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Proposal of a Fuzzy Model for Sensory Analysis of Cheeses

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Abstract

The consumer's preference for handcrafted raw milk cheeses has steadily grown because of its intensity and flavor variation compared to industrial cheese. “Minas frescal” cheese is one of the most popular cheeses in Brazil, its production has a high yield, besides simple and fast manufacturing. This work aimed to elaborate and perform physical-chemical and sensorial analyzes through the Fuzzy logic of homemade and industrialized fresh cheeses. The cheese samples were composed of homemade white cheese, homemade cheese of beet and industrial cheese and were submitted to tasters of the city of Petrópolis. This model has shown to be consistent and aims to improve cheese manufacturing processes capable of allowing greater consumer acceptability.

Keywords: Fuzzy; Cheese; Sensorial analysis.

1. Introduction

The history of cheese dates back to ancient times, although many experts consider the Middle Ages to be the starting point of their manufacture. There are reports of consumption of solidified milk dating to 7,000 years BC and archaeological findings that reveal the existence of cheeses made from cow's milk and goat's milk 6,000 years BC [2]. Cheese is a dairy concentrate made up of proteins, lipids, carbohydrates, minerals, calcium, phosphorus and vitamins, including A and B. It is one of the most nutritious foods known. A cheese with 48% fat contains about 23-25% protein which means that in terms of protein value, 210 g of this product is equivalent to 300 g of meat.

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The minerals participate in the process of milk coagulation, influencing the texture of the cheese. The residual liquid, whose fat content varies with the type of cheese, is called lactose; much of it is eliminated during the manufacturing process and used as raw material in the production of yoghurts, ricotta and other products [1]. Cheesemaking involves some general procedures and others that are specific to each type. Milk used in the production of fresh cheese must be pasteurized. For those that go through a maturation period before being consumed, the milk may or may not be used raw, depending on the type of cheese [2]. Sensory analysis is an interdisciplinary science in which evaluators are invited, using the complex interaction of sense organs (sight, taste, touch, and hearing) to measure sensory characteristics and acceptability of food products and many other materials [4]. The Fuzzy methodology allows to work the ambiguity of the sensorial analysis. This opens the perspective of alternative quantitative structure, which vague assertions may have relevant values in the interval between zero and 1 [3].

Sensory methods are based on responses to stimuli, which produce sensations whose dimensions are: intensity, extension, duration, quality, and pleasure or displeasure. While stimuli can be measured by physical and chemical methods, sensations are measured by psychological processes. Sensory analysis has been applied in the development and improvement of products, quality control and process development. Sensory methods can be classified into analytical and consumer acceptance [4].

In the manufacture of the handcrafted cheeses the prevention and correction of the defects are more difficult when compared to the industrial cheeses. This is because, in handcrafted cheeses, the main raw material, that is, milk, can not be standardized as it is in industry [5]. The milk does not present constant physical-chemical pattern and can vary still more with the different seasons of the year. It is up to the artisan or cheesemaker responsible for the production to adapt the manufacturing technique to the different types of milk received during the year and to the temperatures and environmental conditions of the manufacturing and maturation to obtain cheeses in perfect condition.

In the light of the above, this work was conducted with the objective of evaluating the physicochemical properties and acceptance of homemade white cheese, homemade beet cheese and industrial cheese.

2. Methods

Collective Nutrition, by its very characteristic, leads to accidental samples, resulting from spontaneous demand. A true consumer-oriented test requires selecting a team representative of the population chosen as the object of the survey. For the sensorial analysis, coded samples were used as follows: 131 (homemade beet cheeses); 226 (homemade white cheeses); 351 (industrial cheeses).

The acceptance test consists of a set of scientifically recognized methodological procedures designed to measure the acceptability index of the food. Fuzzy logic allows computing with words, converting stimuli into responses or measures into control actions. The test had the taster indicated how much he liked or disliked each sample in a globalized way and in relation to specific attributes, among them: texture, color, aroma and flavor. For each attribute, triangular fuzzy numbers $\tilde{a}_x$, defined by $\tilde{a}_x = \{a_1; a_2; a_3\}$ as shown in the figure below.

Figure 1: Triangular Fuzzy Numbers, $\tilde{a}_x$

For the value of x equal to x the degree of pertinence varies according to the line of the triangle in which the value belongs. Therefore, to determine the degree of pertinence for any value of x, we use:

$$\mu_x(\tilde{a}) = \begin{cases} 0 & , \tilde{a} < \tilde{a}_1 \quad \text{“low”} \\ (\tilde{a} - \tilde{a}_1) / (\tilde{a}_2 - \tilde{a}_1) & , \tilde{a}_1 < \tilde{a} < \tilde{a}_2 \quad \text{“acceptable”} \\ 1 & , \tilde{a} > \tilde{a}_2 \quad \text{“recommended”} \end{cases}$$

Figure 2: Membership function, μ_x

Let f (x) be a set of fuzzy sets, where x is a set denoted by, so the set will be the set of ordered pairs: variable, continuous or discrete, of the universe under study. The function μ_x (ã) is the degree of pertinence of ã in Ã, reading μ_x: Ã → Ω is a function of Ã to the space Ω , called pertinence space, when in the interval [0,1]. Also, μ_{S1} (ã) | x □□ {ã $_{ANALYTICAL}$} and μ_{S2} (ã) | x □□ {ã $_{ACCEPTABLE}$}. In this way, the triangular fuzzy numbers for sensory analysis for acceptability ($\tilde{a}_{S1}$) were being, $\tilde{a}_i$ (0,1, 0,9, 0.1) for "liked very much", $\tilde{a}_j$ (0.2, 0.6, 0.2) to "liked" and $\tilde{a}_l$ to it (0.2, 0.2, 0.2) to "disliked much".

The cheese samples were analyzed following the analytical standards of the Adolfo Lutz Institute (1985). Carbohydrate determinations were determined by the Fehling's method. Total lipids, by extraction of the lipid residue from the dry matter, through the Soxhlet apparatus, using hexane as solvent. The moisture content of the “Minas Frescal” cheeses was determined by the greenhouse method at 105 ° C. Acidity, through method by means of pH determination, titration through Dornic grade. Finally, the peroxidase test was carried out to evaluate if the pasteurisation process was efficient. Thus, the triangular fuzzy numbers for sensory analysis for physicochemical results ($\tilde{a}_{S2}$) were found to be $\tilde{a}_t$ "satisfactory," (0,1, 0.9, 0.1), $\tilde{a}_r$ to "suitable" and $\tilde{a}_u$ (0.2, 0.2, 0.2) to "unsatisfactory".

The sensorial analyzes were carried out at the Arthur Sá Earp Neto Faculty (FASE), located in Petrópolis/RJ. The choice of location was due to the fact that it was easier for the tasters to approach. Also, tests were carried out with 100 testers, among them students and staff of the Institution (FASE), of both sexes, who were not previously trained for the analysis.

3. Results

The experimental design was completely randomized, with 3 replicates for all analyzes. All data are presented according to their mean. The data collected were statistically evaluated by analysis of variance, ANOVA and tabulated in Microsoft EXCEL 2010 software version 14.0. The procedure for acceptability of the product in hedonic tests in the sensory analysis, starting from the same hypotheses of LINZOLITTI and his colleagues [3], *ie*:

- ***Hypothesis 1*** - Fuzzy logic can be applied for decision-making on the acceptability of a product subjected to hedonistic tests in sensory analysis;

- ***Hypothesis 2*** - Compositions "consumer characteristic" and "sensations proved by the product", composed by intervening factors are the necessary entities to the convergence to the decision making;

- ***Hypothesis 3*** - There is a hierarchy of infra-composition components; and

- ***Hypothesis 4*** - The level of evaluative acuity of the composition "characteristic of the consumer" in the acceptability of the product is differentiated by the attribute gender and age.

The results allowed to evaluate the functions of pertinence for the intervening factors, with their respective normalizations. The "consumer characteristics" and "hedonistic sensations about the product" compositions, the first one composed by the sex and age intervening factors and the second by the intervening factors level of consumer satisfaction, characteristic and frequency of use of the product, were the necessary entities to decision-making (Table 1 and 2). The construction of the rules for the model was done in 3 steps through the extraction of fuzzy rules from support vector machines (FREx_SVM). In this way, 125 rules were formulated for the model [7].

Table 1: Bromatological analyzes of samples of “Minas frescal” cheese produced in the state of Rio de Janeiro from August to December 2015, according to Adolf Lutz Institute [15].

Bromatological Analyzes	Beet Cheese House made (handcrafted)	White cheese House made (handcrafted)	Industrial cheese
Moisture	“satisfactory ” (0.1,0.8,0.1)	“suitable” (0.2,0,7,0.2)	“suitable” (0.2,0.5,0.2)
Lipids	*	*	*
Carbohydrates	**	**	**
pH	“unsatisfactory” (0.1,0.2,0.1)	“suitable” (0.2,0.4,0.2)	“unsatisfactory” (0.1,0.3,0.1)
Peroxidase	Negative	Negative	Negative
Funccion, μ_{S1}**(ã)**	“low”	“reasonable”	“low”

* The literature does not inform the recommended result. ** None of the three samples analyzed showed the presence of reducing sugar, and no turning occurred in any of the triplicates.

Table 2: Results of Acceptability of "Minas frescal" cheese samples, according to the Ministry of Agriculture standards [16].

Bromatological Analyzes	Beet Cheese House made (handcrafted)	White cheese House made (handcrafted)	Industrial cheese
Collor	"liked" (0.2,0.6,0.2)	"much liked" (0.1,0.8,0.1)	"much liked" (0.1,0.9,0.1)
Aroma	"liked" (0.2,0.7,0.2)	"liked" (0.2,0.7,0.2)	"much liked" (0.1,0.8,0.1)
Flavor	"liked" (0.2,0.5,0.2)	"liked" (0.2,0.7,0.2)	"much liked" (0.1,0.8,0.1)
Texture	"liked" (0.2,0.5,0.2)	"much liked" (0.1,0.8,0.1)	"much liked" (0.1,0.9,0.1)
Global Assessment	"liked" (0.2,0.5,0.2)	"much liked" (0.1,0.8,0.1)	"much liked" (0.1,0.9,0.1)
Funccion, μ_{S2}**(ã)**	"reasonable"	"recommended"	"recommended"

4. Discussion

The specialist evaluates the alternatives according to a personal sensory scale. The main advantage of the systematic fuzzy is that the evaluator is not forced to a rigid formulation, being able to express its satisfaction with the product colloquially, escaping from the usual rules of the sensorial analysis [7]. In the data presented in Table 1, it is observed that the humidity of the 3 analyzed samples of fresh "Minas fescal" cheese, 2 samples presented "satisfactory" values, having high humidity according to the current legislation for humidity of RDC nº 274, of October 15 of 2002 [14]. In relation to industrial cheese, it had a medium moisture content, since the legislation has a "suitable" value for moisture. According to Silva and his colleagues (2003) the "Minas frescal" cheese is a product with "adequate" moisture content, allowing the development of microorganisms. As for the presence of microorganism, a specific test was used as an indication of the possible presence of pathogen, capable of detecting health risks to consumers [8]. In the result of the determination of carbohydrate by the Fehling method, the samples, following the method recommended by Adolf Lutz (1985), did not have the color change, for both blue and red brick, justifying that they had insignificant amounts of reducing sugar or even there was no reducing sugar in them. It was observed that of the 3 analyzed samples, all obtained negative reactions. Peroxidase is an enzyme present in milk, which is destroyed when heated above 75 ° C for more than 20 seconds (temperature and time limits for pasteurizing milk). The development of a salmon color indicates peroxidase positive, however the 3 samples remained unchanged in staining. This result corroborates with a study by Franco and his colleagues (2011), since the two whole milk samples did not show orange coloration, indicating that the peroxidase were denatured, similar to the homemade cheeses where whole milk was used in their manufacture. Absence of peroxidase in pasteurized milks may be associated with milk over coating to mask poor microbiological quality of the raw material. However, it may also be due to failures during milk processing and the time / temperature of pasteurization determined in Brazilian legislation [12]. Table 2 shows the mean values of the scores assigned by the testers in the Acceptability Test. Homemade and industrial white cheeses were well accepted in all the analyzed attributes, registering "satisfactory" values, which correspond, in the hedonic scale, in "moderately liked" to "liked very much". According to Dutcosky (2013) above 70% the product is well accepted in the market. Finally, for the conditions presented by the model, a result for the F (Fisher) Test of 3.02 was reached, which indicates the consistency of the model.

5. Conclusion and Recommendation

Initially, according to the titration through Dornic grade, the values obtained were below 10%. Basically, pasteurized milk, to be considered suitable for consumption and of good quality, must present "satisfactory" acidity sensorial characteristics (BRASIL, 2002). According to Silva and his colleagues (2009) of the 348 analyzed samples, 26 (7.5%) presented with Dornic acidity outside the standards required by the legislation. These results indicate that there was probably no immediate refrigeration immediately after pasteurization, or because of poor hygiene during production. This confirms the values below the legislation, since the homemade cheeses did not undergo pasteurization. According to [10]; the high acidity in milk may result from the acidification of lactose, caused by the multiplication of deteriorating and / or pathogenic microorganisms. The cheeses type “Minas frescal", presented distant levels of those reported in the literature in relation to moisture, lipids and acidity. These microbiological data demonstrate the need for greater control during cheese processing, mainly because this product is predominantly handcrafted. Thus, in order to contribute to the improvement of the quality of the product in question, it is fundamental to invest in the sanitary education of the producers and in the dissemination of processing techniques based on Good Manufacturing Practices, with the concern of controlling the production, which may enhance its insertion in the consumer market. In general, white homemade and industrial cheeses evaluated in this work obtained good marks in all the sensorial characteristics studied, what constitutes a good acceptance, besides presenting the interest in the purchase.

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