TECHNOLOGICAL AND SENSORY QUALITY OF RESTRUCTURED LOW-FAT COOKED HAM CONTAINING LIQUID WHEY

Características tecnológicas e sensoriais de apresuntados com baixo teor de gordura elaborados com soro de leite

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ABSTRACT

The use of liquid whey to replace water (at 0, 25, 50, 75 or 100%) in a restructured cooked ham formulation was studied and several technological and sensory quality properties were determined. The test results showed no statistically significant differences ($P < 0.05$) in weight loss attributes (cooking yield, storage loss, reheating loss and refreezing loss) and instrumental texture (TPA test) parameters. However, for CIELAB color, samples were ($P > 0.05$) less reddish (a* value reduction) and more grayish and yellowish (lesser C* and higher h values) with higher whey additions. A lower ($P < 0.05$) flavor preference among samples with 25 and 50% liquid whey substitution was observed. Also, the sensory color was different ($P < 0.05$) in the products formulated with more than 25% of this adjunct, although the overall sensory impression was not affected ($P > 0.05$). These results suggest that up to 38% natural fresh liquid whey can be added to a restructured cooked ham formulation with similar results to products cured with a conventional formulation.

Index terms: Color, texture, weight loss, byproduct.

RESUMO

As propriedades tecnológicas e sensoriais de apresuntados elaborados com soro de leite em substituição à água de formulação (0, 25, 50, 75 ou 100%) foram avaliadas. Não foram observadas diferenças significativas ($P > 0{,}05$) nos testes de perda de peso (cozimento, refrigeração, reaquecimento e ciclo de congelamento) e na textura objetiva (teste TPA). No entanto, para a cor objetiva (CIELAB), as amostras se apresentaram ($P < 0{,}05$) menos avermelhadas (redução no valor a*) e mais acinzentadas e amareladas (menor valor C * e maior h) com maiores adições de soro de leite. Foi observada ($P < 0{,}05$) uma menor preferência de sabor entre as amostras com 25 e 50% de substituição da água de formulação por de soro de leite. Além disso, a cor percebida foi diferente ($P < 0{,}05$) nos produtos formulados com mais de 25% de soro de leite, embora a impressão global não tenha sido ($P > 0{,}05$) afetada. Esses resultados sugerem que até 38% de soro de leite natural e fresco pode ser adicionado a uma formulação de apresuntado com resultados similares aos produtos curados com uma formulação convencional.

Termos para indexação: Cor, textura, perda de peso, subproduto.

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INTRODUCTION

Comminuted meat products, the largest category of processed meat products, are complex food systems in which water absorption, gelation and emulsion formation influence the stability and texture of the cooked product. In these products, meat proteins provide a functionality that may require enhancement or supplementation by non-meat ingredients.

During the past few decades, there has been an economic incentive for using high-protein non-meat additives, including milk proteins, to decrease ingredient costs and increase yield (ELLEKJAER et al., 1996; YETIM et al., 2006). Adding dairy protein ingredients to meat products improves stability (reduced processing “shrinks” and cooking losses), fat-binding and the textural characteristics of cooked meats. When used in restructured products these exogenous proteins can improve the binding strength, firmness and sliceability (XIONG, 2009), with a positive effect on yield.

Several studies have been conducted on enabling the use of proteins from whey in the preparation of different meat products, evaluating the effects of its addition on sensory and technological quality of the product (BAARDSETH et al., 1992; EL-MAGOLI et al., 1996; ELLEKJAER et al., 1996; LYONS et al., 1999; BARBUT, 2006), but most research has utilized whey protein concentrates and isolates. Use of fluid whey into comminuted meat products is not widely available.

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Some research groups (ZORBA et al., 1995; YETIM et al., 2001; YETIM et al., 2006; TERRA et al., 2009) have conducted studies on emulsion type meat products and observed that emulsion stability, technological and sensory characteristics were similar or more desirable in products with higher amounts of whey added. However, only few reports (MARRIOTT et al., 1998) are available on restructured cooked meat products. In these products, the addition of water is much higher than in emulsion type meat products. So, it is important to obtain reliable, practical, technical and scientific information concerning liquid whey incorporation in restructured cooked meat products.

The aim of this study was to establish the effects of the inclusion of liquid whey, as a substitute for water, on the technological and sensory quality properties of restructured cooked ham. This will enable the use of whey as a valuable resource to produce conventional products, without the cost of drying or other processing methods.

MATERIALS AND METHODS

Sample preparation

Three batches of each product (treatments) were formulated with 54% boneless pork legs and 38% water, with the remaining 8% consisting of commercial curing ingredients: 1.0% salt; 1.7% Rendmax 208 (nitrite/nitrate, ascorbate and polyphosphate blend); 1.7% SUPRO 500E (isolated soy protein); 1.7% cassava starch; 1.1% E-max 206 (maltodextrin); 0.3% Max Sabor 207 (monosodium glutamate); 0.1% CEAMGEL M-920 (carrageenan); 0.01% carmine dye; and 0.5% Condimento Presunto California (ham flavoring and seasonings). The pork meats were provided by a meat packer in Lavras, MG, and the cured adjuncts were graciously donated by New Max Industrial Ltd. (Americana, SP, Brazil).

Pasteurized liquid whey (containing 5.53% lactose, 0.98% protein and 0.75% fat) was obtained from the processing of Minas Frescal cheese and used as a substitute for 0, 25, 50, 75 or 100% (treatments) of the formula water. The materials were mixed, stuffed into vacuum-packs (nylon-polystyrene), shaped in stainless steel forms, and cooked to an internal temperature of 73°C in a water bath. The products were then chilled in an ice bath to room temperature and stored at 2-4°C overnight for further evaluation.

Weight loss attributes evaluation

The cooking yield percentage was determined as the weight of the cooked product after 24 hours of chilling divided by the weight of the uncooked product and multiplied by 100. After that, the proximal composition (moisture, fat, protein and ash) were determined (AOAC, 2002) to characterize the products.

The storage loss of ham samples was determined following the description given by Yang et al. (2001). After 10 days of chilling storage (2-4° C), the samples were removed from the vacuum packages, patted dry with paper towels and weighed. Storage loss was calculated as the percentage weight loss of the products after storage.

Three segments measuring 20 x 60 x 20 mm were obtained from the cooked ham and used to determine reheating losses (HACHMEISTER; HERALD, 1998). Each sample of cooked ham was weighed and placed in a beaker containing approximately 300 mL of boiling, distilled water. Beakers were covered with watch glasses and allowed to stand for 6 min. Reheated segments were drained on a paper towel, cooled for 2 min, and weighed. Reheating losses were calculated as follows: [(initial weight – reheated weight)/initial weight] x 100.

The refreezing loss of ham samples was determined as described by Lee et al. (2002) with modifications. First, 4 segments measuring 60 x 60 x 10 mm were obtained from the cooked ham, weighed, individually packaged and frozen (-18° C, 24 h) and thawed (room temperature, 4 h) repeatedly, for up to 4 cycles. Refrozen segments were wrapped in a filter paper, placed between two glass plates and pressed using a standard weight of 2 kg for 5 minutes. For each cycle, the sample was removed from the filter paper, weighed and refreezing losses calculated as: [(initial weight – refrozen weight)/ initial weight] x 100.

Instrumental analysis

Samples were tested by instrumental color, using a Minolta CR-300 (Konica Minolta, Japan) colorimeter, and Texture Profile Analysis (TPA), using a universal Texture Analyzer TA.XT2i (Stable Micro Systems Ltd., England), as describe by Ramos and Gomide (2009).

The color of cooked hams was measured by the CIELAB system with illuminant D65 and 10° standard observer. Six measurements representing the entire internal cross-section surface were taken from each sample. Lightness (L*), redness (a*) and yellowness (b*) were recorded. Chroma (C*) was calculated as $(a^{*2} + b^{*2})^{1/2}$ and hue angle (h) as $\tan^{-1}(b^*/a^*)$.

After color analysis, twelve cubes with 1.0 cm^3 were cut from internal cross-section surface and a uniaxial compression test was run using a flat compression plat. The crosshead speed was 180 mm/ min and the specimens were compressed twice to 50% of their original height. There was no time to rest between the two cycles of compression. Force time curves were recorded and five texture attributes (hardness, springiness, adhesiveness, cohesiveness and chewiness) were calculated.

Sensory evaluation

Sensory characteristics were evaluated after chilling storage (2-4º C) for 48 hours by 95 non-trained panelists using a multiple-comparison test (MEILGAARD et al., 1999). Sliced samples were presented in a test room, with individual booths and red light (to mask any differences in meat color), for evaluation of texture, taste and overall impression. The color evaluation was performed, in vacuum packed slices, in an appropriate test room.

A reference sample (labeled R, without whey addition) was presented to the panelist with several coded samples (formulations with 0 to 100% whey as substituted for water). The sensory panel was asked to compare each sample with the reference sample, classifying them as "equal preference", "most preferred" or "least preferred", and assessing the intensity of preference on a nine-point hedonic scale (where 1 corresponded to the lowest preference, 5 to no preference and 9 to the highest preference).

Statistical Analysis

Collected data were subject to a one-way ANOVA using the SAS System for Windows™ program, version 8.0 (SAS Institute, Inc.). When significance ($P < 0.05$) was determined for treatments, the means were separated using Duncan's multiple range test.

RESULTS AND DISCUSSION

No significant ($P > 0.05$) differences were noted in proximal composition, with average values of 76.42±0.88% for moisture, 16.25±1.51% for protein, 2.05±0.49% for fat and 3.98±0.63 for ash. Moreover, the products elaborated had an elevated protein concentration and low fat values when compared with Brazilian legislation limits (BRASIL, 2000) which impose requirements for minimum protein (13%) and maximum fat (12%). In fact, the elaborated products can be referred to as low-fat hams, since the fat content was less than 3.0% (BRASIL, 1998).

Weight loss attributes evaluation

No significant ($P > 0.05$) differences were found between treatments in weight loss attributes (Table 1).

Milk products added to meat systems usually decrease the cooking loss (KER; TOLEDO, 1992, HAYES et al., 2005). Although a slight reduction can be observed in higher whey-replaced treatments, differences in cooking yields observed in this study were not significant ($P > 0.05$). These results agree with other researchers who state that the addition of liquid whey to restructured cooked ham (MARRIOTT et al., 1998) and frankfurter (YETIM et al., 2001) and bologna (TERRA et al., 2009) type sausages do not affect the cooking losses.

Table 1 – Weight-loss attributes values (± standard deviation) of whey-added restructured cooked hams.

Characteristics (%)	Percentage whey as a substitute for water					Average
	0	25	50	75	100	
% whey in ham formulation	*0.0*	*9.5*	*19.0*	*28.5*	*38.0*	-
Cooking yield	96.11±0.56	96.10±0.30	96.01±0.61	95.71±1.06	95.80±0.28	95.95±0.56
Reheated loss	8.25±1.43	9.21±2.30	7.16±1.50	7.98±1.51	9.36±2.76	8.42±1,89
Storage loss	3.98±0.39	4.12±0.70	4.29±0.49	4.64±0.33	4.26±0.99	4.26±0.58
RFL, cycle 1	6.18±1.07	6.62±0.25	6.57±1.48	6.55±1.48	6.33±0.35	6.45±0.95
RFL, cycle 2	8.47±1.22	10.90±2.03	9.81±1.85	8.58±1.17	7.87±0.02	9.13±1.68
RFL, cycle 3	9.23±0.69	12.61±1.91	10.40±1.18	9.44±1.07	10.24±1.89	10.39±1.73
RFL, cycle 4	11.36±0.95	12.12±1.12	10.97±2.00	1 0.37±1.38	9.09±0.35	10.78±1.47

No significant ($P > 0.05$) differences were noted between treatments for any evaluated characteristics. Refreezing Loss (RFL): cycle 1 = frozen and thawed one time; cycle 2 = frozen and thawed two times; cycle 3 = frozen and thawed tree times; and cycle 4 = frozen and thawed four times.

The loss of water or soluble material during processing of a meat product is important from technological, economic and sensory perspectives. The average storage and refreezing losses observed in this work were similar to those reported by (PEDROSO; DEMIATE, 2008) in turkey cooked ham elaborated with carrageenan and cassava starch. Marriott (1998) also found no significant (P > 0.05) differences in storage loss in samples with 20% and 30% liquid whey from those without the addition of this adjunct.

The reheating and refreezing losses are indices of the behavior of cured meat products used in frozen products, such as pizzas and lasagna, which can pass through processes such as cycles of freezing and heating. These processes can also generate a number of problems with softening of the mass and weeping in the finished dish. However, none of these indices differed (P > 0.05) from the control samples that contained water in the cure formulation instead of liquid whey (0% whey), which means that liquid whey can be added in the product formulation without inducing any alteration in weight loss attributes.

Instrumental evaluation

The fluid whey addition had no significant (P > 0.05) effect on the products lightness (L*) and yellowness (b*) (Table 2). However, whey-replaced treatments at more than 50% induced lowest redness (a*) values. This can be due to whitish (milky) translucent color of whey, which weakens the intensity of red color originated from cured heme pigments.

This color change can also be attributed to a mild non-enzymatic browning, like a Maillard reaction, induced by higher amounts of lactose as whey is added. Lactose, as a reducing sugar, promotes the browning in foods by reacting with proteins, peptides and amino acids to form compounds that are highly flavored and golden brown in color (ARAÚJO, 2011).

This hypothesis is supported by the reductions (P < 0.05) in chroma (C*) values, at the same manner as observed for redness. According to Ramos and Gomide (2009), chroma is the term describing color intensity compared to a neutral gray of the same value. So, with whey additions the product redness being less pure, i.e. more grayish. Also, the hue angle increases (P < 0.05) in higher whey-replaced treatments, with cured color became more yellowish.

The objective TPA measurements resulting from the use of a bi-cyclical compression test are presented in Table 3. No significant (P > 0.05) differences were observed in textural properties between treatments.

Yetim et al. (2006) found higher values for hardness in whey-substituted sausages, although the control and 100% whey-containing sausages had similar values. They also observed higher values for chewiness in control and 25% whey-containing sausages and a significantly reduced in springiness values with higher liquid whey additions. These differences, not observed in this study, were attributed by the authors to the slight but statistically significant increase in fat content with higher whey-replaced treatments since a number of researchers reported that the meat emulsion was softer and had poorer binding properties when the fat content was reduced as the protein content is kept constant. This would explain the lack of difference observed in our study since fat content was lower (2% against 18-19%) and no significantly differences (P> 0.05) was found between treatments. However, although not significant (P > 0.05), a small increase in hardness and chewiness can be observed in products with higher whey added (Table 3).

Table 2 – Color parameters (CIELAB ± standard deviation) of whey-added restructured cooked hams.

Characteristics	% whey as a substitute for water					Average
	0	25	50	75	100	
% whey in ham formulation	*0.0*	*9.5*	*19.0*	*28.5*	*38.0*	-
Lightness (*L**)	62.14±4.06	62.98±0.72	63.08±4.91	62.39±0.23	63.74±4.08	62.86±3.20
Redness (*a**)	14.30±1.20^{a}	14.02±0.28^{a}	12.20±1.38^{c}	13.14±1,04^{b}	12.69±1.34^{bc}	13.27±1.28
Yelowness (*b**)	5.98±0.50	6.08±0.42	6.01±0.54	6.06±0.67	5.87±0.59	6.00±0.49
Chroma (*C**)	15.51±1.27^{a}	15.28±0.14^{ab}	13.62±1.43^{c}	14.49±0.83^{bc}	14.00±1.46^{c}	14.58±1.24
Hue angle (*h*)	22.70±1.05^{a}	23.44±1.81^{a}	26.31±1.49^{b}	25.05±3.87^{b}	25.04±0.29^{b}	24.51±2.34

Different letters (a, b) in the same row, for each parameter, indicate significant differences between means (P < 0.05) by Duncan's multiple range test.

Table 3 – Textural properties (TPA parameters) of whey-added restructured cooked ham.

Characteristics	% whey as a substitute for water					Average
	0	25	50	75	100	
% whey in ham formulation	*0.0*	*9.5*	*19.0*	*28.5*	*38.0*	-
Hardness (N)	16.54±0.13	13.43±0.11	20.79±0.04	17.84±0.08	19.28±0.13	17.57±0.23
Cohesiveness	0.537±0.03	0.595±0.039	0.496±0.014	0.548±0.121	0.561±0.023	0.547±0.053
Adhesiveness (N.mm)	5.67±0.01	4.75±0.16	6.64±0.02	5.69±0.07	5.36±0.02	5.62±0.32
Springiness (mm)	4.58±0.03	4.66±0.03	4.68±0.04	4.63±0.02	4.59±0.14	4.63±0.07
Chewiness (N.mm)	40.53±0.33	37.14±0.55	48.31±0.15	45.00±0.90	49.42±0.15	44.08±0.74

No significant (P > 0.05) differences were noted between treatments for any evaluated characteristics.

Moreover, and most importantly, one should take into account differences in the type of product. In emulsified products, the texture is dependent on the emulsion stability, i.e. the water-fat interface. Several authors (ZORBA et al., 1995; YETIM et al., 2001; 2006; TERRA et al., 2009) observed that as the concentration of liquid whey in the sausage formulation was increased, the stability of emulsion formed also increased. In restructured products, however, the water holding capacity (WHC) becomes more important than emulsion capacity. So, it is possible that changes in textural parameters, which could indicate improvements in biding capacity, firmness and slicing of products with additions of whey proteins, has been masked by the presence of other additives and ingredients that have these functions, like hydrocolloids (carrageenan and starch) and soy protein isolate (FEINER, 2006). Thus, it is necessary to study the use of fluid whey in restructured meat products removing such ingredients/additives.

The effects of fluid whey addition on the texture of restructured meat products are not widely available. Similar to this paper, Marriott et al.(1998) found no significant (P > 0.05) differences in hardness in low-fat (3.9 to 4.4% fat) restructured ham without and with 20% and 30% liquid whey additions.

Sensory evaluation

The inclusion of liquid whey in the cure formulation for cooked ham as a substitute for water had no effect on overall impression and texture, as evaluated by the non-trained sensory panel (Table 4), since none of these scores differed (P > 0.05) from the control samples that contained water instead whey (0% whey).

Working with a non-trained sensory panel, Terra et al. (2009) did not find any differences (P > 0.05) in texture, color, flavor and aroma of bologna-type sausages with different whey-replaced treatments. With a trained sensory panel, Yetim et al (2001) also found no differences (P > 0.05) in texture, color, flavor and aroma, off-flavor or juiciness of frankfurter sausages formulated with different whey concentrations. In restructured cooked ham formulated with whey, Marriott et al. (1998) did not find any differences *(P > 0.05)* in juiciness, tenderness, flavor or visual discoloration, also evaluated by a trained sensory panel. However, in this work, the flavor and color of restructured cooked ham was affected *(P < 0.05)* by the addition of liquid whey in the product formulation.

Hypothetically, a potential existed for off-flavor development in products containing higher liquid whey substitutions (MARRIOTT et al., 1998). Ellekjaer et al. (1996) reported higher off-flavor development and stickiness in cooked sausages containing higher whey protein contents. However, in the restructured cooked ham, only the samples with 25% and 50% liquid whey-replaced treatments showed lower preferences than for the control. Furthermore, since no differences were observed (*P* > 0.05) in products with higher amounts of whey added (75 and 100% whey) it may be that the greatest development of off-flavor occurs with the addition of small amounts of liquid whey in the product. Another possibility is that the flavor enhancement given by the lactose in higher amounts of added whey compensates for other flavor differences, as observed by Lee, et al. (1980) in meat loaf containing dry whey. It is possible that Marriott et al. (1998) and Yetim et al. (2001) may not have detected this flavor (or off-flavor) difference probably because they evaluated smoked products, which may have masked the results.

Table 4 – Sensory quality preferences* of liquid whey-substituted cooked hams compared to reference sample.

Characteristics	% whey as a substitute for water				
	0	25	50	75	100
% whey in ham formulation	*0.0*	*9.5*	*19.0*	*28.5*	*38.0*
Texture	5.06±1.23	4.66±1.26	4.85±1.50	4.80±1.41	4.69±1.35
Color	5.53±1.29[a]	5.23±1.41[a]	4.25±1.39[b]	4.53±1.51[b]	4.39±1.35[b]
Flavor	5.24±1.39[a]	4.47±1.52[b]	4.64±1.66[b]	4.98±1.36[ab]	4.88±1.60[ab]
Overall impression	5.05±1.15	4.69±1.33	4.79±1.47	4.85±1.20	4.96±1.42

* 1 = less preferred and little difference from the reference sample; 5 = equally preferred and no difference; 9 = most preferred and difference from the reference sample very intense. Different letters (a, b) in the same column for each parameter indicate significant differences between means ($P < 0.05$) by Duncan's multiple range test.

Only the products elaborated with 25% liquid whey replacement treatments did not differ ($P > 0.05$) from the control sample in sensory color. These differences correlate with observations from the instrumental color measurement, with samples having reduced redness and increased grayness and yellowness with whey additions (Table 2). These results are in agreement with Ellekjaer et al. (1996), who observed a reduction in the strength of color, as assessed by trained panelists, in cooked sausages as whey protein was added.

It is possible, however, that the difference observed in the color of ham with high levels of added whey can be prevented by higher concentrations of carmine dye in ham formulation. Moreover, although color differences were perceived by the consumer panel, the overall impression had no affect on preference and most panelists had no negative criticism of the products.

CONCLUSION

Liquid whey can successfully replace up to 100% of added water, corresponding to 38% of the product formula, in a restructured cooked ham formulation, with a resultant product that is similar in technical and quality properties and overall sensory impressions to non-whey added ham.

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