REDUCING SALT AND SODIUM NITRITE IN COOKED TURKEY HAM: EFFECT OF CELERY EXTRACT AND STARTER CULTURE ON PHYSICOCHEMICAL PROPERTIES

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Abstract - Sodium chloride and sodium nitrite are key ingredients for the manufacture of meat products. Its functions include technological and preservative properties. The sodium nitrite is an important additive for manufacturing cured meat products due to its role in controlling the growth of *Clostridium botulinum* spores. However, several studies had related its intake with cancer risk increasing. Many natural compounds can be used as substitute sodium nitrite because they are rich in nitrate, a source of nitrite after reducing in meat processing. These studies had investigated the challenges to assess the safety and stability of the natural source of sodium nitrate along shelf life in different process conditions and meat products formulations. This work aimed to study the reformulation of cooked turkey ham combining sodium chloride reduction and sodium nitrite replacement by natural celery extract focusing on physicochemical properties.

Key words – Meat color, Sodium nitrite replacer, Sodium reduction

I. INTRODUCTION

Recently the salt and additives reducing have been extensively studied with the goal to achieve healthier meat products with sensorial properties. High sodium intake has been correlated with hypertension, one of most important public health problem in the world. Reducing salt in meat products, however, is a great challenge considering its technological, sensorial and preservative critical functions in processing.

Sodium nitrite is considered a critical additive in the manufacture of meat products by their functions performed: development of color and flavor, antioxidant and preservative action by inhibiting the growth of *Clostridium botulinum* [1, 4, 5]. However, several toxicological attributes have been attributed to this compound and there are many studies to establish safe levels of addition in the formulations to reduce the risk of high concentrations of nitrosamines, a carcinogenic compound, in favorable conditions. From the technological point of view, one of the most important properties in cured meat products is development color of cured meat [6], although this compound needs to be reduced to nitric oxide to be effective in the curing reactions, which comes through the action of reducing agents or culture starters.

The use of natural plant extracts as a source of sodium nitrate has been reported in the literature as a strategy to reduce nitrite levels and replace the sodium nitrite in cured meat products [6].

According Gotterup et al. (2007) nitrate is reduced to nitrite and after to nitric oxide, the agent that participates in the curing reaction that takes place through the addition of antioxidants or by addition of microbial cultures. *Staphylococcus carnosus* can be used with the nitrate reducing agent with very good performance, besides having an important role in the development of flavor, odor and color of fermented products [7]. This study aims to evaluate the sodium nitrite replacement by extracts of starter culture and celery extract in a low sodium turkey ham, investigating the combined effect of these reformulations on their physicochemical properties.

II. MATERIALS AND METHODS

Treatments: Four sodium nitrite-added controls and four no sodium nitrite-added treatments with 0, 25%, 50% or 75% of their NaCl replaced by KCl were used for this study (Table 1). Celery extract powder (Chr. Hansen) and starter culture (Bactoferm CS-300 - Chr. Hansen)

(*Staphylococcus carnosus spp.utilis* and *Staphylococcus carnosus*) were used in no sodium nitrite-added treatments.

Processing: Turkey meat was ground using a 35-plate in cold conditions (1°C). Raw material and the ingredients (Table 1) were tumbled under vacuum continuously for 30 min to achieve adequate protein extraction and free brine pickup. After tumbling, meat batter was transferred to a rotary vane vacuum-filling machine and it was stuffed into 75 mm impermeable plastic casings. The casings had an O_2 permeability rate of 25 $cm^3/m^2/24h$ at 1 atm and a water vapor permeability of 15 $g/m^2/24$ h. After being stuffed, F4, F5, F6 and F7 formulations were placed into a smokehouse rack and transferred to a single truck smokehouse oven and incubated for 120 min at 40°C. Timing started when the internal temperature of the sausages reached 37°C. This temperature and time combination was chosen to allow enough time for nitrate-to-nitrite conversion, by the temperature sensitive starter culture, while maintaining temperatures that minimize undesirable microbiological growth. Upon period of incubation, F4-F8, the controls (FC, F1, F2 and F3) were placed in the thermal processing oven on the same smokehouse rack. Cooking was accomplished using a common sausage smokehouse schedule reaching an internal temperature of 72°C. After thermal processing, the samples were chilled to below 8°C and stored at 4°C.

Physical and chemical analysis: The determination of pH was performed after the postproduction by homogenizing 10 g of each sample with distilled water in a sample: water ratio of 1:10. The homogenate was subjected to a pH test using a meter electrode (DM 22, Digimed, São Paulo, Brazil) for 5 min while the pH readings were performed. Three sausages per batch were used to evaluate the pH and each sample was analyzed in triplicate. The color determination was performed after the postproduction, with a Hunter Lab colorimeter (Colourquest-II, Hunter Associates Laboratory Inc., Virginia, USA) using a 10 mm port size, illuminent D_{65} an a 10^0 standard observer. CIELAB L*, a* and b* values were determined as indicators of lightness, redness and yellowness. Color variables were measured at four points on the central part of the cut surface of three slices of the five sausages per batch. Before each series of measurements, the instrument was calibrated using a white ceramic tile. The degree of lipid oxidation was performed after the post-production. Three sausages per batch were used to measure the degree of lipid oxidation and each sample was analyzed in triplicate. It was assessed by measuring 2-thiobarbituric reactive substances (TBARS) values according to Tarladgis et al., (1960) and modified by Zipser & Watts (1962). TBARS values were reported as mg of malonaldehyde equivalents/kg of meat sample. Residual nitrite was determined after the post-production, according to the methodology described by the Association of Official Analytical Chemists [2]. Three sausages per batch were used to measure the residual nitrite and each sample was analyzed in triplicate.

III. RESULTS AND DISCUSSION

Aw and pH: Although the results (Table 2) had showed a significant difference among treatments ($p<0.05$), under practical overview, it is expected that the pH and Aw values don´t influence the m quality properties of final products. For the treatments containing celery extract, the sample had presented a tendency to reduce pH values. This can be explained by fermentation process during reducing sodium nitrate to nitrite by starter culture (Bactoferm CS-300).

Residual NO_2: The results showed in Table 2 indicate that NO_2 residual was found in all treatments. Therefore, the celery extract plus starter culture were efficient to produce nitrite from nitrate over processing conditions. No significant difference ($p<0,05$) was found in the samples containing the same sodium chloride level and with sodium nitrite replacer (F1 vs F5; F2 vs F6; F3 vs F7 and F4 vs F8). These results indicate the efficiency of celery extract as a nitrate source to promote nitrite for cure reactions. The anaerobic condition favor the reduction of nitrate to nitrite [5].

L, a*, b* values:* The values of L* and a* showed no significant difference ($p<0.05$) among the treatments. However, for the samples

containing celery extract as nitrite source, the value of b* showed significant difference ($p<0,05$) when compared with treatments without celery extract addition.

Table 1. Raw material and ingredients used for the manufacture of nitrite-added controls (NO_2+$LS_{0\%}$, NO_2+$LS_{25\%}$, NO_2+$LS_{50\%}$, NO_2+$LS_{75\%}$) and no-nitrite-added (CE+$LS_{0\%}$, CE+$LS_{25\%}$, CE+$LS_{50\%}$, CE+$LS_{100\%}$) turkey cooked sausages

Ingredient	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**
Turkey breast	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Water	24.48	24.27	24.27	24.27	24.12	23.92	23.92	23.92
Cassava starch	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Isolated soybean protein	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Refined sugar	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Sodium tripolyphosphate	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Refined carraggenan	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Monosodium glutamate	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Spices	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sodium erythorbate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sodium chloride	2.00	1.50	1.00	0.50	2.00	1.50	1.00	0.50
Potassium chloride	-	0.51	1.03	1.54	-	0.51	1.03	1.54
Sodium nitrite	0.02	0.02	0.02	0.02	-	-	-	-
Celery extract	-	-	-	-	0.35	0.35	0.35	0.35
Starter culture	-	-	-	-	0.02	0.02	0.02	0.02

F1- NO_2+$LS_{0\%}$ F2 -NO_2+$LS_{25\%}$; F3 - NO_2+$LS_{50\%}$; F4 - NO_2+$LS_{75\%}$; F5 - CE+$LS_{0\%}$; F6 - E+$LS_{25\%}$; F7 - CE+$LS_{50\%}$; F8 - CE+$LS_{75\%}$

The b* value of the treatments with addition of celery extract were higher than the treatments with addition of sodium nitrite.

TBARS value: Treatments with replacement of sodium nitrite by celery extract (F5, F6, F7 and F8) showed no significant difference ($p<0.05$) than the control sample. The formulations F2, F3 and F4 were significantly different ($p<0.05$) when compared to control sample. The addition of sodium nitrite interferes with the determination of TBARS in distillation step reducing the number of TBARS and this reduction occurs in a linear fashion with increasing concentration of nitrite (OSAWA; MERRIMAN; GONÇALVES, 2005).

Table 2. Physicochemical properties of nitrite-added controls and no-nitrite-added turkey cooked ham

Sample	**pH**	**Aw**	**Residual NO_2)**	**L***	**a***	**b***	**TBARS** (mg/kg)
F1	6,20 $(0,01)^{bc}$	0,976 $(0,001)^{cd}$	20,09 $(1,14)^{abc}$	70,33 $(0,55)^{a}$	6,25 $(0,46)^{a}$	6,27 $(0,47)^{c}$	0,422 $(0,029)^{cd}$
F2	6,21 $(0,01)^{b}$	0,977 $(0,001)^{cd}$	20,05 $(3,11)^{abc}$	69,80 $(1,13)^{a}$	6,89 $(0,55)^{a}$	6,04 $(0,63)^{c}$	0,560 $(0,103)^{b}$
F3	6,23 $(0,02)^{a}$	0,979 $(0,001)^{ab}$	21,54 $(3,57)^{ab}$	69,98 $(0,96)^{a}$	6,34 $(0,17)^{a}$	6,14 $(0,43)^{c}$	0,558 $(0,047)^{b}$
F4	6,16 $(0,02)^{d}$	0,976 $(0,000)^{cd}$	23,28 $(1,75)^{a}$	70,65 $(0,51)^{a}$	6,75 $(0,34)^{a}$	7,14 $(0,68)^{ab}$	0,774 0,076)^{a}
F5	6,15 $(0,01)^{d}$	0,978 $(0,002)^{bc}$	16,95 $(3,70)^{c}$	69,71 $(0,58)^{a}$	6,63 $(0,24)^{a}$	6,75 $(0,11)^{bc}$	0,450 $(0,069)^{cd}$
F6	6,14 $(0,01)^{de}$	0,975 $(0,000)^{a}$	18,54 $(0,96)^{bc}$	69,96 $(0,72)^{a}$	6,71 $(0,61)^{a}$	7,35 $(0,19)^{ab}$	0,418 $(0,029)^{cd}$
F7	6,13 $(0,01)^{e}$	0,978 $(0,001)^{bc}$	21,89 $(1,19)^{ab}$	70,86 $(0,82)^{a}$	6,578 $(0,586)^{a}$	7,59 $(0,53)^{a}$	0,501 $(0,105)^{cd}$
F8	6,18 (0,01)b	0,980 $(0,001)^{a}$	23,2872 $(3,19)^{a}$	70,73 $(0,63)^{a}$	6,263 $(0,318)^{a}$	7,40 $(0,30)^{a}$	0,348 $(0,034)^{d}$

F1- NO_2+$LS_{0\%}$ F2 -NO_2+$LS_{25\%}$; F3 - NO_2+$LS_{50\%}$; F4 - NO_2+$LS_{75\%}$; F5 - CE+$LS_{0\%}$; F6 - E+$LS_{25\%}$; F7 - CE+$LS_{50\%}$; F8 - CE+$LS_{75\%}$

IV. CONCLUSION

The replacement of sodium nitrite by celery extract was effective for production of low sodium turkey ham considering the pH, Aw, color and lipid oxidation at the end of processing. However, studies should be conducted to ensure the microbiological safety and physicochemical stability along shelf life before using by meat industry.

REFERENCES

1. Akhtar, S.; Paredes-Sabja, D.; Torres, J. A.; Sarker, M. R. Strategy to inactive *Clostridium perfringens* spores in meat products. Food Microbiology, p. 1 – 6, 2009.
2. Association Of Official Analytical Chemists. Official Methods of
3. Analysis. Horwits, W. (Ed.). Washington, DC, 1990.
4. Gotterrup, J.; Olsen, K.; Knöchel, S.; Tjener, K. Stahnke, L. H.; Moller, J. K. S. (2007). Relationship between nitrate/nitrite reductase activities in meat associated staphyloccus and nitrosylmyoglobin formation in a cured meat model system. International Journal of Food Microbiology, v. 120, p. 303 – 310.
5. Honikel, K-O. The use and control of nitrate and nitrite for the processing of meat products. Meat Science, v.78, p. 68 – 76, 2008.
6. Sebranek, J. G. & Bacus, J. N. Cured meat products without direct addition of nitrate or nitrite: what are the issues? Meat Science, v. 77, p. 136 – 147, 2007.
7. Simonová, M.; Strompfvá, V.; Marcináková M.; Laucová, A.; Vesterlund, S.; Moratalla, M. L.; Bover-Cid, S. & Vidal-Carou, C. Characterization of *Staphylococcus xylosus* and *Staphylococcus carnosus* isolated from Slovak meat products. Meat Science, v. 73, p. 559 – 564, 2006.
8. Tarladgis, B. G.; Watts, B. M. & Younathan, M. T. A distillation method for the quantitative determination of malonaldehyde in rancid foods. J. Aim. Oil. Chem., v. 37, p. 44 – 48, 1960.
9. Zisper, M. W.B & Watts, B. M. A modified 2-tiobarbituric acid (TBA) method for determination of manoladehyde in cured meats. Food Technology, v. 16, n. 7, p. 102 – 104, 1962.