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SENSORY DESCRIPTIVE ANALYSIS, SENSORY ACCEPTABILITY AND EXPECTATION STUDIES ON BISCUITS WITH REDUCED ADDED SALT AND INCREASED FIBER

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ABSTRACT

The aims of this study were to formulate biscuits with 50% more fiber and 50% less added salt than classic formulations, to describe their sensory characteristics, to measure expectation/sensory acceptability, and to investigate if sensory acceptability for these biscuits was related to the interest in consuming food products with less salt and/or more fiber content. A 2×2 factorial design was used to develop four formulations: conventional fiber/conventional salt; conventional fiber/reduced salt; increased fiber/conventional salt; and increased fiber/reduced salt. Differences in the sensory profiles measured by a trained panel were of low magnitude, except for presence and taste of bran. Adolescent and adult consumers evaluated acceptability in three stages: blind with three-digit codes; expectation of the label only; and biscuit + label. The low salt formulations received the lowest scores in the expectation stage, but in the blind and biscuit + label stages acceptability of all formulations was similar. The variables that explained overall acceptance were: measurement stage; formulation salt level; interest in reducing consumption of high salt foods; and interest in consuming bakery products with fiber.

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PRACTICAL APPLICATIONS

Increasing fiber content of biscuits by 40 to 50% helps achieve recommendations to increase fiber intake in daily diets. Also, as biscuits currently on the Argentine and other world markets present two extreme varieties – with or without added salt – formulating a biscuit with 50% less added salt facilitate sodium reduction. In our research we have found that these goals can be achieved without seriously affecting sensory acceptability. We propose the articulation of the necessary strategies with the food industry to market biscuits with less added salt and more fiber for the general population; and the use of these healthier biscuits by institutional food services.

INTRODUCTION

In Argentine and other world markets, bakery goods with high fiber and reduced salt contents are generally not available in the same product. These products would help comply with two nutritional goals of the Argentine Dietary Guidelines (AADYND 2000) and the World Health Organization (WHO 2003), which recommend increasing the consumption of fiber and reducing sodium consumption. Therefore, it is important to develop healthy bakery products such as biscuits with higher content of fiber and lower content of added salt.

By adding 40% or 50% of fiber to the biscuits typically consumed by a population would help achieve above recommendations. Also, as biscuits currently on the market present two extreme varieties – with or without added salt – formulating a biscuit with 50% less added salt would help comply with sodium reduction recommendations (AADYND 2000; WHO 2003). Adams *et al.* (1995) found that at the same sodium concentration perception of salty taste was different according to the type of food. From these results, we considered it important to measure the sensory profile and consumer acceptability of these biscuits.

Expectation plays an important role in food consumption, because it may improve or degrade perception of a product even before it is tasted (Deliza and MacFie 1996). The nutritional information or label also generates expectations. On the one hand, knowing the product is low in salt may lead the consumer to score the food product lower than if they ignore this information. On the other hand, knowing the product is low in salt may lead older consumers to score the product higher because they think the food will be good for their health (Levis and Chambers IV 1996). Also, sensory descriptive analysis (Meilgaard *et al.* 2007) allows the analytical knowledge of the sensory changes produced by fiber increase and salt reduction.

It would be valid to ask if there is a relationship between the interest revealed by consumers towards healthy food and his/her acceptability for the biscuits formulated with a healthy purpose. For instance, a person that is very interested in consuming low-salt foods could have a high acceptability for low-salt biscuits; conversely a consumer that does not manifest interest in the salt content of food products could have a low acceptability for low-salt biscuits.

The objectives of this study were: (1) formulate biscuits with more than 40% fiber and 50% less added salt than the classic commercial biscuits; (2) conduct sensory descriptive analysis of the formulated biscuits to quantify the effects of the formulation changes; (3) measure expectation and sensory acceptability for the developed food products; and (4) investigate if sensory acceptability for biscuits with different contents of salt and fiber is related to the interest in consuming food products with less salt and/or more fiber content.

MATERIAL AND METHODS

Biscuit Formulations

Following a factorial design to analyze the effect of reducing salt content and increasing fiber content, four biscuit formulations were developed: conventional fiber/conventional salt; conventional fiber/reduced salt; increased fiber/conventional salt; and increased fiber/reduced salt. The formulation of the biscuits is shown in Table 1.

Biscuits prepared with wheat flour (100%) were named biscuits with conventional fiber while those elaborated with wheat flour (70%) and whole wheat flour (30%) was called biscuits with increased fiber.

TABLE 1.
FORMULATION OF BISCUITS IN PERCENT OF INGREDIENTS

Raw material	Conventional fiber/conventional salt	Conventional fiber/reduced salt	Increased fiber/conventional salt	Increased fiber/reduced salt
Wheat flour	61.5	61.1	43.1	43.3
Whole-wheat flour	–	–	18.5	18.54
Fresh yeast	3.1	3.05	3.1	3.1
NaCl	0.9	0.45	0.9	0.46
Sucrose	1.2	1.2	1.2	1.2
Water	27.7	28.7	27.7	27.8
Oil	5.6	5.5	5.5	5.6

TABLE 2.
BISCUITS COMPOSITION PER 100 g OF PRODUCT

Nutrients	Conventional fiber/conventional salt	Conventional fiber/reduced salt	Increased fiber/conventional salt	Increased fiber/reduced salt
Lipids (g)	9.7	9.7	9.8	9.8
Proteins (g)	8.6	8.6	9.0	9.0
Carbohydrates (g)	68.1	68.1	66.9	66.9
Dietary fiber (g)	2.4	2.4	3.7	3.7
Sodium (mg)	549.9	277.2	553.45	280.7

The average salt content of seven popular commercial cracker biscuits commercialized in Argentina, as stated on their labels, was 562 mg Na/100 g. Thus, biscuits with conventional salt were formulated to contain this average value of salt and those with reduced salt contained 50% less added salt than the biscuits with conventional salt.

Table 2 shows the nutritional information of macronutrients (carbohydrates, proteins and lipids) and sodium of all formulations. The biscuits with increased fiber had approximately 50% more fiber than the conventional ones, and the biscuits manufactured with reduced salt, had approximately 50% less salt than the conventional ones. This was one of the objectives of our study.

Typical recipes were consulted for preparation and cooking of the product (Tressler and Sultan 1975). Biscuits were manufactured in the kitchen of an institutional service with capacity to prepare the total number of samples required for the tests. For each formulation two batches were prepared to consider possible variations from batch to batch. Once made the biscuits were frozen at −18C until tested.

Biscuit compositions were obtained by mass balance of components. This would have been sufficient, but as a check on the validity of this mass balance, the increased fiber/reduced salt formulation was analyzed for humidity (AOAC 926.05 2000), ashes (AOAC 930.22 2000), fat (AOAC 935.38 2000), proteins (N × 5.71 AOAC 950.36 2000), carbohydrates (calculated by difference as $100 - [\%H + \%C + \%G + \%P + \%F]$), total dietary fiber (AOAC 985.29 2000) and sodium (previous treatment AOAC 968.08 2000 and later quantitative analysis by atomic absorption spectrometry). For this formulation, analytical values coincided with the mass balance, thus the mass balance was considered adequate for the other formulations.

Sensory Analysis

Trained Sensory Panel. A panel of eight assessors selected and trained for quantitative descriptive analysis (QDA) (Stone and Sidel 2004) following

the guidelines of the ISO 13299 (ISO 2003) was used. The laboratory where the tests were performed was accredited to perform sensory descriptive analysis under the ISO/IEC 17025 (ISO 2005).

Six training and consensus sessions were conducted. The task of the assessors was to determine the descriptors that would represent the sensory characteristics of the samples and their intensity on a scale ranging from 0 to 10. Table 3 shows the sensory descriptors with their definitions and references.

Assessors received samples monadically in random order. Samples were removed from the freezer an hour before testing. Room humidity was checked not to be higher than 50% to thus avoid moisture uptake during the evaluations (Nikolaidis and Labuza 1996). Water was used to cleanse the palate during testing. A 2-min interval was allowed between one sample and the next.

Assessment of aroma, taste and texture was conducted in a sensory laboratory, whereas appearance was assessed in a color cabin with D65 artificial daylight illumination. Each batch was evaluated by triplicate. Thus we had 4 formulations $\times$ 2 batches $\times$ 3 replicates = 24 evaluations. These 24 evaluations were randomized over assessors and served over four sessions, that is, six evaluations per session.

Consumer Panel (Acceptability and Sensory Expectation Tests). Two groups of 96 consumers each (Hough *et al.* 2006), teenagers and adults, participated in the study.

Teenagers constitute a group of interest to researchers who work on nutritional education for the acquisition of appropriate eating behaviors and for developing actions to prevent chronic noncommunicable diseases and promote health. Therefore it is necessary to know their opinion on the development of healthy products. Teenagers were 13–14 years old, approximately half were girls and half were boys, recruited from two high schools from the city of Nueve de Julio, Buenos Aires, Argentina. Nueve de Julio is a town 260 km to the west of Buenos Aires with 40,000 inhabitants. The ethnic origin and the eating habits are similar to those observed in larger cities such as Buenos Aires. We assumed that teenagers from Nueve de Julio would have similar preferences regarding this type of biscuits as teenagers from most other cities in Argentina.

Adults were recruited among people who worked at food service locations in Greater Buenos Aires which concentrates a third of the Argentine population. Their median age was 35 years and there were 75% men and 25% women (in Argentina more men than women work in these locations). These workers' opinions were considered important because they participate in the preparation and distribution of food and they provide nutritional information of meals. They all consumed cracker type biscuits regularly. Assessments were conducted at the food service location to which each participant belonged.

TABLE 3.
SENSORY DESCRIPTORS WITH THEIR DEFINITIONS AND REFERENCES

Descriptor	Definition	Reference	Consensus value of reference on 0–10 scale
Color intensity	Average intensity of color taking into account its hills and valleys.	Biscuit with conventional fiber/conventional salt	7
Uniformity of toasted color	Uniformity of toasted color on the whole surface of the biscuit	Biscuit with conventional fiber/conventional salt	7
Height/thickness	Height/thickness of the cookie when looked at horizontally	Biscuit with conventional fiber/conventional salt	7
Presence of bran	Amount of bran (dark particles) present in the upper surface of the biscuit	Biscuit with conventional fiber/conventional salt	0
Internal airiness	Amount of bubbles and voids present in the inner mass of a broken biscuit	Biscuit with conventional fiber/ conventional salt	6
Fried aroma and flavor	Intensity of aroma and flavor of fried sunflower oil	Bread cubes fried in sunflower oil that had been heated to 185 ± 5C for 2.5 h. Served at room temperature	7
		Biscuit with conventional fiber/ conventional salt	4.5
Baked/ toasted aroma and flavor	Aroma and flavor associated to bakery products	Pastry (2 parts of flour + 1 part of water) made into cookies (3 × 3 × 0.3 cm) and baked at 200C-10 min	5
		Biscuit with conventional fiber/conventional salt	3
Salty	Characteristic taste of NaCl	0.25% (w/v) NaCl solution	4
		Biscuit with conventional fiber/conventional salt	3
Bran taste	Taste of wheat bran	Wheat bran	10
		Biscuit with conventional fiber/conventional salt	0
Residual taste	Total intensity of taste that persists in the mouth after you swallow the sample	Biscuit with conventional fiber/conventional salt	4.5
Manual hardness	Force required to break the sample when it is cut with the hands	Fitz Roy (Firmat, Santa Fé) toast	1.5
		Biscuit with conventional fiber/conventional salt	5
Oral crispy texture	Energy with which the biscuit makes crack-crunch-bang during the first two or three bites	Fitz Roy (Firmat, Santa Fe) gluten toast	7
		Biscuit with conventional fiber/conventional salt	5

Tests included three stages:

(1) Blind acceptability – consumers tested the samples for acceptability of appearance, consistency, taste and overall acceptance. Samples were served monadically in a balanced order of presentation. For each attribute they used a 10-point scale (1 = dislike extremely and 10 = like extremely), writing down their score as a number (Curia et al. 2001).
(2) Label expectation – participants received a closed package of biscuits. The attributes assessed were the same as those measured in the first test but this time participants had to measure how much they thought they would like the biscuit according to label information (type of biscuit and ingredients). The consumers did not see or taste the sample at this stage.
(3) Acceptability with label. Participants received a labeled package with biscuits. The same attributes as mentioned above were assessed, but now consumers had the biscuits together with their labels.

At the end of the test a questionnaire was conducted with the following questions measured on 1–9 scales:

(1) Consumption of salt and fiber estimated by each consumer (little to a lot).
(2) Interest in consuming bread, buiscuits and flour with fiber; and interest in reducing consumption of high-salt foods (no interest to very interested).

As the same 96 teenagers and 96 workers participated in the three stages, an interval of 7 days was allowed between stages to minimize assessors remembering previous scores for acceptability. Other authors have used similar intervals (Levis and Chambers IV 1996; Sosa and Hough 2006).

Statistical Analysis

Tests with Trained Assessors. The trained sensory assessor's performance was monitored using general Procrustes analysis and by analyzing assessor × sample interactions for each descriptor. The discriminative power of each individual assessor was assessed using an analysis of variance (ANOVA).

After monitoring, ANOVA was applied to the obtained data considering salt content, fiber content and batch as fixed effects and assessor as a random effect. A value of 5% was considered significant for the comparison of averages. Fisher's least significant difference (LSD) method was used for significant differences.

Acceptability and Sensory Expectation Tests. ANOVA was performed on acceptability scores with salt content, fiber content, stage and age group as

fixed effects, and consumer as a random effect nested within age group. Averages were compared using Fisher's LSD method. A value of 5% was considered significant for the comparison of averages.

It was also of interest to correlate the overall acceptance of consumers for the different biscuits with the following explanatory variables:

(1) int_salt: interest in reducing consumption of high-salt foods (1/10 scale);
(2) int_fiber: interest in consuming bread, biscuits and flours with fiber (1/10 scale);
(3) cons_salt: amount of salt that is considered to be incorporated to food (scale: 1 = little and 9 = a lot);
(4) cons_fiber: amount of fiber that is considered to be incorporated to food (scale: 1 = little and 9 = a lot);
(7) salt: level of salt in the formulation of biscuits (conventional and reduced).;
(8) fiber: level of fiber in the formulation of biscuits (conventional and increased);
(9) age: age of consumer (teenagers and workers);
(10) stage: measurement stage (blind acceptability, label expectation and acceptability with label);

The last four variables are categorical variables and can be introduced in a multiple regression by the use of "dummy" variables as shown by Draper and Smith (1981).

Thus, the model was as follows:

$$\begin{aligned} \textit{Overall acceptance} = a + b(\text{int\_salt}) + c(\text{int\_fiber}) + d(\text{cons\_salt}) \\ + e(\text{cons\_fiber}) + f(\text{salt}) + g(\text{fiber}) + h(\text{age}) + i(\text{stage}) \end{aligned} \quad (1)$$

In this equation some variables will be important in explaining overall acceptance and others will not. To determine which variables significantly explained overall acceptance "stepwise regression analysis" was conducted. Procedures from Genstat 9th edition (VSN International Ltd., Hempstead, UK) were applied for all the analyses

RESULTS AND DISCUSSION

Sensory Descriptive Analysis

Performance tests showed that all assessors performed satisfactorily. No significant differences were found between batches of the same formulations,

TABLE 4.
QUANTITATIVE DESCRIPTIVE ANALYSIS. AVERAGE VALUES FOR THE DIFFERENT DESCRIPTORS IN RELATION TO THE MAIN EFFECTS SALT AND FIBER. RATING SCALE FROM 1 TO 10 POINTS

Descriptor	Salt		Fiber	
	Conventional	Reduced	Conventional	Increased
Appearance				
Color intensity	5.9†	5.9	6.5	5.3*
Toasted color uniformity	6.3	6.7*	6.6	6.4
Height/thickness	5.8	5.8	5.8	5.9
Bran presence	3.2	3.2	0.0	6.3*
Internal aerated	4.9	5.1	5.0	5.0
Manual texture				
Hardness	4.9	4.4*	4.9	4.4*
Aroma				
Frying oil	3.8	3.9	4.2	3.5*
Baked/toasted dough	3.2	2.7*	2.8	3.0
Taste				
Salty	2.1	1.3*	1.9	1.5*
Frying oil	3.6	3.3	3.7	3.2*
Baked/toasted dough	3.4	3.4	3.2	3.6*
Bran	1.6	1.9*	0.1	3.4*
Residual	3.9	3.8	4.1	3.5*
Mouth texture				
Crispy	3.9	4.1	4.0	4.0

* Indicates significant differences between main effect levels ($P < 0.05$).
† These are main effect averages, thus this value is for conventional salt content averaged over both conventional and increased fiber content.

thus mean values over batches are reported. Table 4 shows average values of the QDA for the different descriptors in relation to the main effects of the factorial design: salt and fiber. Overall, the magnitude of differences between design effects was small, even for the difference in salty taste between biscuits with conventional sodium and biscuits with a 50% decrease in salt content. The exception, as expected, was descriptors associated to bran.

For salty taste the salt × fiber interaction was significant at 9% that indicated a tendency. The difference in the salty taste of fiber-increased biscuits ($1.8 - 1.2 = 0.6$) was smaller than those with conventional fiber ($2.4 - 1.4 = 1.0$). The simpler the food item (containing few ingredients) – for example, mashed potatoes – the greater the perceived saltiness. So, in our study, the increase in fiber content of the biscuits would positively accompany the decrease in salt content. Adams *et al.* (1995) found in their work that the

TABLE 5.
CONSUMER TESTS. OVERALL ACCEPTANCE AVERAGES FOR THE SALT CONTENT X STAGE INTERACTION. RATING SCALE FROM 1 TO 10 POINTS

Stages	Biscuits conventional salt	Biscuits reduced salt
Blind acceptability	7.9	7.8
Label expectation	7.7	7.1*
Acceptability with label	7.6	7.4*

* Indicates significant differences (least significant difference for = 0.18, $P < 0.05$).

perception of the salty taste at the same concentration of sodium differs with the type of food used as vehicle.

Consumer Tests

For overall acceptance, significant differences were found for the main effects of evaluation stage, salt content and fiber content, although the magnitude of the differences were small. Differences were not significant between teenagers and adults. Following are the averages for each significant effect:

(1) stage: 7.8 for blind acceptability, 7.4 for label expectation and 7.5 for acceptability with label;
(2) salt content: 7.5 for reduced salt and 7.7 for conventional salt;
(3) fiber content: 7.6 for conventional fiber and 7.5 for increased fiber.

No differences were observed among the age groups. Scores for appearance, consistency and taste were similar to those for overall acceptance. It is interesting to note that for taste acceptability, average differences between conventional salt and reduced salt were low although there was a 50% reduction in the amount of added salt.

Significant differences were observed for the following interactions for overall acceptance, though they were low in magnitude.

Salt Content × Stage (Table 5). In the blind condition test, samples with conventional salt and those with reduced salt had similar averages: 7.9 and 7.8 respectively. In the descriptive test, sensory differences between samples with conventional salt and those with reduced salt were low in magnitude (see Table 4) and it is thus reasonable that blind acceptability was similar. Adams *et al.* (1995) suggested that added salt can be reduced to a third or more in some food products without considerably altering consumer acceptability. In the label only stage, the effect of information played an important role because participants thought they would like low-salt biscuits less than conventional

TABLE 6.
CONSUMER TESTS. OVERALL ACCEPTANCE AVERAGES FOR THE STAGE X SALT CONTENT X FIBER CONTENT. RATING SCALE FROM 1 TO 10 POINTS

Stages	Conventional fiber/conventional salt	Conventional fiber/reduced salt	Increased fiber/conventional salt	Increased fiber/reduced salt
Blind acceptability	8.0†	8.0	7.8	7.6
Label expectation	7.7	7.1	7.6	7.2
Acceptability with label	7.7	7.4	7.5	7.5

† Least significant difference to compare means = 0.26, $P < 0.05$.

ones. These results agree with the study by Levis and Chambers IV (1996) who concluded that when participants read the concept "low sodium content" they assigned middle rank scores. Conversely, when participants read "no salt added" they assigned low rank scores. In the acceptability with label test, scores of reduced salt biscuits were not as low as consumers expected (label expectation), nor were they as high as in the blind condition test.

Stage × Salt Content × Fiber Content. This interaction represents the four factorial design formulations at each evaluation stage (Table 6). Consumers assigned the lowest scores in the label expectation test especially in the reduced salt formulations. The effect on acceptability of reducing the salt content of biscuits with conventional fiber is similar in relation to the reduction of salt content in biscuits with high fiber. There was a tendency for the trained panel to find that differences in salty taste were higher for the biscuits with conventional fiber, but consumers did not detect the difference or didn't find it relevant. For these interactions appearance, consistency and taste followed a similar pattern as to overall acceptance.

Relationship between Consumer Interest in Healthy Food and Their Acceptability for the Biscuits

The result of the stepwise multiple regression indicated that the variables that were important in explaining overall acceptance were: interest in reducing consumption of high salt food products (int_salt); interest in consuming bakery products, biscuits and flour with high fiber (int_fiber); salt level in the biscuit formulations (salt); and measurement stage (stage). The resulting equation was

$$\begin{aligned} \textit{Overall acceptance} = {} & 6.52 + 0.041(\text{int\_salt}) + 0.147(\text{int\_fiber}) \\ & - 0.273(\text{salt}) - 0.438(\text{label expectation stage}) \\ & - 0.308(\text{acceptability with label stage}) \end{aligned} \quad (2)$$

(1) int_salt: numerical from 1 to 10;
(2) int_fiber: numerical from 1 to 10;
(3) salt: 0 for conventional, 1 for low;
(4) label expectation stage: 0 for blind acceptability, 0 for acceptability with label, 1 for label expectation;
(5) acceptability with label stage: 0 for blind acceptability, 0 for label expectation, 1 for acceptability with label stage.

This equation can be used to predict overall acceptance for different situations. For example: the overall acceptance for a reduced salt biscuit presented with its label for a consumer who scores a 6 for interest in reducing high-salt foods, and a 9 in consuming high-fiber bakery products will be:

$$\begin{aligned} \textit{Overall acceptance} &= 6.52 + 0.041(6) + 0.147(9) - 0.273(1) - 0.438(0) \\ &\quad - 0.308(1) = 7.51 \end{aligned} \tag{3}$$

Statistical software allows obtaining predicted values of overall acceptance for different values of the explicative variables and the standard deviations of the prediction. Some examples are shown in Table 7. The overall acceptance is more sensitive to changes in int_fiber than to changes in int_salt. Also, standard deviations are relatively small, indicating relatively good prediction by the equation.

TABLE 7.
PREDICTED VALUES OF OVERALL ACCEPTANCE ACCORDING TO EXPLICATIVE VARIABLES

Stage	int_salt†	int_fiber‡	Salt§	Prediction
Blind acceptability	3	9	Reduced	7.7
	3	9	Conventional	8.0
	9	3	Reduced	7.0
	9	3	Conventional	7.3
Label expectation	3	9	Reduced	7.3
	3	9	Conventional	7.5
	9	3	Reduced	6.6
	9	3	Conventional	6.9
Acceptability with label	3	9	Reduced	7.4
	3	9	Conventional	7.7
	9	3	Reduced	6.7
	9	3	Conventional	7.0

Average standard deviation: 0.105 (minimum 0.099–maximum 0.110).
† Interest in reducing consumption of high salt food products.
‡ Interest in consuming bakery products, biscuits and flour with high fiber.
§ Salt level in the biscuit.

CONCLUSIONS

The sensory profile of the four formulations was similar except for bran presence and taste. Reduction of 50% in added salt produced a low magnitude variation in salty taste.

The differences in acceptability among formulations found in the present work were of low magnitude. The highest scores were for blind acceptability. Conversely, in the label expectation stage, averages decreased for biscuits with labeled "low in salt content." In the acceptability with label stage, scores increased again. It was interesting to find that these products with low salt content had high acceptability among teenagers who were used to consuming products high in salt content.

Results from this study showed that it would be important among health professionals to identify the barriers that hinder acceptability of low-salt food products and modify the negative expectations before conducting a nutritional intervention. Also, we propose the articulation of the necessary strategies with the food industry to market biscuits with less added NaCl and more fiber for the population in general; and the use of these healthier biscuits by institutional food services

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