Acceptance of microfiltered milk by consumers aged from 7 to 70 years

Aceitação de leite microfiltrado por consumidores com idade entre 7 e 70 anos

RIALA6/1493

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Recebido: 25.10.2011 – Aceito para publicação: 25.08.2012

ABSTRACT
Microfiltration of milk reduces its microbial load providing a longer shelf life and preserving its nutritional and sensory characteristics. The present study compared the effect of the microfiltration treatment and of the milk pasteurization regarding the sensory acceptability by consumers aged from 7 to 70 years using a 7-point hedonic scale. The obtained results were evaluated by variance analysis and Duncan's test. Microbiological, acidity, instrumental color and heat treatment extent analyses were also performed. Microfiltered milk showed a higher microbial counting reduction and lower acidity**;** and lesser change in color coordinates was found when compared to pasteurized milk**,** indicating the lack of reactions caused by heating. In the sensory acceptability, two groups were formed ($p > 0.05$) for microfiltered milk, being a group consisted of children, adolescents and elderly, who rated the highest sensory scores**,** and the second one formed by adults. Comparing the two kinds of milk, pasteurized and microfiltered samples, no difference in the acceptation was found only in the group constituted by children**.** These findings highlight ~~s~~ the importance in assessing the sensory quality of milk**,** seeing that the sensory perception is linked with the consumer purchase choice.
Keywords. shelf life, age groups, microfiltration, pasteurization.

RESUMO
A microfiltração do leite reduz a carga microbiana e proporciona maior vida útil e preservação de suas características nutricionais e sensoriais. O presente estudo comparou o efeito dos tratamentos de microfiltração e de pasteurização de leite quanto à aceitabilidade sensorial pelos consumidores com idade entre 7 e 70 anos, utilizando-se a escala hedônica de 7 pontos. Os resultados foram avaliados pela análise de variância e teste de Duncan. Análises microbiológicas, acidez, cor instrumental e extensão do tratamento térmico também foram realizadas. O leite microfiltrado apresentou maior redução na contagem microbiana, menor acidez e também menor mudança nas coordenadas de cor em comparação ao leite pasteurizado, indicando-se a ausência de reações causadas pelo calor. Na aceitabilidade sensorial, verificou-se a formação de dois grupos diferentes ($p > 0,05$) em relação ao leite microfiltrado: um grupo constituído pelas crianças, adolescentes e idosos, os quais apresentaram maiores escores sensoriais, e outro formado pelos adultos. Na comparação dos dois tipos de leite, somente o grupo constituído pelas crianças não demonstrou diferença entre o leite pasteurizado e o leite microfiltrado quanto à aceitação. Esses dados ressaltam a importância do estudo da qualidade sensorial do leite, porque a percepção sensorial está associada à escolha de compra pelo consumidor.
Palavras-chave. vida de prateleira, faixa etária, microfiltração, pasteurização.

INTRODUCTION

Milk is a biological fluid rich in proteins, fat and minerals making it a high nutritional food source and also a substrate for microbial growth[1]. Therefore, milk for human consumption requires proper treatment for microbial reduction to prevent public health problems. Heat treatment has been used for milk preservation since the beginning of industrialization of this beverage[2]. However, there is a slight loss of nutritional value as a result of this treatment due to protein denaturation and destruction of other sensitive components, such as vitamins and minerals[3]. According to Gandy et al.[4], drastic heat treatments also cause the loss of sensory quality of milk with the development of tastes, such as a cooked and oxidized flavor, and odors, such as a cooked smell.

The processing of liquid milk by the dairy industry has evolved to apply more drastic heat treatments, such as ultra pasteurization and sterilization, with the objective of extending milk shelf life making it more competitive on the market[2,5]. In recent years, however, the road to competitiveness is no longer the same because consumers have demanded healthier and more natural foods[6].

Microfiltration technology arose in response to industry needs to adapt to the demands of modern consumers and to survive on the market because the microfiltration process allows to obtain milk with a low microbial load, which preserves its natural constituents, thus, offering a product with an extended shelf life and preserved sensory and nutritional characteristics[7].

On the other hand, many consumers are resistant to new technologies due to traditional eating habits and lack of knowledge regarding the unconventional conservation methods, which can cause difficulties for the use of microfiltration in the non-thermal treatment of milk[8]. Moreover, according to Chapman and Boor[2], children and adults behave differently in relation to food making it important to evaluate the sensory acceptability of consumers from different age groups.

In this context, the objective of the present study was to evaluate the effect of thermal (pasteurization) and non-thermal (microfiltration) treatment on drinking milk by considering the physicochemical and microbiological quality of the milk and the influence of the treatments on sensory acceptance of the milk by consumers of different ages.

MATERIAL AND METHODS

Samples

The experiment was conducted in a microfiltration pilot scale plant (Tetra Pak Filtration Systems, France) that contained a Sterilox ceramic membrane system with a pore size of 0.8 µm, surface area of 0.24 m^2, flow of 120 L.h^{-1} liters per hour and a concentration factor of 20:1. Raw milk was skimmed at 30 °C (0.4 ± 0.1% fat; w/w) and heated to 50 °C before being subjected to the microfiltration process as recommended by Carvalho and Maubois[7]. The permeate from the microfiltration process (microfiltered milk) was supplemented with cream previously treated at 80 °C for 15 min[9] and then homogenized. Milk with the standardized fat content of 3.1 ± 0.1% (w/w) was immediately stored and cooled to a temperature of 4 ± 1 °C. Figure 1 shows a flowchart of standardized microfiltered milk production.

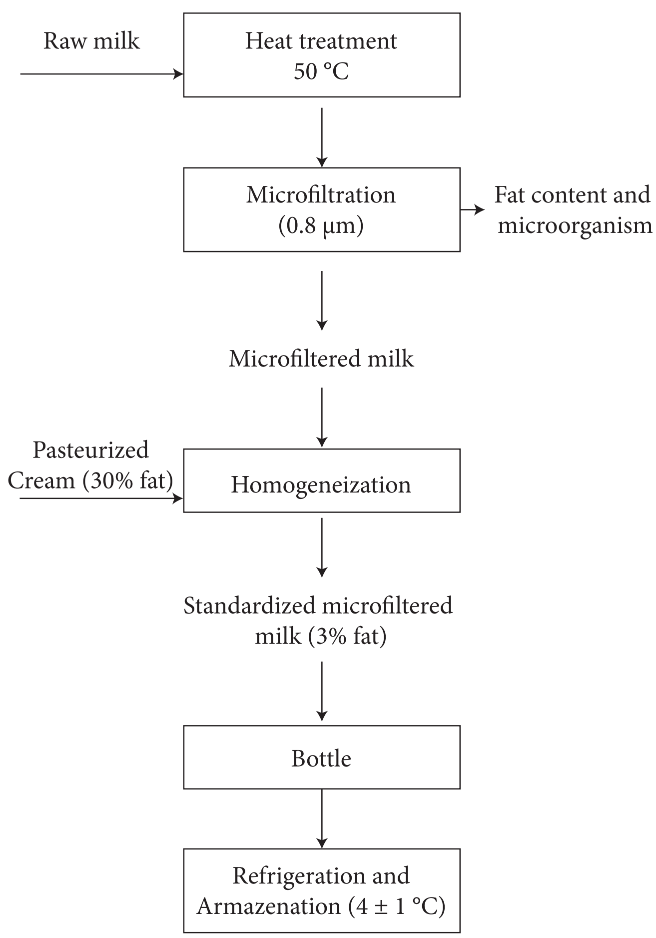

Figure 1. Flow diagram of the acquisition of standardized microfiltered milk

At the same time, a batch of standard milk with 3.0 ± 0.2% (w/w) fat was pasteurized at 72 °C for 15 s in a plate heat exchanger (BrasHolanda, Pinhais, Brazil) at the Dairy School of the Department of Food Technology at Federal University of Viçosa in Brazil.

Microbiological evaluations

Milk samples were collected at the end of the microfiltration process in previously sterilized 200-mL bottles, and the samples were immediately analyzed. The same conditions were applied to the pasteurized milk, pasteurized cream and raw milk samples. Samples were analyzed by enumerated counts of mesophilic aerobes, total coliforms and thermotolerant coliforms using Petrifilm according to methodology recommended by the American Public Health Association[10]. All analyses were performed in duplicate.

Enzyme indicators of thermal treatment

The extent of heat treatment in milk was evaluated by considering the enzyme activity of phosphatase and peroxidase. The detection of peroxidase was performed using an alcoholic solution of guaiacol and alkaline phosphatase using a kit from Labtest Diagnostica (SA) according to the Official Physical-Chemical Analytical Methods for Control of Milk and Dairy Products[11].

Acidity analysis

The determination of acidity of microfiltered and pasteurised milk (expressed as g lactic acid/100 g of milk) was performed according to the AOAC[12] and the Official Physical-Chemical Analytical Methods for Control of Milk and Dairy Products[11].

Analysis of color

Color parameters were determined using the Konica Minolta Color Reader CR-10, which performed measurements in an 8-mm reading area. The equipment possessed the following specifications: illuminant CIE D65 (natural daylight) placed at an angle of 8° and CIE 10° standard observer. The Commission Internationale de l'Eclairage (CIELAB) system was used with the following parameters: L* (luminosity; black = 0 to white = 100), a* (-a represents green, -60; and +a represents red, +60) and b* (-b represents blue, -60; and +b represents yellow, +60). Readings were performed in triplicate.

Sensory evaluation

Consumers

The group of consumers that participated in sensory tests consisted of volunteers of different ages, which was divided into the following four subgroups with 100 consumers per group: children (group 1); adolescents (group 2); adults (group 3); and the elderly (group 4).

To obtain a more detailed profile of the consumers under study, a questionnaire was proposed to volunteers providing information on their educational level (schooling), family income, frequency of milk consumption, forms of milk consumption, knowledge on the concept of "milk microfiltration" and nutritional importance of milk. The data used from the groups represented by children and the elderly (group 1 and 4, respectively) only encompassed their education level and whether they liked milk.

Data collected via the questionnaire was used to establish a profile of consumers participating in the sensory test using descriptive statistical analysis.

Sensory acceptability

The acceptance test was performed in different locations as a function of the particularities of each group. For the groups 1 and 2 (7 to 10 year old children and adolescents 11 to 16 years old, respectively), the test was conducted in public schools. For group 3 (adults 17 to 55 years old), the evaluations were performed in the sensory analysis laboratory at the Federal University of Viçosa. For group 4 (elderly 56 to 70 years old), the test was conducted at the center for elderly recreation at the Federal University of Viçosa. Although the test locations were different, the following environmental conditions were controlled: pasteurized and microfiltered milk samples were properly coded; the content volume (mL) provided was standardized; and the temperature was controlled at 4 ± 1 °C.

Because the number of participants recommended in the literature[13,14] for effective tests varies according to the test site (30 consumers in the laboratory and 100 consumers in a central location), a total of 100 consumers per group was standardized.

Because people of different age groups participated in the analysis, different types of hedonic scales were used to meet the peculiarities of each group. Thus, for the groups represented by children (7-10 years old), a facial scale with seven points was used[2,13,14,15]. For the other groups, a nominal scale with seven points was used[13].

The acceptance data of microfiltered and pasteurized milk were evaluated by analysis of variance (F-test) for each group. Sensory acceptability of microfiltered milk was also evaluated by comparing the groups together to determine which age group had the greatest acceptance of milk without heat treatment (microfiltered) by F-test and a means test (Duncan's test).

RESULTS AND DISCUSSION

Microbiological Analyses

Table 1 shows the counts of total coliforms, thermotolerant coliforms and mesophilic aerobic microorganisms present in pasteurized and microfiltered milk.

Raw milk showed counts of mesophilic aerobes and total coliforms higher than the maximum limit set by the Ministry of Agriculture, Livestock and Supply[16] suggesting that the raw material used in the experiment was of low quality. On the other hand, the microfiltration process was quite efficient because it removed all forms of vegetative life present in raw milk to undetectable levels, which did not occur with the pasteurization process.

Contamination of the standard microfiltered milk may have been due to the addition of cream, which contributed to a low microbial load in the microfiltered milk. However, this contamination was acceptable because the quantity of microorganisms found in the standardized microfiltered milk was lower than that permitted by Instruction No. 51 of the Ministry of Agriculture, Livestock and Supply[16] for pasteurized milk. Even with the addition of cream to the microfiltered milk, the count of mesophilic aerobes was still lower than that of pasteurized milk indicating its greater efficiency in milk processing.

Lawrence et al.[17] affirmed that microfiltration may be used for the separation of microorganisms from the milk because it can reduce the use of high thermal treatment to avoid denaturation of milk proteins. However, this reduction is dependent on the initial microbial load found in raw milk[18].

Enzyme indicators of thermal treatment

During the pasteurization treatment, various milk enzymes are inactivated, and enzyme inactivation assays, such as the alkaline phosphatase test, have been used for years to verify the adequacy of milk pasteurization[3].

The alkaline phosphatase test showed a positive result for microfiltered milk indicating that this processing technique did not inactivate the enzyme, which occurs with thermal treatment. With respect to pasteurized milk, the test showed a negative result indicating that the milk received appropriate heat treatment. Although alkaline phosphatase was not inactivated in the microfiltration treatment, microbiological analysis showed the superior quality of this milk compared to pasteurized milk.

Peroxidase is not destroyed by slow or fast pasteurization, but it is destroyed by high temperatures. This enzyme exerts an inhibitory action on microorganisms due to the oxidation of protein sulphhydryl groups essential for its metabolism. Peroxidase is used as an indicator of intense heat treatment applied to milk[19]. The peroxidase test showed positive results for both the microfiltered and pasteurized milk indicating that there was no abuse of heat treatment in processing the milk.

Milk Acidity

According to Brazilian legislation[16], milk naturally has a certain acidity at the time at which it is obtained ranging from 0.14 to 0.18 g lactic acid per 100 mL of milk. Legislation considers milk to be sour when presenting acidity greater than 0.18% (w/v), which may result from milk acidification by microorganisms multiplying within the product itself that metabolize lactose and produce lactic acid. In the present study both the microfiltered and pasteurized milk had acidity values within those permitted by legislation with acidity values of 0.16 and 0.18% for microfiltered and pasteurized milk, respectively.

Table 1. Count of mesophilic aerobic, total and thermo- tolerant coliforms in samples of raw, pasteurized and microfiltered milk, pasteurized cream and standardized microfiltered milk

Samples	Total coliforms ($CFU.mL^{-1}$)	Thermo-tolerant coliform ($CFU.mL^{-1}$)	Mesophilics ($CFU.mL^{-1}$)
Raw milk	2.4×10^5	$< 1 \times 10^1$	2.9×10^6
Pasteurized milk	$< 1 \times 10^1$	$< 1 \times 10^1$	1.8×10^3
Microfiltered milk	$< 1 \times 10^1$	$< 1 \times 10^1$	$< 1 \times 10^1$
Pasteurized cream	$< 1 \times 10^1$	$< 1 \times 10^1$	1.3×10^2
Standardized microfiltered milk	$< 1 \times 10^1$	$< 1 \times 10^1$	4.0×10^0

Table 2. Color coordinates *L*, a** and *b** for the microfiltered and pasteurized milks

Samples	L*	a*	b*
Standardized microfiltered milk	67.9 ± 0.2	-1.1 ± 0.1	5.1 ± 0.1
Pasteurized milk	76.5 ± 0.1	1.4 ± 0.1	12.6 ± 0.1

Instrumental evaluation of color

Color is one of the most important attributes of acceptability and quality of food products[20]. Table 2 shows the values for the *L**, *a** and *b** parameters of microfiltered and pasteurized milk.

Both microfiltered and pasteurized milk may be considered clear because the L* values were greater than 50 (L* > 50)[21], and the pasteurized milk had a higher luminosity than microfiltered milk.

For pasteurized milk, *a** and *b** values were positive indicating that they were in the red and yellow regions. Padilha et al.[22] reported that the combination of positive *a** and *b** values result in a brown color. Jing and Kitts[23] and Dattatreya and Rankin[24] affirmed that factors, such as reducing sugar, moisture, structure of particles contained in food, temperature and pH, involved in the processing of milk or dairy derivatives contribute to the Maillard reaction, thereby generating changes in color. Additionally, Chevalier et al.[25] reported that the Maillard reaction may occur in the less extreme processing steps, i.e., an intense chemical catalyst is not necessarily required for reactions to occur.

According to Dattatreya and Rankin[24], the highest *b** values obtained for pasteurised milk are related to the intermediate phase of the Maillard reaction where there is an increased production of yellow compounds.

The *a** values obtained for microfiltered milk in the present study indicated that it was greener than pasteurized milk because no interference of reactions between milk components occurred due to heat treatment in pasteurized milk.

Sensory evaluation

Consumers

The socioeconomic and cultural profile of consumers who participated in the sensory analysis representing the age group from 17 to 55 years (group 3) consisted of people who were heterogeneous in terms of socioeconomic and social variables. It was represented by a majority with a higher level of education (incomplete higher education 81.6%) and intermediate socioeconomic level (US$ 302 to US$ 2718 per mouth 76%).

The frequency of milk consumption varied widely in this group, with 60.5% of the consumers drinking milk more than 5 times a week, which may be the result of a wide range of consumer ages comprising this group (17 to 55 years old). According to the Milk Industry Foundation[26], milk consumption is in an inverse relation to the age of the consumers.

Regarding the type of milk consumed, there was a greater consumption of ultra high temperature (UHT 56.7%) milk followed by milk with a smoother heat treatment (pasteurized: HSTS – high temperature short time 35.6%). The form of milk consumption was often based on the addition of other ingredients (especially powdered chocolate 55.1% and coffee 27.5%) with only a small percentage of consumers (8.2%) with a habit of drinking plain milk. These results were consistent with the findings reported by Sampaio and Da Silva[27] when evaluating the milk consumption habits of the Brazilian population. Sampaio and Da Silva[27] found that only 2% of surveyed consumers drink plain milk, and they also reported that 52% of the surveyed consumers drink milk with chocolate powder and that 41% add milk to coffee.

When the term "microfiltered milk" was mentioned to consumers, explaining the process and its nutritional influence, most of than approximately 70.7%, had an understanding with respect to application of the milk microfiltration process and its implication on health. This result may be due to the significant percentage (62%) of consumers who had attended college.

Acceptability among different age groups

Table 3 shows the average acceptance of microfiltered and pasteurized milk for consumers of different age groups. The group represented by children (7-10 years old) was the only group that did not discriminate the samples with respect to acceptance, by F-test ($p > 0.05$). According to Kimmel et al.[28], children are eager to please adults reflecting the inclination to confirmatory or socially desirable responses. Other difficulties that may be encountered in research with young children include their shorter attention span and the fact that their cognitive abilities are not yet fully developed, which may result in extreme or random results[15,29,30,31,32].

On the other hand, adolescents (11 to 16 years) were able to discriminate the microfiltered and pasteurized milk samples ($p < 0.05$) assigning scores between the hedonic terms "like" and "liked very much", in the seven points scales, for the two samples, with a significant preference for the microfiltered milk. According to Gandy et al.[4] and Chapman and Boor[2], heat treatment causes a strong cooked flavor in milk that is unfavorable with regard to sensory acceptability of consumers in this age group.

The adult group (17-55 years old) indicated that they did not like microfiltered milk assigning scores between the terms "disliked" and "indifferent". In relation to pasteurized milk, the consumer group studied showed slight product acceptance by assigning scores between the terms of "indifferent" and "liked". The low sensory acceptability of the assessed milk types may be attributed to consumers not having a habit of drinking plain milk.

For the elderly group, sensory acceptability of the two milk types (microfiltered and pasteurized) was satisfactory with a significant preference for pasteurized milk reflecting the habitual consumption of this beverage. According to Chapman and Boor[2], this preference is due to the accentuated cooked taste of heat-treated milk reflecting the preference of pasteurized milk among older consumers.

Table 3 also presents a comparison of the acceptance of microfiltered milk among different age groups. The groups represented by children, adolescents and elderly showed no significant difference ($p > 0.05$) in relation to sensory acceptability. Moreover, the group of adults (17 to 55 years old) showed significant difference ($p < 0.05$) in relation to sensory acceptability indicating lower acceptance of the microfiltered milk.

Table 3. Sensory acceptance of microfiltered and pasteurized milk in different age groups

Consumers	Microfiltered milk	Pasteurized milk
Children	5.7^{aA}	5.9^{a}
Adolescents	5.8^{aA}	5.1^{b}
Young adults and Adults	3.6^{bB}	4.7^{a}
Elderly	5.8^{bA}	6.1^{a}

Lowercase letters in the lines indicate significant difference ($p < 0.05$), by test F. Capital letters in the column indicate significant difference ($p < 0.05$), by test of Duncan

These results indicated a potential market for the microfiltered milk because most consumers (75%) demonstrated good acceptance for this milk. The sensory unacceptability of microfiltered milk of the adult group may be due to the habit of adults of not consuming plain milk normally, which was the condition of the sensory test.

CONCLUSION

The application of microfiltration membrane technology allows the food industry to use a new tool capable of improving the microbiological quality of dairy products. In the present study, microfiltration was more effective than pasteurization in reducing the microbial load present in raw milk, which may result in a longer shelf life of products originating from such milk. The evaluated physicochemical parameters also presented values in accordance to Brazilian legislation for pasteurized milk.

Regarding acceptance, it was clear that both the microfiltered and pasteurized milk showed good acceptance with the exception of consumers between 17 and 55 years suggesting a large potential market for microfiltered milk. However because consumers are accustomed to the taste of cooked milk, the revival of an appreciation for the taste of raw milk is needed, which would allow greater acceptance and use of this milk for consumption or as an ingredient in various products.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the CNPq and Fapemig for their financial support.

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