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REDUCTION OF UP TO 75% NACL IN BRAZILIAN CHEESE PUFF DOES NOT ALTER SENSORY ACCEPTABILITY AMONG TEENAGERS

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ABSTRACT

The aim of the study was to verify the sensory acceptability and physicochemical composition of Brazilian cheese puff made with different levels of sodium chloride (NaCl), potassium chloride (KCl) and monosodium glutamate (MSG) among teenagers. In Step 1, five sample formulations were made with the addition of NaCl and KCl, jointly or individually, in the percentages of 0 to 0.60%. Step 2 used the same addition percentages that were used in Step 1, with the addition of 0.30% of MSG, though. In Step 1 there was no significant difference between the formulations for the features appearance, aroma, texture and colour. However, the sample that had 0.45% of KCl presented a lower acceptance for the features flavour, aftertaste, overall acceptance and purchase intent. In Step 2, with the addition of MSG, there was a general increase of the products' acceptability. The raw product presented the following levels of moisture, ash, protein, lipid, carbohydrate and energy, respectively: 31.81 $g.100g^{-1}$, 2.41 $g.100g^{-1}$, 6.91 $g.100g^{-1}$, 14.44 $g.100g^{-1}$, 44.43 $g.100g^{-1}$ and 329.58 $kcal.100g^{-1}$. The formulation F4 (addition of 0.15% NaCl and 0.45% KCl), with a greatest KCl level and sensory acceptance similar to the control formulation, presented contents of 338.70 and 375.60 mg/days of sodium (Steps 1 and 2, respectively), with an average reduction of 34.70 and 27.59% in comparison with control. We can reduce the NaCl level (75%) and increase the addition content of KCl (0.45%) in cheese puff without interfering in the teenager public's sensory acceptance. Adding MSG in the product increases its acceptance.

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INTRODUCTION

The most naturally abundant salt in foods in sodium chloride (NaCl). It is often used to add salinity and enhance the products' flavour. However, in the last few years, this mineral's consumption increased in most countries, presenting a variation of 9 to 12 g/day per person, amounts that are above the World Health Organization's (WHO, 2014) daily intake recommendations of 5 g (2.000 mg of sodium/day) tops. As for children and teenagers, this recommendation is even lower, under 2 g (800 mg of sodium/day). People in these age groups are considered more vulnerable due to their consumption of foods with high levels of calories, sodium, saturated fat and sugar. Additionally, they present a low consumption of fruits and vegetables.

An excessive intake of sodium is directly linked to the development of several chronic diseases, such as hypertension,

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cardiovascular diseases, kidney diseases, osteoporosis and cancer, which increase the expenditures with public health (Wong *et al*., 2017). Consequently, in Brazil, the Ministry of Health and the National Sanitary Surveillance Agency are encouraging strategies to reduce the level of sodium in foods through national campaigns. They are focusing on educational and informative actions targeted to health professionals, handlers, food industry and general population, especially children and teenagers. In this last case, they highlight an encouragement to a healthy diet, especially linked to a NaCl intake reduction, adding more fruits, vegetables and foods with a low fat level in their diet (Brasil, 2016). The consumption of processed foods in industrialized countries represents the main sodium source in our diet. Among them, we can highlight meat products (18%), bread and baked goods (13%), milk products (12%) and sauces and spreads (11%). Herbs, spices and table salt represent 23% of our sodium intake (Mhurchu *et al*., 2011). Therefore, reducing the sodium level in processed foods seems to be an effective strategy to significantly reduce a population's sodium intake (Daugirdas, 2013). NaCl provides a microbiological safety, changes the products' structural and functional characteristics (Busch *et al*., 2013) and generates a better acceptability. These factors are mentioned by the food industry as the main hindrances to reduce salt as an addition ingredient in foods. However, studies show that a 25% (McMahon *et al*., 2016) and 50% (Bolhuis *et al*., 2011) reduction of the NaCl level in bread does no change its sensory characteristics. In this context, researches that are trying to reduce the level of sodium in baked goods are essential to ensure its final quality (Felicio *et al*., 2013) and acceptance by the consumers, encouraging also healthier food consumption.

Cheese puff is a Brazilian typical baking good. They present a high consumer acceptance, especially by the teenager public, since they may be considered as fast food. Additionally, they are easy to make and are cheap, facts that increase their domestic commercialization, with an impressive expansion tendency in the international market (Pereira *et al*., 2010). Cheese puff is made by the mixture of sour cassava flour, cheese, water, fat and salt, but they also may include other ingredients, especially eggs and milk (Pizzinatto, 2000). They are usually baked. Cheese puff is a carbohydrate source (38.5 $g.100g^{-1}$), they have considerable amounts of protein (3.6 $g.100g^{-1}$) and lipid (14 $g.100g^{-1}$), and they also have a high sodium level (403 $mg.100g^{-1}$) (TACO, 2011). Consequently, they might be considered a potential product for the addition of said substitute ingredients in their formulation.

Potassium chloride (KCl) is often used to replace NaCl. It is considered safe and its antimicrobial properties are similar to NaCl's. In our body, potassium may reduce the risk of cardiovascular diseases and hypertension because it has a beneficial effect on our blood pressure (WHO, 2014). Additionally, increasing our potassium consumption may reduce our calcium urinary excretion, resulting in a positive balance of this mineral, cooperating for our bone mass maintenance and consequently in the osteoporosis prevention (Cruz *et al*., 2011). In spite of that, a KCl excessive use may result in some sensory problems, such as a possible salty taste reduction; introduction of metallic, bitter and astringent aftertastes; colour and texture irregularities; and low NaCl amount to make a safe product in terms of microbiological balance (Aliño *et al*., 2009). The use of some substances called flavour enhancers may increase the foods' acceptance, promoting the "umami" taste. Among these ingredients, the most used one is the Monosodium Glutamate (MSG), which enhances natural flavours and aroma (Jinap and Hajeb, 2010). However, to sell new products in the market, it is essential to apply scientific tests. They would allow an evaluation and optimization of its possible sensory, technological and physicochemical changes. In this sense, sensory analyses are considered as an essential requirement during the entire measuring process of the foods' characteristics. A positive result in acceptability indicates that the consumer is satisfied with the new food, promoting its possible commercialization (Meilgaard *et al*., 2016). The purpose hereof was to verify the sensory acceptability and physicochemical composition of cheese puff made with different levels of sodium chloride, potassium chloride and monosodium glutamate among teenagers.

MATERIALS AND METHODS

Raw material: The basic ingredients that were used in the formulations were bought in supermarkets of the city of Guarapuava, Paraná, Brazil. However, the salts were donated by partner companies and had the following classification: NaCl (for analysis, F.A.), molecular weight of 58.44 and; KCl (F.A.), molecular weight of 74.55; the MSG that we used was a commercial product, containing 12.300 mg Na/100 g.

Preparation cheese puff: The products were prepared at the Laboratory of Technique and Diet of Midwest State University, Guarapuava, Paraná, Brazil. The following ingredients were used for the basic formulation: cassava flour (42.88%), eggs (18.01%), whole milk (17.67%), grated cheese (12.86%) and soy oil (7.98%). In Step 1, five cheese puff formulations were made with different NaCl and KCl levels, which were: F1, control (0.60% NaCl - 100%), F2 (0.45% NaCl - 75% and 0.15% KCl - 25%), F3 (0.30% NaCl - 50% and 0.30% KCl - 50%), F4 (0.15% NaCl - 25% and 0.45% KCl - 75%) and F5 (0.60% KCl - 100%). In Step 2, we used the same salt addition percentages used in Step 1, but each sample received MSG in the percentage of 0.30%, totalizing 5 formulations. The salt addition levels established in Steps 1 and 2 were defined through preliminary sensory tests made with the product. Initially, each formulation's ingredients milk, oil and salts were cooked by approximately 5 minutes, under a temperature of 95.8 °C, which were poured on the cassava flour for scalding. Then we added the eggs and cheese, mixing them manually (5 minutes) until we got homogeneous dough. The dough pieces rested for 15 minutes in a fridge (5 °C). Each formulation was placed in aluminum baking pans (40 cm x 30 cm) and backed in a conventional oven (Atlas®, Brazil), preheated at medium temperature (180 °C) for approximately 30 minutes.

Sensory analysis: Two hundred and forty-eight teenagers, regular consumers of cheese puff, enrolled in public schools of the city of Guarapuava, Paraná, Brazil took part in the sensory analysis. The untrained consumers included students of both genders, aging from 14 to 17 years old. The sensory evaluation was made in a classroom, in individual booths, under natural light. The evaluated features were appearance, aroma, flavour, aftertaste, texture, colour and overall acceptance. We used a 9-point structured hedonic scale, varying from dislike extremely (1) until like extremely (9). In purchase intent test, a 5-point attitude structured scale was used, varying from 1 (definitely would not buy it) to 5 (definitely would buy it) (Meilgaard *et al*., 2016). Each sample was served to consumers in white plates coded with randomly selected 3-digit numbers in monadic form and using balanced design (Macfe *et al*., 1989). Sensory evaluations were performed by consumers under fluorescence lighting. After consuming each sample, consumer was instructed to drink water for palate cleansing. Samples were evaluated in triplicate in separate session. A ranking test was applied to compare the samples' differences in the specific feature of their salty taste, since the cheese puff' sodium was reduced. The consumers classified the samples in a salty taste ascending order, from less salty to more salty (Meilgaard *et al*., 2016). The sensory acceptability index (AI) was calculated by multiplying the average score reported by consumers to the product by 100, dividing the result by the maximum average score given to the product within the hedonic scale for 9.0 points.

Physicochemical composition: The centesimal composition was evaluated in triplicate in the raw cheese puff control formulation. All results were expressed in weight base. The moisture and ash levels were determined in oven (105 °C) and muffle (550 °C) (AOAC, 2011), respectively. The lipid content was assessed by the cold extraction method (Bligh and Dyer, 1959). The protein quantification was made through the sample's total nitrogen level, Kjeldahl method (semimicro level with a nitrogen conversion factor of 6.25) (AOAC, 2011). The carbohydrate level was theoretically calculated (by difference) in the triplicates' results, according to the formula: *% Carbohydrates = 100 - (% moisture + % protein + % lipid + % ash + % fiber*). For the total caloric theoretical calculation, we used the conversion values for lipid (9 kcal/g), protein (4 kcal/g) and carbohydrate (4 kcal/g) (Merrill and Watt, 1973). The Daily Reference Values (DRV) was calculated for 50 g of the sample, based on the mean values recommended for teenagers (14 to 17 years old), resulting in: 1944.42 kcal/day, 250.6 g/day carbohydrate, 47.6 g/day protein and 70.6 g/day lipid. The DRV for the micronutrients was calculated for 3767.19 mg/day sodium and 2.573.87 mg/day potassium (DRI, 2005). The physicochemical composition related to the sodium and potassium levels was evaluated in triplicate in the five raw cheese puff formulations (Steps 1 and 2). The samples were initially digested with HNO_3 and H_2O_2. The quantification was determined by optical emission spectrometry with inductively coupled plasma (ICP OES) (Thermo Fisher Scientific®, iCAP 6300 Duo model, England).

Statistical analysis: The data were evaluated through an analysis of variance (ANOVA) and Tukey's test. In the sensory analysis, we also used the Friedman test and Christensen' Table (Christensen *et al*., 2006), which indicated a least significant difference (LSD) between the samples and the number of opinions obtained in the ranking test. All tests were analyzed with a 5% level of significance, with the assistance of the Statgraphics plus® software, version 5.1.

Ethical issues: This paper was approved by the Research Ethics Committee of Midwest State University, ruling no. 345.569/2013. The following factors were considered as exclusion criteria: being allergic/intolerant to at least one of the ingredients used in the formulations, subjects over 17 and under 14 years old, not being a student of the evaluated school, or fail to deliver a Term of Free and Clarified Consent signed by his/hers legal guardian.

RESULTS AND DISCUSSION

Sensory analysis: The sensory test results of the cheese puff made with a NaCl level reduction (Step 1) and MSG addition (Step 2) are described in Table 1. In Step 1, there was no significant difference between the formulation features appearance, aroma, texture and colour. As for flavour, aftertaste, overall acceptance and purchase intent, the sample F5 received the lowest scores by the consumers ($p<0.05$), with no difference between the other formulations. This fact may be explained by KCl's characteristic of giving a bitter aftertaste to the products (Cruz *et al*., 2011). Another fact is that sodium has a flavour enhancing ability in foods. Therefore, products with extremely reduced levels thereof might have their acceptance reduced. With the addition of MSG (Step 2), generally, we managed to increase the scores for all evaluated features. We should mention that only aftertaste presented a significant difference, in which F5 got the lower score, with no difference between the other samples. Similar results were reported by Bolhuis *et al*. (2011), who evaluated the substitution of NaCl by KCl and flavour enhancers in bread. When additioned in foods, MSG has a flavouring function that is similar to free glutamate, already present in some foods, which justifies the greater acceptance of the products in Step 2. However, when we use KCl as the only salt in the product, its property of producing bitter and metallic tastes is highlighted, which can reduce the food's acceptance. Consequently, NaCl and KCl combinations are more sensory accepted, a fact that minimize this effect (Sinopoli *et al*., 2012).

In the ranking test, F5 was reported as the least salty sample by the consumers (Step 1 and 2). In our body, sodium has specific mechanisms, involving epithelial channels in the flavour bud receiving cells. One of them is responsible for sodium, which identifies salty tastes. Another is exclusive for other minerals, not identifying salty tastes and generating other tastes. Additionally, when we add KCl, the salty taste may be impaired, since it may generate metallic and bitter tastes (Liem *et al*., 2011). Another explanation may be the MSG combination with NaCl. To perform its function, MSG requires two MSG parts for one of NaCl, which makes the food to remain salty even with salt reduction (Reyes, 2011). This effect was not seen in F5 due to the exclusive addition of KCl in this formulation, hindering the salty taste's evaluation. Although, even after the addition of MSG, lower scores were attributed to F5 in the salty taste feature.

In Step 1, we generally see that F1, F3 and F4 were the ones that got higher AIs, above 70%. We should highlight that F5 got a low AI in the features aroma, flavour, aftertaste, overall acceptance and purchase intent. As for F2, F3 and F4, they received lower AI for colour and aftertaste. In Step 2, adding MSG to the formulations increased the AI of most features, except for texture and colour. However, F5 remained with AI under 70% in the features aroma, flavour, aftertaste, colour and purchase intent. In Step 1, most consumers classified the samples with the scores 6 (disliked slightly), 7 (disliked moderately) and 8 (disliked extremely) for every feature (Figure 1). We should highlight, however, the elevated percentage of ≤ 5 scores (neither like nor dislike) in F5, indicating its lower acceptance. With the MSG addition (Step 2), we got a general increase of the scores 7 and 8 for every feature, improving the products' acceptance. The F5 sample, in spite of the scores' increase, continued as the least desired by the consumers.

Table 1. Sensory scores (mean ± standard deviation) and acceptability index (AI) of the cheese puff with the addition of several levels of sodium chloride (NaCl) and potassium chloride (KCl), and with (Step 1) or without (Step 2) addition of monosodium glutamate

Parameter	F1	F2	F3	F4	F5
Step 1					
Appearance	7.04±0.20^{a}	6.58±0.24^{a}	7.08±0.22^{a}	7.13±0.23^{a}	6.40±0.20^{a}
AI (%)	78.22	73.11	78.66	72.22	71.11
Aroma	6.40±0.19^{a}	6.42±0.22^{a}	6.62±0.20^{a}	6.61±0.23^{a}	6.00±0.20^{a}
AI (%)	71.11	71.33	73.55	73.44	66.66
Flavour	6.42±0.28^{a}	6.30±0.26^{a}	6.48±0.28^{a}	6.45±0.30^{a}	4.81±0.35^{b}
AI (%)	71.33	70.00	72.00	71.66	53.44
Aftertaste	6.42±0.21^{a}	5.84±0.26^{a}	6.00±0.27^{a}	5.45±0.36^{a}	4.30±0.28^{b}
AI (%)	71.33	64.88	66.66	60.55	53.75
Texture	6.48±0.23^{a}	6.34±0.22^{a}	6.41±0.20^{a}	6.35±0.27^{a}	6.40±0.22^{a}
AI (%)	72.00	70.44	71.22	70.55	71.11
Colour	6.30±0.29^{a}	6.12±0.26^{a}	6.17±0.27^{a}	6.21±0.29^{a}	5.94±0.29^{a}
AI (%)	70.00	68.00	68.55	69.00	66.00
Overall acceptance	7.09±0.17^{a}	6.31±0.23^{a}	6.42±0.26^{a}	6.43±0.28^{a}	4.68±0.32^{b}
AI (%)	78.77	70.11	71.33	71.33	52.00
Purchase intent	3.85±0.14^{a}	3.61±0.19^{a}	3.51±0.17^{a}	3.58±0.16^{a}	2.50±0.18^{b}
Notes sum*	218^{a}	193^{a}	191^{a}	206^{a}	170^{b}
Step 2					
Appearance	7.03±0.17^{a}	7.01±0.17^{a}	6.92±0.17^{a}	6.44±0.23^{a}	6.47±0.20^{a}
AI (%)	78.11	77.88	76.88	71.55	71.88
Aroma	6.31±0.22^{a}	6.63±0.19^{a}	6.61±0.20^{a}	6.51±0.23^{a}	6.23±0.19^{a}
AI (%)	70.11	73.66	73.44	72.33	69.22
Flavour	6.71±0.23^{a}	6.69±0.20^{a}	6.50±0.23^{a}	6.31±0.20^{a}	5.88±0.25^{a}
AI (%)	74.55	74.33	72.22	70.11	65.33
Aftertaste	6.38±0.22^{a}	6.20±0.21^{a}	6.09±0.22^{ab}	6.02±0.23^{ab}	5.31±0.24^{b}
AI (%)	70.88	68.88	67.66	66.88	59.00
Texture	6.38±0.19^{a}	6.56±0.18^{a}	6.36±0.19^{a}	6.39±0.21^{a}	6.40±0.20^{a}
AI (%)	70.88	72.88	70.67	71.00	71.11
Colour	6.71±0.21^{a}	6.83±0.19^{a}	6.73±0.22^{a}	6.19±0.23^{a}	6.19±0.23^{a}
AI (%)	74.55	75.88	74.77	68.77	68.77
Overall acceptance	7.03±0.18^{a}	6.81±0.17^{a}	6.74±0.17^{a}	6.52±0.17^{a}	6.40±0.21^{a}
AI (%)	78.11	75.66	74.88	72.44	71.11
Purchase intent	3.81±0.12^{a}	3.87±0.13^{a}	3.66±0.12^{a}	3.62±0.14^{a}	3.42±0.15^{a}
Notes sum*	201^{a}	203^{a}	183^{a}	198^{a}	138^{b}

Distinct letters in row indicate significant differences by Tukey's test ($p \leq 0.05$). Values are mean of three replicates. Step 1: F1 (0.60% NaCl), F2 (0.45% NaCl and 0.15% KCl), F3 (0.30% NaCl and 0.30% KCl), F4 (0.15% NaCl and 0.45% de KCl) and F5 (0.60% KCl). Step 2: Addition of 0.30% monosodium glutamate in each of the formulations. *Least significant difference (LSD) of ≥ 35 between the samples present statistic difference ($p < 0.05$), according to Christensen's Table (Christensen *et al.*, 2006) for 64 judgments and 5 samples.

Table 2. Physicochemical composition of sodium (Na) and potassium (K), and Daily Reference Values (DRV)* (average portion of 50 grams) of the cheese puff (raw) formulations'

Parameter	F1	DRV %*	F2	DRV %*	F3	DRV %*	F4	DRV %*	F5	DRV %*
Step 1										
Na (mg.100g^{-1})	518.70^{a}	6.90	458.70^{b}	6.08	398.70^{c}	5.30	338.70^{d}	4.50	278.70^{e}	3.70
% Na reduction	0.00		11.57		23.13		34.70		46.27	
K (mg.100g^{-1})	79.16^{e}	1.53	157.68^{d}	3.06	236.21^{c}	5.11	314.73^{b}	6.11	393.26^{a}	7.63
% K increase	0.00		99.19		198.40		297.59		396.79	
Step 2										
Na (mg.100g^{-1})	555.60^{a}	7.74	495.60^{b}	6.60	435.60^{c}	5.80	375.60^{d}	5.00	315.60^{e}	4.20
% Na increase/ reduction	7.11$^{\mu}$		4.45$^{\beta}$		16.02$^{\beta}$		27.59$^{\beta}$		39.15$^{\beta}$	

Distinct letters in row indicate significant differences by Tukey's test ($p \leq 0.05$). Values are mean of three replicates. Results expressed in weight base. *DRV: nutrients evaluated by the DRI mean (DRI, 2005). $^{\mu}$% increase in comparison with F1 (Step 1). $^{\beta}$% reduction in comparison with F1 (Step 1). Step 1: F1 (0.60% NaCl), F2 (0.45% NaCl and 0.15% KCl), F3 (0.30% NaCl and 0.30% KCl), F4 (0.15% NaCl and 0.45% de KCl) and F5 (0.60% KCl). Step 2: Addition of 0.30% monosodium glutamate in each of the formulations.

Subjects whose diet has a high sodium level may be more sensitive to products made with a reduced level thereof (Drake *et al.*, 2011), which may also explain the results hereof. More than 70% of the Brazilian teenagers present a sodium intake superior to the tolerable upper intake level (UL: 2300 mg/day) (IBGE, 2011). This fact hinders the food's acceptance, which may influence in the lower scores reported for F5 (Step 1).

Physicochemical composition: The raw cheese puff formulation was evaluated in its centesimal composition. Its levels of moisture (31.81 g.100g^{-1}), ash (2.41 g.100g^{-1}), protein (6.91 g.100g^{-1}), lipid (14.44 g.100g^{-1}), carbohydrate (44.43 g.100g^{-1}) and energy (329.58 kcal.100g^{-1}) were similar to the ones reported in the literature (TACO, 2011). The DRV (DRI, 2005) of an average portion of 50 g of cheese puff (raw) represents 4.25% protein, 8.45% lipid, 7.09% carbohydrate and 7.08% energy. The mean levels of sodium and potassium of the five cheese puff (raw) formulations are presented in Table 2. Knowing that F4 (Step 1 and 2) got a better sensory acceptance (Table 1), that is, a greater KCl addition level and a similar acceptance to the control formulation, we managed to perform an average reduction of 31.45% of sodium in comparison with the control product. The sodium level reduction verified for cheese puff contribute with the new world demands and with world action initiatives related to the prevention and control of chronic diseases, especially for children and teenagers (WHO, 2014; Brasil, 2016). In spite of the positive results obtained herein, the NaCl is essential in the process of production and conservation of several foods, such

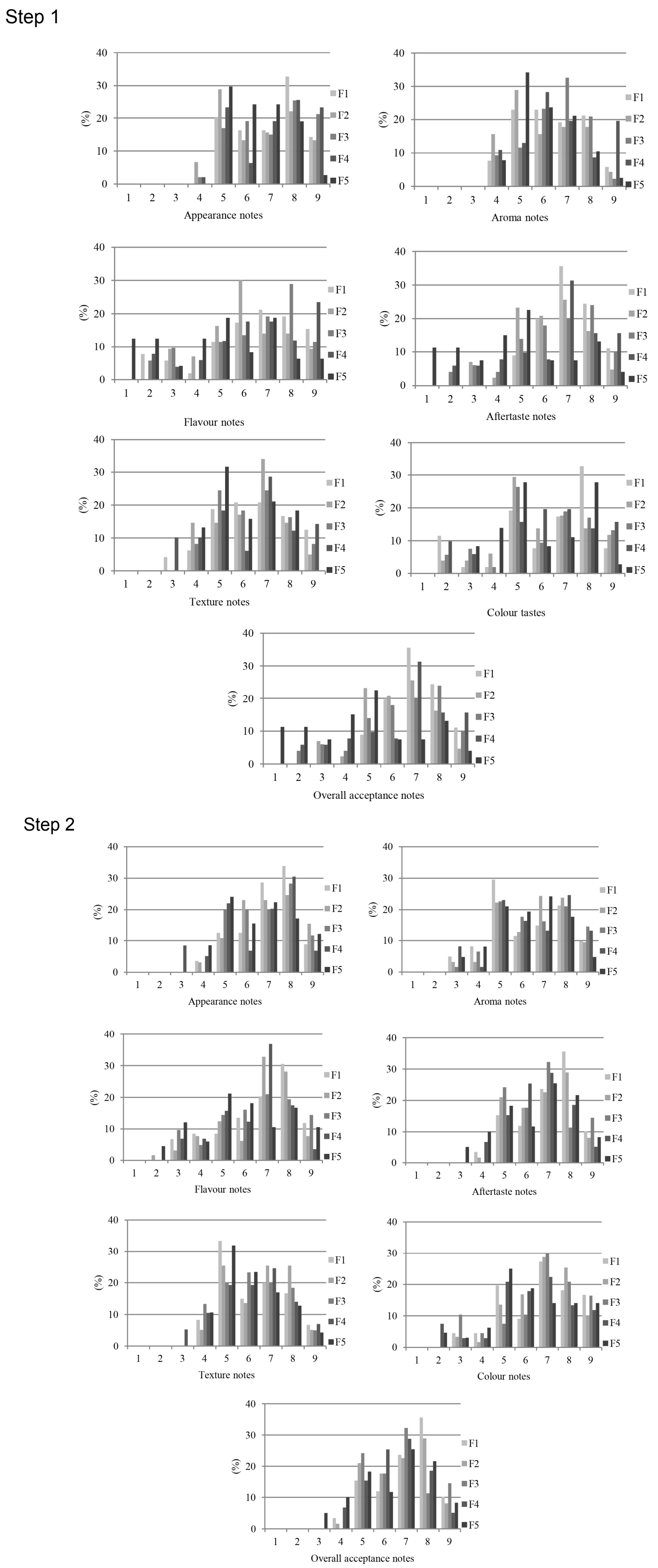

Figure 1. Distribution of the consumers by the hedonic values obtained in the sensory evaluation of the cheese puff with reduced levels of sodium chloride. Step 1: F1 (0.60% NaCl), F2 (0.45% NaCl and 0.15% KCl), F3 (0.30% NaCl and 0.30% KCl), F4 (0.15% NaCl and 0.45% de KCl) and F5 (0.60% KCl); Step 2: Addition of 0.30% monosodium glutamate in each of the formulations.

as meats, breads, cheeses, dough, etc (Doyle and Glass, 2010). This fact increases our difficulty to use very reduced sodium levels in the food industry, which demonstrate the necessity of new researches that may cooperate for a lower sodium addition in foods.

Conclusion

We can reduce the NaCl level (75%) with the addition of KCl (0.45%) in cheese puff without interfering in the teenager public's sensory acceptability. Reducing the NaCl level in cheese puff promotes a healthier diet and cooperates with the world actions related to the prevention and control of chronic diseases. We suggest other studies that may cooperate to a lower use of sodium in foods.

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