INSTRUMENTAL EVALUATION OF COLOR AND TEXTURE OF LOW-FAT, LOW-SODIUM CHLORIDE FRESH SHEEP MEAT SAUSAGE

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Abstract – This study evaluated instrumental measurements of color and texture of fresh sheep meat sausages containing passion fruit meal (PM) and KCl. Color analysis revealed no significant difference ($p > 0.05$) in L* values between F1, F2, F3 and F4 or between F4 and F5 and C, F5 and F6. Mean a* values in formulation C were different from the others ($p < 0.05$). No significant difference was observed ($p > 0.05$) between F4, F5 and F6, as well as F1, F2, F3, F4 and F5. Mean texture varied between formulations. No significant difference was observed ($p > 0.05$) in hardness between F2, F4, F5 and F6, or between F1, F3, F4, F5 and F6 and C. Mean chewiness also varied across formulations. No significant difference was observed ($p > 0.05$) between F1, F2, F4, F5 and F6, and between F1, F3, F4 and F6 and C, F1 and F3. The results show that formulations in which fat levels were the lowest because of replacement with PM, especially F2, presented paler red color and higher resistance, possibly due to the stabilizing and thickening properties of the pectin in PM.

I. INTRODUCTION

The awareness of the importance of healthy food habits, the concerns with quality of life and the commercialization of diet products have led more and more consumers to prefer diet and light food products. Additionally, the high prevalence of diabetes mellitus, cardiovascular diseases, hypertension and obesity also plays a role in this growth. In this context, one of the main concerns in the food industry is the development of products that meet the requirements of different consumer profiles. Among these, the group of people with hypertension stands out, due to low sodium restrictions in diets (1). Epidemiological studies have shown that individuals consuming low sodium diets presented lower blood pressure levels, compared with those that consumed sodium-free foods (2).

In Brazil, studies have investigated the effect of the reduction of sodium levels on sensorial properties of Toscana sausages (3), of the reduction of fat and salt contents in pork sausages using xantham gum and potassium chloride (KCl) (4), and of the reduction of fat content in Toscana sausage using pectin and inulin (5).

Apart from the products mentioned, low-fat, low-salt fresh sheep meat sausages are considered potentially healthier foods. High fiber and potassium foods are believed to lower the risk of systemic hypertension, and are seen as "protection foods" (6). In turn, low-fat, low-sodium encased meat products have become the object of several studies. In this sense, this study aimed at assessing instrumental color and texture of fresh sheep meat sausages containing passion fruit meal (PM) and KCl.

II. MATERIALS AND METHODS

Samples of fresh sheep meat sausages were prepared according to the recommendations defined by the National Institute of Industrial Property (INPI) in the reference agroindustrial plant administered by Federal Institute Espírito Santo (IFES), in Alegre, state of Espírito Santo (ES), Brazil. Seven formulations were used, one of which was the control. Formulations were chosen after five pretests, which defined acceptable levels of reduction of fat and sodium levels. Table 1 shows the decrease in fat and sodium in each formulation.

Table 1. Reduction of fat and NaCl levels in fresh sheep meat sausages (%).

Formulation	Fat	NaCl
Control	0	0
F1	59	0
F2	59	50
F3	59	25
F4	31	0
F5	31	50
F6	31	25

Fat was partially replaced by passion fruit meal, according to Oliveira (7), containing on average 26.4% pectin. Reduction of sodium levels was carried out replacing NaCl by KCl. Formulations are presented in Table 2.

Table 2. Composition of the seven fresh sheep meat sausage formulations (%)

Raw material	Control	F1	F2	F3	F4	F5	F6
Sheep meat	76.66	82.36	82.36	82.36	80.30	80.30	80.30
Fat	20.00	8.20	8.20	8.20	13.80	13.80	13.80
Salt (NaCl)	2.20	2.20	1.10	1.65	2.20	1.10	1.65
KCl	0.00	0.00	1.10	0.55	0.00	1.10	0.55
Sugar	0.095	0.095	0.095	0.095	0.095	0.095	0.095
Water	1.00	4.70	4.70	4.70	2.35	2.35	2.35
Passion fruit meal	0.00	2.40	2.40	2.40	1.20	1.20	1.20
Sodium nitrite	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Sodium erythorbate	0.025	0.025	0.025	0.025	0.025	0.025	0.025

Samples were wrapped in aluminum foil and cooked at 160ºC for 30 min on the top tray in a conventional electric oven (General Electric Deluxe Grill) preheated at 260ºC for 10 min. Cooking proceeded for 10 min after the temperature inside samples reached 75ºC, measured using a thermometer with a probe and an alarm (Incoterm ®). Samples were removed from the oven and the excess humidity on the surface was wiped off using tissue paper.

Samples were then cut into 25-mm-thick slices. Eight readings were carried out in each. Instrumental color was analyzed by reflectance in a spectrometer (ColorQuest XE) using D65 as light source, a 10º observation angle in the CIELab system (1978). Results were expressed as angular coordinates L* = luminosity (0 = black; 100 = white), a* (-80 to 0 = green; 0 to + 100 = red) and b* (-100 to 0 = blue; 0 to +70 = yellow).

Instrumental measurements of texture were carried out based on the texture profile analysis (TPA), where samples were assessed in a TAXT2 texture analyzer. Samples of each formulation were sliced as described and submitted to the compression test using a 25-kg load. After, samples were pressed to 40% of original thickness using a 50-mm cylindrical probe set at 2.0 mm/s as pretest, 1.5 mm/s as test and 2.0 mm/s return speeds. The texture parameters evaluated were hardness (strength required to press the sample), cohesiveness (measure of sample deformation before break), chewiness (strength required to chew the sample before swallowing) as described by Tobin et al. (8), and gomosity (energy required to break the semisolid food ready to be swallowed). All analyses were carried out in triplicate.

The data obtained were submitted to Analysis of Variance (ANOVA) and the Student-Newman-Keuls (SNK) test in the software SAS version 9.3 (9).

III. RESULTS AND DISCUSSION

The results of the instrumental color analyses are shown in Table 3.

Table 3. Results of instrumental color analyses of fresh sheep meat sausages

Formulation	L^*	a^*	b^*
C	$44.31^{c} \pm 1.40$	$9.06^{a} \pm 0.93$	$13.55^{a} \pm 0.92$
F1	$49.92^{a} \pm 1.55$	$6.54^{c} \pm 0.66$	$14.95^{a} \pm 1.27$
F2	$50.66^{a} \pm 1.60$	$6.81^{c} \pm 0.51$	$14.75^{a} \pm 0.64$
F3	$50.70^{a} \pm 1.05$	$6.75^{c} \pm 0.19$	$14.13^{a} \pm 0.78$
F4	$48.87^{ab} \pm 2.10$	$7.44^{bc} \pm 1.03$	$13.95^{a} \pm 1.12$
F5	$46.77^{bc} \pm 3.60$	$7.09^{bc} \pm 1.35$	$15.02^{a} \pm 0.87$
F6	$45.20^{c} \pm 2.32$	$8.04^{b} \pm 1.08$	$14.33^{a} \pm 1.19$

[a b c] Means in the same column followed by different lowercase letters differed in the SNK test ($p < 0.05$).

Except for b*, all color parameters presented variations in formulation means. No statistically significant difference was observed ($p > 0.05$) in L* values (luminosity) between formulations F1, F2, F3 and F4, and between formulations F4 and F5 and formulations C, F5 and F6. Yalinkiliç et al. (10) analyzed nine sucuk samples (a dried, fermented sausage typically consumed in Turkey) presenting different levels of fat and orange fiber, and noted increased L* values, compared with samples containing orange fiber. Fernandez-Lopez et al. (11) also observed the same results in dried, cured sausages marketed in Spain.

The mean a* values (red) in formulation C were different from the others ($p < 0.05$). No statistically significant difference was observed between formulations F4, F5 and F6, and between formulations F1, F2, F3, F4 and F5 ($p > 0.05$). In their study, Yalinkiliç et al. (10) observed that mean a* values of samples remained constant, also reported by Fernandez-Lopez et al. (11), which

differed from the findings obtained in the present study.

Mean b* values (yellow) did not differ ($p < 0.05$) between formulations. However, the studies cited above reported an increase in b* in samples containing higher orange fiber levels, contrasting with the present study.

Instrumental texture results are shown in Table 4.

Except for cohesiveness, all texture means varied between formulations. No statistically significant differences ($p > 0.05$) were seen in hardness between formulations F2, F4, F5 and F6, and between formulations F1, F3, F4, F5 and F6 and the control. Mean chewiness values varied across formulations. No significant difference ($p > 0.05$) was observed between formulations F1, F2, F4, F5 and F6 and between formulations F1, F3, F4 and F6 and F1, F3 and the control. F2, which was produced with 59% less fat and 50% less salt, presented the highest consistency (hardness and chewiness). According to Bartolomeu (12), tilapia mortadella samples with higher wheat flour contents presented higher hardness.

Table 4. Results of instrumental texture of fresh sheep meat sausage samples

F	H	C	Ch
C	$2007.02^{c} \pm 216.51$	$0.58^{a} \pm 0.08$	$998.63^{c} \pm 148.22$
F1	$2849.35^{b} \pm 198.96$	$0.55^{a} \pm 0.05$	$1234.07^{abc} \pm 172.80$
F2	$3475.00^{a} \pm 262.42$	$0.55^{a} \pm 0.03$	$1520.61^{a} \pm 52.80$
F3	$2703.43^{b} \pm 373.84$	$0.49^{a} \pm 0.03$	$1075.60^{bc} \pm 169.46$
F4	$3029.40^{ab} \pm 256.35$	$0.53^{a} \pm 0.04$	$1334.25^{ab} \pm 215.37$
F5	$3266.54^{ab} \pm 455.07$	$0.53^{a} \pm 0.01$	$1430.40^{a} \pm 221.07$
F6	$3019.54^{ab} \pm 166.24$	$0.52^{a} \pm 0.01$	$1310.74^{ab} \pm 81.81$

$^{a\ b\ c}$ Means in the same column followed by different lowercase letters differed in the SNK test ($p < 0.05$). F: Formulations; H: Hardness; C Cohesiveness; Ch: Chewiness.

This finding was also reported by Cardoso (13), in a study that found that hardness is associated with increased fiber levels. This was confirmed in the present study, with samples in which fat was partially replaced with passion fruit meal.

IV. CONCLUSION

The formulations prepared with lower fat levels using passion fruit meal, especially F2, presented lower a* values, that is, a pale red product, together with increased b* values (more easily observable yellow tones). F2 was also more resistant, possibly to the gelling, stabilizing and thickening properties of the pectin present in passion fruit meal.

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