LOW-COST EMULSION-TYPE SAUSAGES REFORMULATED WITH REDUCED SODIUM CONTENT: EFFECTS OF Na-LACTATE REPLACEMENT BY K-LACTATE ON COLOR AND TEXTURE PROFILE

Renata Nascimento[2], Thales L. C. de Oliveira[1], Natália M. M. Alencar[1], Maria T. E. L. Galvão[1], Débora B. Moura[2], Andrea C. S. Barreto[3], Marcelo. A. Morgano and Marise A. R. Pollonio[1*]

[1]Department of Food Technology. Food Engineering Faculty. State University of Campinas, FEA/UNICAMP, Campinas, São Paulo, Brazil; [2]Brasilfoods BRF – São Paulo, São Paulo, Brazil; [3]University of São Judas Tadeu, São Paulo, São Paulo, Brazil.

Abstract – The effects of Na-Lactate (NaL) substitution by K-lactate (KL) as well as NaCl replacement (50%) by KCl on color and texture profile of low-cost emulsion-type sausages using high levels of mechanically deboned poultry meat (60%) were investigated. Six formulations containing 2% NaCl or 1% NaCl + 1%KCl without or with the addition of 3% Sodium lactate or 3% Potassium lactate were analyzed. The results showed that the substitution of Na-lactate by K-lactate at 30g/kg decreased the sodium content. Texture profile analysis revealed significant differences only in chewiness. Product containing 3% Potassium lactate and 1% NaCl + 1% KCl showed the highest values of chewiness compared to products containing 2% NaCl and 3% Sodium lactate and 1% NaCl + 1% KCl. Internal and external color (L*, a* and b* values) were significantly affected (*p*≤0.05) mainly on the surface suggesting further investigation. However, the proposed reformulation can be a feasible alternative to reduce sodium in sausages.

Key Words – Color, Mechanically deboned poultry meat (MDPM), Sodium chloride, Potassium chloride

I. INTRODUCTION

Several studies have related high level of sodium intake to the incidence of hypertension, one of the main risk factors of cardiovascular disease. In human daily diet, the Na^+ amount arising from processed meats is significant, being their consumption criticized [1]. Taking into account its functions (flavoring agent, microbial control, myofibrillar protein extraction agent), salt reduction in emulsified meat products is a complex challenge. NaCl substitutions have been studied showing some success with chloride salts such as KCl, $MgCl_2$ and $CaCl_2$ [2,3]. Nevertheless, microbiological stability, physico-chemical and sensory changes were reported.

Salt replacement/reduction becomes a greater challenge mostly in low-cost formulations containing Mechanically Deboned Poultry Meat (MDPM), a by-product obtained from the deboning process of poultry meat carcasses [4]. Despite the evident economic benefits of its use, manufacturers still have to address their negative effects on final meat product such as color depreciation, texture changes, increased lipid oxidation susceptibility and higher microbiological load [5]. In Brazil, according to MAPA (2000), MDPM is allowed in emulsion-type meat products (sausages and bolognas) in concentrations up to 600g/kg.

To improve quality and extend shelf-life, mainly in low-cost formulations (with MDPM added), the meat processing industry has been using some alternative additives, such as Na and K-lactate. These are chemical additives that act as antimicrobial agents, moisturizer, and acidity regulators (pH) as well as flavor and color enhancer agents and antioxidant [6]. Na-lactate is normally used in concentrations of 20-40g/kg in emulsion-type sausages contributing to increase the sodium levels in the final product. A feasible alternative to promote sodium reduction ensuring quality and safety can be the replacement of Na-lactate by K-lactate. However the impacts of this substitution on color and texture are not precisely documented, especially when NaCl is replaced by KCl, consisting in a relevant meat science research gap.

In this context, this study aimed evaluate the effects of Na-lactate substitution by K-lactate in emulsion-type sausages containing high levels of mechanically deboned poultry meat (MDPM) with a replacement of 50% NaCl by KCl on sodium content, color and texture profile.

II. MATERIALS AND METHODS

The emulsion-type sausages were prepared following conventional processing and formulation as depicted in Table 1. The sodium and potassium lactates were kindly provided by PURAC (commercially called NaL PurasalS® and KL (PurasalP®, Brazil). After processing, the meat emulsion was mechanically embedded (Mainca, model EC12, Spain) in permeable cellulose casings (VISKASE Brazil, 24 mm ø), cooked, cooled in a water/ice bath, manually peeled, vacuum packed and stored in a controlled cold chamber at 4-7°C during research. The physico-chemical analysis were carried out after 2 weeks (14 days) of storage.

The sodium and potassium contents were determined following AOAC [7], recommendations. Color was measured using a Hunter Lab Colorquest II (Hunter Associates Laboratory Inc., Virginia, USA) colorimeter with a 20mm port size, illuminant D_{65} and a 10^{o} standard observer. CIELAB L*, a* and b* values were determined as indicators of lightness, redness and yellowness. Color was measured at different points on the internal portion and on the surface of the products. All measurements were taken at room temperature (25^{o}C).

Texture profile analysis was performed according to Bourne [8] using a TA-xT2i Texture Analyzer, (Stable Micro Systems Inc. Godalming, UK) coupled to a microcomputer equipped with Texture Expert Software. A P-35 probe was used (long shaft, regular base). The following parameters were determined: hardness (N/cm2), springiness (cm), cohesiveness, and chewiness (N/cm) using a compression velocity of 1.0 mm/s and a force of 0,05g. Measurements were made at room temperature.

The data were statistically analyzed by analysis of variance (ANOVA) and Tukey T test at the significance level of 5%. The statistical analyses were carried out using statistical software R version 2.10.1 [9].

III. RESULTS AND DISCUSSION

The sodium/potassium contents, color and texture profile of the different emulsion-type sausages treatments are shown in Table 2. As expected, the replacement of NaCl by KCl and the addition of lactates affected significantly ($p \leq 0.05$) the sausages sodium and potassium contents. F2 (2% NaCL + 3% NaL) showed the highest sodium content among all treatments, reaching almost 1400 mg/100g. F4 (1% NaCl + 1% KCl) and F6 and F4 (1% NaCl + 1% KCl and 1% NaCl + 1% KCl + 3% KL) treatments showed the lowest sodium contents indicating that the use of KL and the addition of KCl replacing part of the NaCl could be a feasible way to reduce sodium content.

Hardness, springiness and cohesiveness were not statistically affected indicating that the reformulations did not have a high impact on texture. However, chewiness values showed some differences. F6 (1%NaCl + 1%KCl + 3%K-lacatate), with minor sodium content, had higher chewiness when compared to the other formulations. This variation may be partially related to variations in emulsion stability and water holding ability imposed by NaCl reduction/substitution. The texture properties of meat batter systems depend on other components besides fat, such as protein and water. The system ionic force influences the protein extraction, conformation and water association, affecting texture responses.

Table 1 Formulations of low-cost emulsion-type sausages containing different levels of NaCl, KCl, Na-lactate and K-lactate.

Raw Material / Ingredients (g/kg)	Treatments / Formulations					
	F1	F2	F3	F4	F5	F6
Bovine forequarter – fore shank	275.40	275.40	275.40	275.40	275.40	275.40
MDPM[a]	413.10	413.10	413.10	413.10	413.10	413.10
Pork backfat	100.00	100.00	100.00	100.00	100.00	100.00
Water/Ice	142.25	112.25	112.25	142.25	112.25	112.25
Salt (Sodium Chloride) - NaCl	20.00	20.00	20.00	10.00	10.00	10.00
Potassium Chloride - KCl[b]	-	-	-	10.00	10.00	10.00
Sodium Lactate - NaL	-	30.00	-	-	30.00	-
Potassium Lactate - KL	-	-	30.00	-	-	30.00
Sodium Nitrite - $NaNO_2$	0.15	0.15	0.15	0.15	0.15	0.15
Tripolyphosphates	2.50	2.50	2.50	2.50	2.50	2.50
Erythorbate	0.40	0.40	0.40	0.40	0.40	0.40
Cassava Starch	20.00	20.00	20.00	20.00	20.00	20.00
Isolated Soybean Protein - ISP	20.00	20.00	20.00	20.00	20.00	20.00
Spices / Seasonings						
White pepper	0.50	0.50	0.50	0.50	0.50	0.50
Garlic powder	2.20	2.20	2.20	2.20	2.20	2.20
Onion powder	2.20	2.20	2.20	2.20	2.20	2.20
Coriander	0.10	0.10	0.10	0.10	0.10	0.10
Cardamom	0.10	0.10	0.10	0.10	0.10	0.10
Marjoram	0.60	0.60	0.60	0.60	0.60	0.60
Jamaica pepper	0.50	0.50	0.50	0.50	0.50	0.50
Total	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00

F1 – Control formulation; F2 – Sodium lactate added; F3 – Potassium lactate added; F4 - NaCl + KCl (50% NaCl replacements); F5 - NaCl + KCl (50% NaCl replacements) added of Sodium Lactate; F6 - NaCl + KCl (50% NaCl replacements) added of Potassium lactate

[a]Mechanically Deboned Poultry Meat – MDPM -[b]Ionic Strength Correction – 38.26g KCl per batches of 3000g.

Control formulation (2% NaCl) showed significantly higher L* values on the surface ($p \leq 0.05$) than F2 (2% NaCl + 3% NaL) and F4 (1% NaCl + 1% KCl). However, internal L* values showed a different behavior. Although all formulations showed a higher internal L* value, the highest values were observed in F2 (2% NaCl + 3% NaL) and control.

Control and F6(1% NaCl + 1% KCl + 3% KL) showed lower a* values on the product surface compared to the other formulations. The a* values measured internally decreased when compared to the values from the surface and the differences between the products were smaller. Control showed an a* value statistically lower than F5 (1% NaCl + 1% KCl + 3% NaL) but did not differ from the other formulations. Formulations containing sodium or potassium lactate (F2, F3 and F6) did not differ.

Despite minor variations, b* values were not significantly affected. At the surface, differences were observed but not showing a reasonable model.

IV. CONCLUSIONS

The use of Na-lactate by K-lactate in low-cost emulsion type sausage using mechanically deboned poultry meat formulated with reduced NaCl levels (with KCl addition) decreased significantly the sodium content of the final product. Some slightly differences in color were observed and there was no effect on the texture profile except in chewiness.

Table 2. Physico-chemical and texture profile of emulsion-type sausages containing MDPM and formulated with low-sodium content

Physico-chemical properties	Treatments / Formulations					
	F1	F2	F3	F4	F5	F6
Sodium (mg/100g)	830,81±46.56^{c}	1400,62±56.40^{a}	813,32±44.65^{c}	466,73±16.23^{d}	1041,81±17.00^{b}	447,45±19.21^{d}
Potassium (mg/100g)	5,11±1.87^{d}	5,06±1.53^{d}	1468,12±11.16^{b}	503,23±9.54^{c}	500,58±14.99^{c}	1934,82±25.64^{a}
Internal Color						
*L**	60.10±0.76^{ab}	60.28±0.28^{a}	58.30±0.80^{bc}	57.17±1.09^{cd}	56.44±0.07^{d}	56.92±0.65^{cd}
*a**	10.59±0.15^{b}	11.23±0.07^{ab}	11.77±0.71^{a}	11.23±0.84^{ab}	12.16±0.65^{a}	11.66±0.15^{ab}
*b**	14.55±0.27^{a}	13.96±0.03^{a}	13.69±0.92^{a}	14.28±0.78^{a}	13.18±1.65^{a}	14.70±0.25^{a}
Surface Color						
*L**	52.11±0.36^{a}	49.97±1.00^{b}	49.46±2.16^{ab}	48.46±0.83^{b}	49.87±0.30^{ab}	49.56±1.63^{ab}
*a**	11.65±0.14^{b}	14.27±0.31^{a}	13.56±0.52^{a}	13.97±0.41^{a}	14.07±0.79^{a}	11.80±0.37^{b}
*b**	17.12±0.10^{bc}	16.71±0.60^{c}	17.84±0.78^{abc}	18.53±0.65^{ab}	19.01±0.80^{a}	17.56±0.54^{bc}
Texture Profile Analysis - TPA						
Hardness	11.57±0.75^{a}	12.15±0.94^{a}	12.13±1.01^{a}	12.32±1.34^{a}	11.68±1.68^{a}	13.01±1.08^{a}
Springiness	0.87±0.02^{a}	0.87±0.02^{a}	0.88±0.02^{a}	0.89±0.01^{a}	0.88±0.02^{a}	0.89±0.01^{a}
Cohesiveness	0.80±0.01^{ab}	0.80±0.08^{ab}	0.80±0.01^{a}	0.80±0.00^{a}	0.79±0.01^{a}	0.80±0.01^{a}
Chewiness	8.08±0.55^{b}	8.44±0.72^{ab}	8.64±0.70^{ab}	8.77±0.94^{ab}	8.10±1.15^{b}	9.37±0.91^{a}

F1 – Control formulation (20g/kg NaCl); F2 – 20g/kg NaCl + 30g/kg Na-lactate; F3 – 20g/kg NaCl + 30g/kg K-lactate; F4 – 10g/kg NaCl + 10 g/kg KCl (50% repleacement); F5 – 10g/kg NaCl + 10 g/kg KCl + 30g/kg Na-lactate; F6 – 10g/kg NaCl + 10 g/kg KCl + 30g/kg Na-lactate.
F1 – Control formulation (20g/kg NaCl); F2 – 20g/kg NaCl + 30g/kg Na-lactate; F3 – 20g/kg NaCl + 30g/kg K-lactate; F4 – 10g/kg NaCl + 10 g/kg KCl (50% repleacement); F5 – 10g/kg NaCl + 10 g/kg KCl + 30g/kg Na-lactate; F6 – 10g/kg NaCl + 10 g/kg KCl + 30g/kg Na-lactate.
Mean values ± Standard deviation. Values followed by a different letter in the same line are significantly different ($p \leq 0.05$) according to Tukey's test.

REFERENCES

1. World Health Organization (2011). Review and updating of current WHO recommendations on salt/sodium and potassium consumption. Call for Public Comments 01 February Geneva, Switzerland.
2. Horita, C. N., Morgano, M. A., Celeghini, R. M. S., & Pollonio, M. A. R. (2011). Physico-chemical and sensory properties of reduced-fat mortadella prepared with blends of calcium, magnesium and potassium chloride as partial substitutes for sodium chloride. Meat Science: 89, 426–433.
3. Ripollés, S., Campagnol, P. C. B., Armenteros, M., Aristoy, M., & Toldrá, F. (2011). Influence of partial replacement of NaCl with KCl, CaCl2 and MgCl2 on lipolysis and lipid oxidation in dry-cured ham. Meat Science 89: 58-64.
4. Mielnik, M. B., Aaby, K., Rolfsen, K., Ellenkjaer, M. R., & Nilsson, A. (2002).
5. Quality of comminuted sausages formulated from mechanically deboned poultry meat. Meat Science 61: 73–84.
6. Pereira, A. G. T., Ramos, E. M., Teixeira, J. T., Cardoso, G. P., Ramos, A. L. S., Fontes, P. R. (2011). Effects of the addition of mechanically deboned poultry meat and collagen fibers on quality characteristics of frankfurter-type sausages. Meat Science: 89, 519–525.
7. Sallam, K. I., & Samejima, K. (2004). Microbiological and chemical quality of ground beef treated with sodium lactate and sodium chloride during refrigerated storage. Lebensmittel-Wissenschaft & Technologie-LWT: 37, 865−871.
8. AOAC (2005). Official methods of analysis of AOAC International (17th ed.). Maryland, USA: Association of Official Analytical Chemistry.
9. Bourne, M.C (1978). Texture profile analysis. Food Technology 32: 62-72.