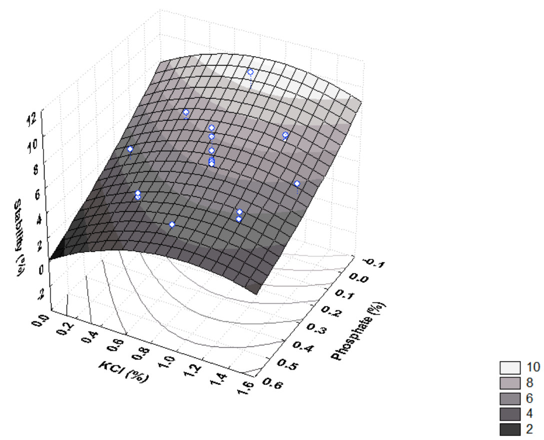
Trials	[Phosphate]	[NaCl]	[KCl]	Stability (%)	Shear force (kg)
1	0.10	1.30	0.46	7.21±0.54	0.79±0.06
2	0.40	1.30	0.46	4.13±0.24	0.87±0.01
3	0.10	2.20	0.46	6.53±0.46	0.85±0.02
4	0.40	2.20	0.46	4.41±0.34	0.79±0.03
5	0.10	1.30	1.24	7.58±0.54	0.87±0.03
6	0.40	1.30	1.24	4.74±0.19	0.99±0.03
7	0.10	2.20	1.24	7.09±0.33	0.95±0.04
8	0.40	2.20	1.24	5.32±0.25	0.91±0.04
9	0.00	1.75	0.85	10.34±0.36	0.62±0.01
10	0.50	1.75	0.85	4.44± 0.37	0.94±0.04
11	0.25	1.00	0.85	8.17± 0.36	0.72±0.02
12	0.25	2.50	0.85	8.87± 0.48	0.87±0.05
13	0.25	1.75	0.20	5.28±0.35	0.89±0.08
14	0.25	1.75	1.50	6.40±0.34	0.78±0.03
15	0.25	1.75	0.85	5.76±0.42	1.07±0.02
16	0.25	1.75	0.85	6.34±0.25	1.02±0.03
17	0.25	1.75	0.85	6.06±0.48	1.00±0.04
18	0.25	1.75	0.85	6.17±0.76	1.06±0.08
19	0.25	1.75	0.85	6.02±0.59	0.98±0.05
20	0.25	1.75	0.85	7.08±0.55	0.95±0.07

Figure 1 shows the response surfaces to the emulsion stability parameter (represented in percentage, therefore, the lower the value, the more stable is the emulsion), in which it was observed that the best KCl and phosphate contents were 0.2% and 0.5%, respectively.

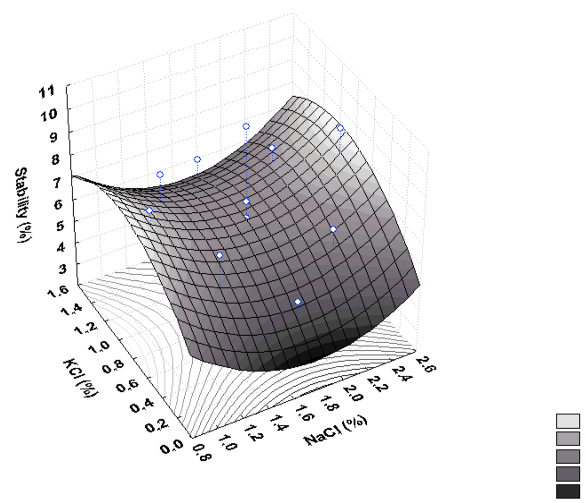
Figure 2 shows the response surfaces for shear force, where the best contents observed for KCl and phosphate were 0.85% and 0.25%, respectively, to reduce sodium content by at least 1% of NaCl in the formulation of emulsion produced with MRCM.



(a)

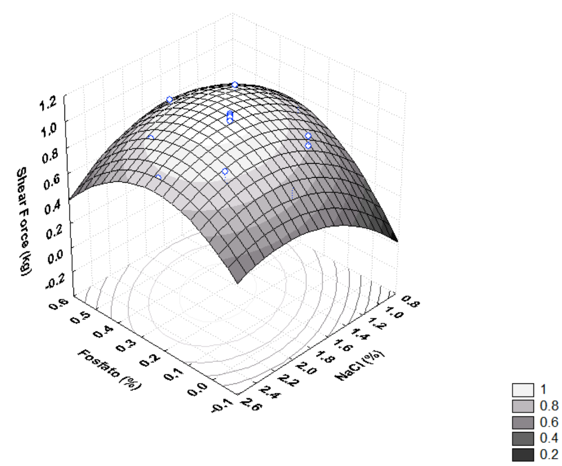


(b)

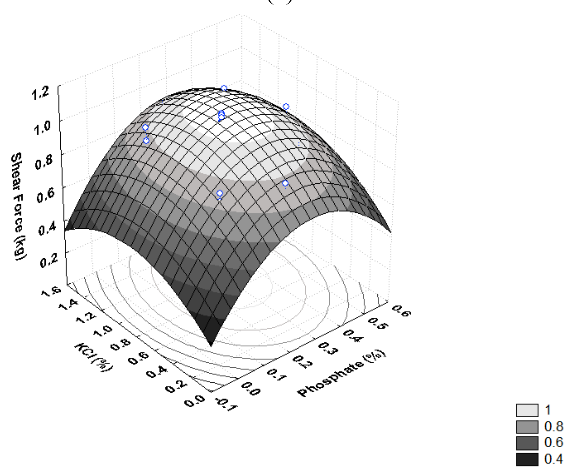


(c)

Figure 1. Surface responses for emulsion stability regarding contents of (a) phosphate and NaCl, (b) phosphate and KCl and (c) NaCl and KCl.



(a)



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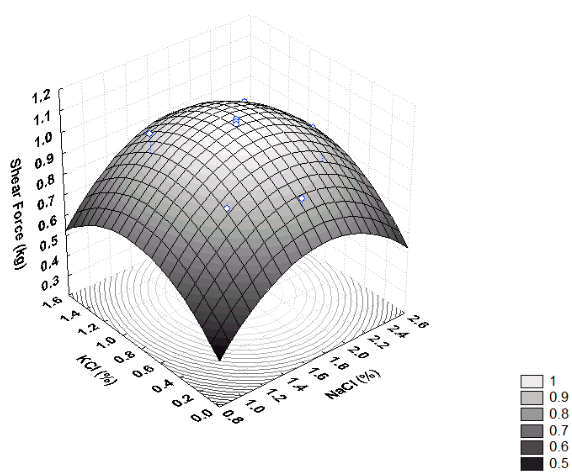

(c)

Figure 2. Surface responses for the shear force regarding (a) phosphate and NaCl, (b) phosphate and KCl and (c) NaCl and KCl.

IV. CONCLUSION

In the joint evaluation of the responses, shear force and emulsion stability, in the studied range, indicated that the conditions for the preparation of meat emulsion using MRCM to obtain higher shear force and emulsion stability are: 0.46% KCl and 0.40% phosphate in the formulations.

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