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Sensory profile of beef burger with reduced sodium content

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ABSTRACT. This study determined the sensory profile of three beef burger samples, namely, CON (control), F25 (25% sodium reduction) and F50 (50% sodium reduction), based on the Quantitative Descriptive Analysis (QDA). The samples´ microbial, physical and chemical composition was evaluated. Twelve panelists were selected and trained using as criteria the panelists´ discrimination power, reproducibility and consensus. Eleven terms were generated by the method of network descriptors. The intensity of each descriptor in each sample was evaluated by unstructured scale of 9 cm. Data were analyzed by ANOVA, Duncan´s mean test and principal component analysis. The sensory profile shows that low sodium beef burgers had lower fat and salty flavor when compared to untreated control and greater flavor and spice aroma. The above proves that reducing sodium intake causes increased perception burger tasters when compared to the presence of spices in the product. Treatment with 50% sodium reduction obtained the best results for texture softness and appearance. There was no significant difference ($p < 0.05$) in the chemical composition of ash, protein and fat in all burgers. In the case of general sensory attributes, treatments with sodium reduction obtained higher intensities of the attributes evaluated, except for meat and salt flavors.

Keywords: meat products, sensory analysis, quantitative descriptive analysis, principal component analysis, sodium chloride, potassium chloride.

Perfil sensorial de hambúrguer bovino com reduzido teor de sódio

RESUMO. Este trabalho determinou o perfil sensorial de três amostras de hambúrguer, controle e com redução de 25 e 50% de sódio, baseado na Análise Descritiva Quantitativa (ADQ). Realizaram-se análises físico-química e microbiológica. Doze provadores foram selecionados e treinados utilizando como critérios o poder discriminativo, reprodutividade e consenso dos provadores entre si. Foram gerados 11 termos descritores pelo método de rede. A intensidade de cada descritor foi avaliada em cada amostra por escala não estruturada de 9 cm. Os dados foram analisados por ANOVA, teste de Duncan e análise de componentes principais. Hambúrgueres hipossódicos apresentaram menor sabor de gordura e salgado, quando comparados ao tratamento controle e sabor e odor de especiarias maior. Este diferencial comprova que a redução de sódio no hambúrguer provoca uma maior percepção de intensidade pelos provadores em relação à presença de especiarias no produto. Para aparência o tratamento com 50% de redução de sódio obteve o melhor resultado e também para textura no atributo maciez. Na composição química dos hambúrgueres não houve diferença significativa para cinzas, proteína e gordura ($p < 0.05$). Nos atributos sensoriais de modo geral, os tratamentos com redução de sódio obtiveram maiores intensidades nos atributos avaliados, exceto para sabor salgado e carne.

Palavras-chave: produtos cárneos, análise sensorial, análise descritiva quantitativa, análise de componentes principais, cloreto de sódio, cloreto de potássio.

Introduction

Significant portion of the sodium in diets comes from processed foods, of which the most important are derived from meat, such as beef burgers. According to Brazilian legislation, it is the industrialized meat product obtained from minced meat, added or not to adipose tissue and ingredients, and molded to the appropriate technological processes (BRASIL, 2000). In addition to palatability, sodium chloride in the product is responsible for the functional development of the properties and decisively influence their stability and conservation (DESMOND, 2006)

The sodium intake by Brazilian reaches approximately 4.5 grams daily, twice the amount recommended by the World Health Organization (IBGE, 2010). The daily consumption of 50 g of meat products, such as sausages and others, may be

associated with increased risk in cardiovascular diseases (42%) and diabetes (19% in the general population) according to the American Heart Association (MICHA et al., 2010).

Consumers´ concern underpinning health effects, associated to excessive sodium consumption, requires that the food industry reduces the use of salt in foods, including those derived from meat while keeping their sensory characteristics. The acceptability of products with reduced sodium by the consumer is also demanded. Sodium reduction in meat products may be achieved by the replacement of NaCl by other non-sodium salts, among which potassium chloride is the most widely used (GARCIA et al., 2013).

One of the problems in decreasing sodium percentage in food is the maintenance of the characteristics of the traditional product, i.e. similarly to the product manufactured with NaCl. Sensory analysis of the products developed is very important to guarantee to the consumer a product with reduced sodium and with sensory characteristics close to those of the traditional product.

Consequently, the sensory profile may be developed by the quantitative descriptive analysis (QDA) method that evaluates all the sensory attributes in the food product, such as appearance, flavor, aroma and texture. Their formulation is adjusted in a specific manner in relation to the analyzed attribute (STONE et al., 1974).

Current assay describes the sensory profile of beef burgers produced with full-sodium ingredients, herbs and spices replacing sodium chloride by potassium chloride at 25 and 50% percentages, using the QDA methodology.

Material and methods

The research was approved by the Committee of Ethics in Research of the State University of Maringá, Maringá, Paraná State, Brazil, under protocol CAAE 21879413.9.0000.0104. Participants signed a consent form agreeing to participate voluntarily in the sensory analysis.

The beef burgers were produced with raw beef, textured soy protein, spices and herbs and cold water in the Meat Technology Laboratory of Food Engineering, State University of Maringá. The meat from slaughtered males, comprising 22 g protein (29% DV) and 5 g total fat (9% DV) per 100 g of meat, was purchased from the same lot from Marfrig Alimentos SA, a Brazilian slaughterhouse industry in Promissão, São Paulo State, Brazil.

The meat cut consisted of the sirloin cap (m.Multifididorsi). The herbs, spices and other ingredients were bought locally in Maringá, Paraná State, Brazil.

The beef burgers were prepared to determine the influence of the substitution of sodium chloride (NaCl) by potassium chloride (KCl), associated with herbs and spices. Three ingredients were formulated: CON (100% NaCl); F25 (25% reduction in the concentration of NaCl); and F50 (50% reduction in the concentration of NaCl) (CARVALHO et al., 2013) as described in Table 1.

Table 1. Composition of the beef burgers.

Ingredients	(%)		
	CON	F25	F50
Meat	88.67	88.67	88.67
TSP[1]	4.00	4.00	4.00
Water	5.00	5.00	5.00
NaCl	2.00	1.50	1.00
KCl	-	0.50	1.00
Allium sativum	0.20	0.20	0.20
Oreganum vulgare	0.02	0.02	0.02
Bixa orellana	0.10	0.10	0.10
Capsicum frutescens	0.01	0.01	0.01

[1]TSP (textured soy protein).

The beef were ground with an electric meat grinder MCR 10 (NR12) - G. Paniz, hand mixed with other ingredients according to GMP (Good Manufacturing Practices) and molded with a manual molder cylinder (10 cm diameter) weighed into 80±0.5 g and thickness 1 cm. After processing, the burgers were identified, packed in polyethylene bags and kept frozen at -18°C for later analysis.

Three samples of each batch of beef burgers were used to assess the microbiological quality of treatments immediately after manufacturing in triplicate. According to legislation Fecal Coliform at 45°C, *staphylococcus* coagulase positive, sulfite reducing *clostridium* at 46°C and Salmonella sp. were evaluated following methodology described by (SILVA et al., 1997).

Ash, crude protein, sodium and potassium content were determined according to (AOAC, 2012) method. Fat content was quantified as described by (BLIGH; DYER, 1959). The samples were quantified in AA240FS atomic absorption spectrophotometer (Varian, USA) in mg per 100 g of product for sodium and potassium. Analyses were performed in triplicate.

For the qualitative descriptive analysis (QDA), selection of panelists was based on their interest and availability to participate in current research. Panelists who showed interest had to identify the odor of basic tastes and ten triangular tests were applied to see whether panelists were able to notice simple differences between samples. The panelist

who obtained more than 75% correct scores on the triangular test initiated the development of descriptive terminology for network method described by (MOSKOWITZ, 1983).

The list of terms that comprised the evaluation form samples after panelist consensus was defined. Panelists´ selection and training were performed with the products to be evaluated and with reference materials, according to Table 2. A table of references with all the attributes, based on the terms set, was elaborated, so that the panelists based the extremes of the scales 1-9 for the analysis of three samples. Sensory tests were applied in individual booths using 9 cm unstructured scale generated for each attribute.

Individual results for each panelist were analyzed statistically by the analysis of variance (ANOVA), taking the samples as sources of variation and replications. Those who showed discriminatory ability ($P_{sample} \leq 0.05$), reproducibility ($P_{replications} \geq 0.05$) and consensus with sensory panelists for most of the attributes evaluated were selected for the descriptive analysis. Data Quantitative Descriptive Analyses were analyzed by analysis of variance (ANOVA) for three variation sources (sample, panelists and the interaction between them) as well as by Duncan´s mean test. Principal Component Analysis (PCA) was applied with XLSTAT statistical software (SAS, 2004).

Results and discussion

In all samples, coliform counts at 45ºC were less than 3 MPN g^{-1}, *Staphylococcus* spp. coagulate positive was less than 102 CFU g^{-1}, *Clostridium* sulfite reducer less than 10 CFU g^{-1} and *Salmonella* spp. was absent in 25 g. These results comply with Brazilian legislation (BRASIL, 2001). NaCl has antimicrobial activity although some studies report that KCl may be a direct replacement for common salt with regard to the control of microbial growth (BIDLAS; LAMBERT, 2008).

The replacement of sodium chloride with potassium chloride did not influence significantly the content of crude protein, total lipids and ash ($p > 0.05$) according to Table 3. Moisture content was different between samples ($p < 0.05$). The replacement of sodium by potassium may have generated a higher fluid loss in treatments F25 and F50, probably due to the fact that sodium increases the water-binding of meat (RUUSUNEN; PUOLANNE, 2005).

Table 3. Proximate analysis, sodium and potassium content.

	Beef burger			
	CON[1]	F25[2]	F50[3]	p < value
Moisture (%)	67.16^{a}±0.05	66.35^{b}±0.21	66.70^{b}±0.05	0.017
Ash (%)	2.56^{a}±0.27	2.66^{a}±0.11	2.54^{a}±0.04	0.779
Crude protein (%)	22.27^{a}±0.21	22.63^{a}±0.46	22.26^{a}±0.25	0.517
Total lipids (%)	9.58^{a}±0.16	9.43^{a}±0.18	9.31^{a}±0.28	0.510
Sodium (mg 100 g^{-1})	600.14^{c}±10.89	445.41^{b}±4.68	300.51^{a}±5.56	0.010
Potassium (mg 100 g^{-1})	196.33^{c}±1.08	244.14^{b}±2.95	300.07^{a}±5.99	0.020

[1]CON (20 g kg^{-1} NaCl + 2 g kg^{-1} *Alliumsativum* + 0.2 g kg^{-1} *Oreganumvulgare* + 1 g kg^{-1} *Bixaorellana* + 0.2 g kg^{-1} *Capsicumfrutescens*); [2]F25 (15 g kg^{-1} NaCl + 5 g kg^{-1} KCl + 2 g kg^{-1} *Alliumsativum* + 0.2 g kg^{-1} *Oreganumvulgare* + 1 g kg^{-1} *Bixa orellana* + 0.2 g kg^{-1} *Capsicumfrutescens*); [3]F50 (10 g kg^{-1} NaCl + 10 g kg^{-1} KCl + 2 g kg^{-1} *Alliumsativum* + 0.2 g kg^{-1} *Oreganumvulgare* + 1 g kg^{-1} *Bixa orellana* + 0.2 g kg^{-1} *Capsicumfrutescens*).

Results from qualitative descriptive analysis (QDA) show a significant difference ($p \leq 0.001$) for all attributes (Table 4), with slightly lower differences related to aroma meat ($p \leq 0.01$). In the case of products with reduced sodium, mainly related to aroma and flavor attributes, the treatments with sodium reduction (F25 and F50) had mean aroma and spices taste attributes ranging between 1.58 and 1.78 times higher than control treatment.

Table 2. Terms generated, defining descriptors and references used for the low-sodium beef burger in Quantitative Descriptive Analysis (QDA).

Descriptors	Defining	Intensity	References
Appearance			
Color	Brown color intensity in meat	Low strong	Beef burger grilled to 72ºC wrapped in aluminum foil or not
Brightness	Brightness intensity on the surface of meat	Low strong	Beef burger grilled with and without oil
Aroma			
Meat	Aroma intensity associated with roast beef	Low strong	Beef burger grilled and boiled in water
Spices	Aroma intensity associated with spices	Low strong	Commercial beef burger with 1-3% spices
Fat	Aroma intensity associated with fat	Low strong	Commercial beef burger against low sodium beef burger
Flavor			
Saltiness	Saltiness intensity associated to sodium chloride	Low strong	Commercial beef burger vs low sodium beef burger
Fat	Fat intensity associated to fat in meat	Low strong	Commercial beef burger vs control low sodium beef burger
Meat	Flavor intensity associated to beef burger grilled	Low strong	Beef burger grilled and boiled in water
Spices	Flavor intensity associated to spices	Low strong	Commercial beef burger with 1-3% spices
Texture			
Tenderness	Force required for compression	Low strong	Beef burger grilled at different temperatures (70 and 80ºC)
Juiciness	Given the presence of moisture in the meat juices	Low strong	Beef burger grilled at different temperatures (70 and 80ºC)

The saltiness flavor and fat flavor excelled in control treatment (CON). When the sodium content is reduced, the herbs´ and spices´ flavor and aroma added to treatments are enhanced and become noticeable to the panelist. They mask the flavor of meat, fat and flavor of fat, which inversely stand out in the control treatment. In a study by (MARANGONI; MOURA, 2011) with Italian salami, the addition of essential coriander oil to the formulation improved the sensory attributes of taste and aroma.

In the case of appearance and texture attributes, the treatment F50 (with 50% sodium reduction) averaged a higher intensity when compared to the control sample (CON) and F25, indicating that sodium reduction in this percentage (50%) did not negatively affectthese attributes. A study conducted by (CLAUDINO; BERTOLONI, 2013) with beef burgersplus different percentages of fat and plasma showed a significant reduction ($p < 0.05$) in hardness when compared to formulations containing 10 and 5% of fat content. Percentage is similar to formulations employed in current study.

Table 4. Qualitative Descriptive Analysis (QDA) of beef burger.

Attributes	Beef burger			
	CON[1]	F25[2]	F50[3]	p value
Appearance color	$6.26^{c} \pm 0.53$	$7.15^{b} \pm 0.29$	$7.75^{a} \pm 0.53$	0.000
Appearance brightness	$5.92^{b} \pm 0.33$	$5.17^{c} \pm 0.20$	$7.51^{a} \pm 0.33$	0.000
Aroma meat	$7.12^{b} \pm 0.45$	$7.63^{a} \pm 0.33$	$7.46^{a} \pm 0.45$	0.005
Aroma spices	$4.70^{b} \pm 0.89$	$7.44^{a} \pm 0.27$	$7.58^{a} \pm 0.89$	0.000
Aroma fat	$6.37^{a} \pm 0.17$	$5.35^{b} \pm 0.29$	$4.80^{c} \pm 0.17$	0.000
Flavor saltiness	$7.51^{a} \pm 0.30$	$6.33^{b} \pm 0.32$	$5.95^{c} \pm 0.30$	0.000
Flavor fat	$7.25^{a} \pm 0.30$	$5.55^{b} \pm 0.33$	$4.80^{c} \pm 0.30$	0.000
Flavor meat	$7.60^{a} \pm 0.27$	$7.10^{b} \pm 0.32$	$7.29^{b} \pm 0.27$	0.000
Flavor spices	$4.65^{c} \pm 0.33$	$7.38^{b} \pm 0.27$	$8.28^{a} \pm 0.33$	0.000
Texture tenderness	$7.27^{b} \pm 0.28$	$7.40^{b} \pm 0.27$	$7.86^{a} \pm 0.28$	0.000
Texture juiciness	$7.17^{b} \pm 0.32$	$7.84^{a} \pm 0.37$	$7.57^{a} \pm 0.32$	0.000

[1]CON (20 g kg^{-1} NaCl + 2 g kg^{-1} *Allium sativum* + 0.2 g kg^{-1} *Oreganum vulgare* + 1 g kg^{-1} *Bixa orellana* + 0.2 g kg^{-1} *Capsicum frutescens*); [2]F25 (15 g kg^{-1} NaCl + 5 g kg^{-1} KCl + 2 g kg^{-1} *Allium sativum* + 0.2 g kg^{-1} *Oreganum vulgare* + 1 g kg^{-1} *Bixa orellana* + 0.2 g kg^{-1} *Capsicum frutescens*); [3]F50 (10 g kg^{-1} NaCl + 10 g kg^{-1} KCl + 2 g kg^{-1} *Allium sativum* + 0.2 g kg^{-1} *Oreganum vulgare* + 1 g kg^{-1} *Bixa orellana* + 0.2 g kg^{-1} *Capsicum frutescens*).

The principal component analysis (PCA) showed that the three treatments differed from each other and in the different quadrants. The attributes meat flavor, salt and fat are similar to the control treatment, while the spices´ flavor attribute is close to the treatments with 25 and 50% sodium reduction (F25 and F50); texture tenderness, appearance color and brightness are close to the F50 treatment, while aroma spices, aroma meat and texture juiciness are found in the same quadrant as treatment F25, inversely related to the attributes of flavor meat and saltiness (Figure 1).

The highest numbers of desirable attributes (aroma and flavor spices) are close to the beef burgers with low-sodium treatments. Natural ingredients, including herbs and spices have been studied as potential co-adjuvants in the sodium reduction of meat products, masking the bitter aftertaste left by potassium chloride (CARRARO et al., 2012).

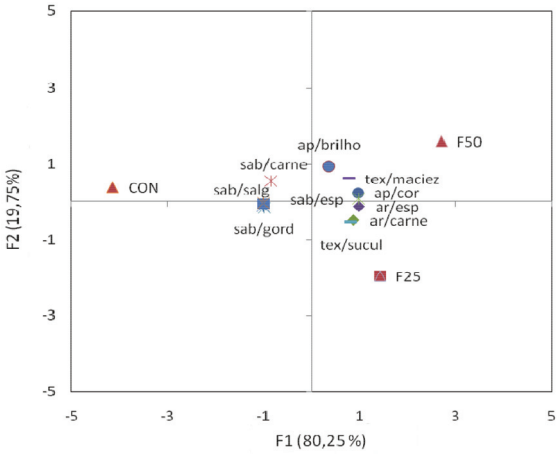

Figure 1. Principal component analysis from the sensory evaluation of low-sodium beef burgers with trained panel.

Conclusion

NaCl reduction and its partial substitution by KCl did not change the chemical composition of beef burgers (except moisture) and did not interfere with microbiological results. The added spices in this product improved sensory attributes of flavor, aroma and texture of beef burgers and masked the flavor fat that was detected with higher intensity in the control treatment.

The reduction of sodium content in percentages of 25 and 50% obtained good intensity of desirable attributes. With the addition of spices and herbs, it could be applied in meat products when its quantitative sensory aspects are observed.

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