



Research Article

SENSORY EVALUATION OF SIMILARITIES BETWEEN ANIMAL-BASED MILK AND NUT-BASED MILK ALTERNATIVES USED IN THE MUHALLEBİ (TURKISH DAIRY DESSERT)

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Abstract

This study aimed to evaluate the similarities between various nut-milk-based recipes for muhallebi (ingredients: custard, rice starch, sugar, and milk) in terms of their sensory characteristics, consumer acceptance, and drivers of liking a new alternative non-dairy dessert. To determine the similarities between dairy and non-dairy milk, a similarity analysis (ISO 10399) with non-trained panellists was conducted, and the similarity levels between the reference (muhallebi with dairy milk) and other two samples (muhallebi with non-dairy milk) were compared. Dessert samples with two different milk alternatives (coconut and almond) were formulated using a mixture design. The results of this study indicate that muhallebi made from almond milk may be an alternative to muhallebi made from dairy milk. Although the muhallebi made with coconut milk was similar to the original in colour, it was criticised by the participants for a lack of taste, and the perception of tasting 'artificial' was noted. Although the colour of muhallebi made with almond milk differed from the original, it was evaluated as a viable alternative product in terms of taste. Consumers have recently begun to demand alternative non-dairy food production due to environmental concerns, health issues, and eating habits. Notably, several plant-based milk alternatives can be used to increase food value. This study is intended to open new avenues for cuisines to reduce their environmental impacts.

Keywords: Sensory Evaluation, Dairy Milk, Nut-based Milk, Sustainability, Similarity, Muhallebi

Introduction

Since humans domesticated animals and adopted dairy products, milk has become essential for human nutrition. For centuries, animal-based products have been an essential part of human eating habits (Romulo, 2022; Astolfi et al., 2020). Milk has been recognised as a main source of protein for human beings (Vanga and Raghavan, 2018). Despite the intensive use and benefits of milk, its consumption brings with it many problems. Additionally, animal-based dairy has been associated with several diseases such as cancers (linked to hormones), heart disease, and chronic gastroenteritis (Ben Jemaa et al., 2021). Due to individuals affected by diseases such as heart disease, depression, allergies, and lactose intolerance, and by changes in lifestyle and dietary habits due to religious and ethical restrictions, have led to the emergence of new functional alternatives. Due to dairy products being thought to cause various problems, there is an increasing need for research into alternative products. For that reason, there is an increasing need for research into alternative products (Silva and Smetana, 2022; Fructuoso et al., 2021; Haas et al., 2019; Leahu et al., 2022; Astolfi et al., 2020). Increasing consciousness of sustainable nutritional production and medical reasons has increased the demand of plant-based products (Greis et al. 2020). Furthermore, the industry supports plant-based production due to increased health expenditure (Halme et al., 2023). In addition, today, people's interest in improving their quality of life by eating healthily has increased. This is based on the increasing knowledge about the relationship between chronic diseases and nutrition (Jeske et al., 2018). Notably, there is a need to identify alternatives to replace milk for people who follow a dairy-free diet (Fructuoso et al., 2021; Haas et al., 2019).

Plant-based alternatives have recently been mentioned as plant products that attempt to replace animal ingredients (Baptista and Schifferstein, 2023). Plant-based milk is a product developed to have a similar feel and taste to milk and is used as a substitute for milk with similar uses and applications (Chandra et al., 2022).

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In addition to taste and similarity, there are also comparisons in terms of nutritional values. For example, Chalupa-Krebzdak, Long and Bohrer (2017) compared plant-based products of different brands with animal milk and found that some plant-based milks, especially soy milk, had protein and energy values close to those of animal milk. Such findings on nutritional values are supported by other studies (Asfolti et al., 2020; Romulo, 2022). On the other hand, there are also opinions that the nutritional values are not as nutritious as animal milk. Nevertheless, in these studies, it is stated that alternative milks can be used in daily life for reasons such as food allergies (Reyes-Jurado et al., 2021).

Worldwide, speciality beverages with plant-based alternatives have the fastest-growing market segment (Park, 2021). The market of plant-based milk, which was 13 billion USD in 2021, is expected to be 31 billion USD in 2031 (UCDAVIS, 2022). The production of plant-based milk alternatives has widespread popularity due to the rise of vegan nutrition, trendy lifestyles, social media influence, and food blogs, resulting in a growing consumer demand and market share. However, as a relatively new product segment, there are some limitations, such as the potential loss of functional components during industrial production, negative sensory properties, production process defects, and insufficient scientific research on nutrient profile, including micronutrients, bioaccessibility of nutrients, and anti-nutrient factors (Bengü and Yılmaz Ersan, 2022).

Nuts, grains, legumes, and seeds are the main source of plant-based drinks (Xie et al., 2023). Plant-based milk is a water-soluble extract of oilseeds, grains, nuts, pseudo-grains, and vegetables (Karimidastjerd and Konuşkan, 2021). Generally, plant-based drinks products are mentioned as drinks, soft drinks, and dairy alternatives (Reyes-Jurado et al., 2021, p.1). These products are more favoured because they are lactose and protein-free, and are lower in calories than milk (Prytulska et al., 2021). Recent research has shown that these plant-based beverages can have numerous health benefits. Research has shown that plant-based beverages are critical in enhancing physiological functions to improve the immune system and to help reduce the risk of cardiovascular and gastrointestinal diseases (Paul et al., 2019).

The consumption of animal-based protein needs high usage for land and water and high greenhouse production due to resource requirements for feed and shelter. For that reason, the impact of gases has unsustainable impacts on the environment (Cardello et al., 2024). The production of these products is the main reason for greenhouse gas (GHG) emissions caused to climate change (Collier et al., 2023). The volume of current global food systems has led to environmental debates, as food accounts for 21–37% of global greenhouse gas emissions. A global shift towards ‘sustainable diets’ is widely promoted due to environmental and health issues. High in plant-based and low in animal-product diets will benefit both health and the environment. (Alae-Carew et al., 2022). Increasing health concerns and sustainability issues regarding animal fat intake, it is estimated that the market share of plant-based alternatives will increase to around 15% compared to cow's milk in developed countries such as the United States, Europe, and Australia (Cardello et al., 2022).

Recently there has been an increase in literature on plant-based production studies. Previous studies have been performed on topics such as the sensory acceptability of the sensory properties of plant-based milk yoghurt products (Gupta et al., 2022; Arise et al., 2022), ice cream production and properties (Leahu et al., 2022; Asres et al., 2022), properties of different types of plant-based milk (Beşir et al., 2022; Velangi and Savla, 2022; Sethi et al., 2016; Romulo, 2022), comparison of animal based milk and plant-based milk (Astolfi, 2020; Haas, 2019; Pointke et al., 2022), perception of usage plant-based milk usage in coffee (Gorman et al., 2021) and environmental effects of plant-based and dairy milk (Huang, 2022).

Dairy is an essential component of dairy-based dessert products. These have become popular because of the rich nutritional components of milk and its ability to be consumed by all age groups (Günaydı and Ayar, 2021). Thus, there is a need to find milk in meals and products consumed daily while also identifying alternatives to replace these products for people who follow dairy-free diets (Fructuoso et al., 2021; Haas et al., 2019). The increasing trend towards plant-based nutrition plays an important role in ensuring the sustainability of human health and global food resources. To achieve this goal, foods need to be improved or reformulated with plant-based products. The main point of these, products will be to design the sensory properties of these products to meet consumer expectations and acceptance and requirements for quality (Cardello et al., 2024). The development of recipes with a lactose-free beverage emerges as a new alternative to produce with nutritional and functional properties for individuals which have various restrictions (Rebouças et al., 2016).

Nut milk alternatives mainly include liquids from almonds, coconuts, hazelnuts, cashews, peanuts, tiger nuts or walnuts (Aydar et al. 2020). Coconut (*Cocos nucifera*) plays an important role in the economies of Southeast Asian countries. Coconut milk contains calcium phosphorus potassium, low-level fat and protein, essential amino acids, and various vitamins. (Pachekrepapol et al., 2021). Coconut milk is associated with

anticarcinogenic, antimicrobial, antibacterial, and antiviral effects (Qadi et al., 2023). Coconut milk is also rich in antioxidants such as vitamin E. Another benefit of coconut milk is that it aids in digestion, nourishes the skin, and has cooling properties (Sethi et al., 2016). Coconut milk is a dairy alternative source rich in various nutrients. Due to its low-fat content coconut milk is an alternative in the production of kefir-based drinks (Abadi et al., 2022). Additionally, the low cholesterol levels in coconut milk make it suitable for use by people with lactose intolerance and heart disease. (Tulashie et al., 2022). Almond milk is lower in calories than cow's milk. This milk is an important beverage for gastrointestinal and cardiovascular health (Alozie Yetunde and Udofia, 2015).

Almonds (*Prunus dulcis*) are among the most commonly consumed nuts. It has 50% fewer calories than cow's milk. It is also suitable for lactose intolerance but not for nut allergies (Velangi and Savla, 2022). Plant-based milks are rich in nutritional content. Almonds are rich in nutritional value and contain essential fatty acids, vitamins, fibre and phytochemicals. An overview of the nutritional and bioactive compositions of coconut and almond milk is presented in Table 1. Coconut milk does not contain lactose like other plant-based milk, making it suitable for people with lactose intolerance (Andreo et al., 2020). Therefore, integrating plant-based milk into such diets without compromising taste and flavour during this integration increases the preference for such diets. They have some disadvantages in that they are nutritionally unstable and their flavour profile is sometimes difficult to accept. (Talay Maraş, 2023). The nutritional properties of plant-based milk vary depending on raw materials and production processes. Almonds contain minimal amounts of calcium and protein compared with dairy (Rincon et al. 2020).

This study aimed to perform a sensory evaluation of desserts in Turkish cuisine using plant-based milk in their recipes. Since the recipes of milk desserts are similar to Turkish cuisine, muhallebi, which has a basic recipe, was studied.

Materials and Methods

This study aimed to determine similarities between recipes made with plant-based and animal milk in two stages. First, an experimental design was used. Experimental applications were carried out in the kitchen under permission number E-89599958-770-480069 (obtained from the dean of the faculty). Second, a sensory evaluation was used to investigate the similarity of the products to the original recipe. In the sensory evaluation section, a scale from 1 (not at all similar) to 5 (extremely similar) was used for taste, smell, density, appearance, colour, and texture, and an open-ended question was asked about general opinions after asking a yes/no question about the consumption of a product. Ethical approval for the involvement of human in this study was granted by Anadolu University Ethics Committee, Reference number 516369, 05/20/2023.

To evaluate the results of the research on potential consumer groups, sensory evaluations were compared according to the demographic variables. At this stage, non-parametric Mann-Whitney U and Kruskal–Wallis tests were applied. Subsequently, radar graphs were created and analysed over the averages to interpret the results. The results were evaluated by considering the answers to open-ended questions.

Experimental Design

The first step in the design was to standardise the recipe. The most common recipe among the muhallebi recipes was used as the standard. In the next stage, nut milk was compared with muhallebi made from animal milk. Coconut and almond milk were selected in terms of colour, texture and taste.

To standardise the recipes, the recipe design steps published the works of the leading names in Turkish cuisine in the sector (Şavkay, 2000; Ertürk, 1971; Halıcı, 2009; Türkan, 2012; Yılmaz, 2004) were taken as the basis for source selection. In the experiments, thickeners and nut-based milk varieties were tested. While preparing the experimental environment, the area where the second stage of the research will be carried out was taken into consideration. Considering that the main research will be carried out in the sensory analysis laboratory and that a professional kitchen should be used while preparing the products, the kitchen of Anadolu University Gastronomy and Culinary Arts Department was determined as the test area. At this stage, the equipment used in the preparation of the products and equipment such as cookers were standardized. External factors that may affect the result such as the time of use of the test environment, the temperature of the environment, the person performing the experiment, and the equipment used were designed to remain the same. The recipes were firstly prepared by ratios according to 200 ml of milk, and then the final control was made according to the amount to be used in the sensory analysis. Descriptions of the experimental studies are given in Table 1.

Table 1. Determination of Reference Samples

	Purpose	Ingredients/Process	Result	Explanation
Experiment 1	Testing the thickener	Wheat flour	Rejected	Flour taste and thickness
Experiment 2	Testing the thickener	Rice flour	Rejected	Not similar
Experiment 3	Testing the thickener	Sweet liquid made with crushed rice (sübye)	Rejected	Similar but not practical
Experiment 4	Testing the thickener	Rice starch	Approved	Similar to the original muhallebi flavour
Experiment 5	Testing milk type	Coconut milk	Approved	Similar
Experiment 6	Testing milk type	Almond milk	Approved	Similar
Experiment 7	Testing milk type	Hazelnut milk	Rejected	Too much hazelnut odour
Experiment 8	Testing the metrics of ingredients	Tested in application metrics	Rejected	Too much sugar, thinner texture
Experiment 9	Testing the metrics of ingredients	Retested after new metrics	Approved	Similar

At the end of the trials, rice starch was used as a thickener, and coconut and almond milk as nut-based milk alternatives. The final recipes are listed in Table 2.

Table 2. Muhallebi Recipe**Muhallebi**

Ingredients	Metric	Explanation
Milk	1 lt	Any milk can be used.
Rice starch	55 gr	
Sugar	100 gr	

Procedure
1- Mix the starch with 300 ml of milk in a mayonnaise pot.
2- Add the milk gradually, put the mixture on the stove, and stir constantly.
3- Add sugar.
4- Cook over low heat for 15 minutes.
5- Cool in the refrigerator.

Notes
- Cooling in the refrigerator at 2 to 4 degrees Celsius for 12 hours provides the ideal consistency.
- Cooking time may vary by +/- 2 minutes depending on the milk used.
- It should be stirred continuously during cooking to prevent it from sticking to the bottom.
Source(s): Authors' work

Sensory Evaluation

Aroma, appearance, mouthfeel and aftertaste can affect the acceptability of food. The consumer's sensory evaluations determine the acceptability of one food product over another. Food acceptance refers to the taste, hedonic tone, liking or disliking, preference and enjoyment that accompanies food consumption (Mielmann et al., 2015). The acceptability of plant-based milk desserts will be compared with animal milk desserts and will be evaluated.

The comparative sensory evaluation (ISO 10399) of plant and animal milk desserts was carried out in the Sensory Analysis and Neurogastronomy Laboratory (Anadolu University Faculty of Tourism) designed according to ISO 8589 (BS ISO 8589, 2010) standards. A total of 78 panellists who were familiar with custard dessert, between the ages of 18-60 and regularly consumed this type of dessert were selected. Custard dessert samples were stored at 4°C for 18 hours and served in disposable plastic containers coded with three-digit numbers. The almond and coconut milk samples were compared with cow's milk-based custard for an overall acceptability rating using a 5-point unipolar liking scale.

Sensory evaluation (SE) was conducted over May 2023 and focused on one reference sample and two samples per session. The sessions were performed in two phases. First, the panellists were informed of the purpose of the study in detail. In particular, they were informed that nut-based milk has added ingredients approved for human consumption, and is halal. They were also told (orally and in writing) that they should not participate if they suffered from any food allergies or intolerance to milk, sugar, rice, or other food ingredients. All participants signed a consent form. Second, sensory evaluation (SE) was performed by panellists (Figure 1).

Fig. 1. Implementation of SE



Results

In the results section, the characteristics of the participants and their distributions are examined. In this manner, it was possible to comment on the representativeness of different genders, ages, and educational status. The demographic distribution of participants is presented in Table 3.

Table 3. Demographic Data

Age	n	%	Education	n	%	Gender	n	%
18–29	32	40.5	High School Diploma and Below	27	34.2	Female	44	55.7
30–39	17	21.5	Associate's Degree Programme	6	7.6	Male	34	43
40–49	19	24.1	Bachelor's Degree	16	20.3			
50 +	10	12.7	Post Graduate	29	36.7			

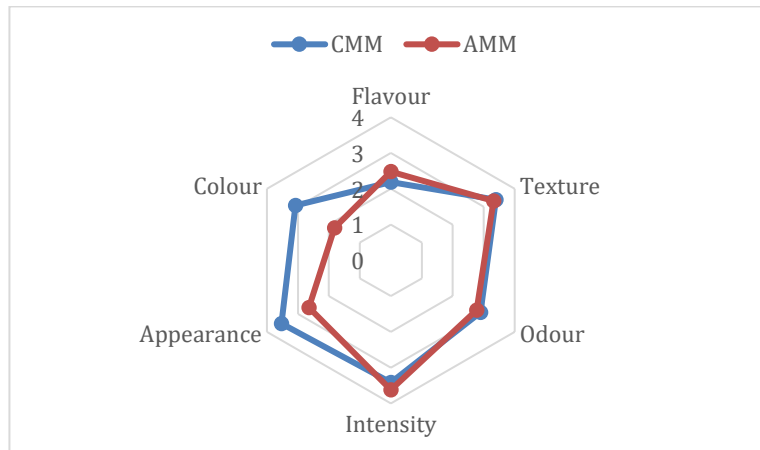
Upon investigating the demographic distribution of the participants, it is evident that the number of people who can represent almost every group was reached. This distribution will allow evaluations to be made between taste criteria and demographic characteristics.

In this study, participants were asked to compare the similarity of muhallebi prepared with coconut milk (CMM) and muhallebi prepared with almond milk (AMM), with the original muhallebi (using cow's milk) as a reference. Responses according to the tasting criteria are presented in Figure 2.

Upon examining Figure 2, it is evident that CMM is more similar to the original in terms of texture, intensity, appearance, and colour, whereas AMM is more similar to the original in terms of texture and intensity. As

shown in Figure 2, it is evident that the taste and intensity of AMM are similar to those of the original. CMM was more similar to the original than the AMM, especially in terms of colour and appearance.

Fig. 2. The Resemblance of CMM and AMM to the original muhallebi



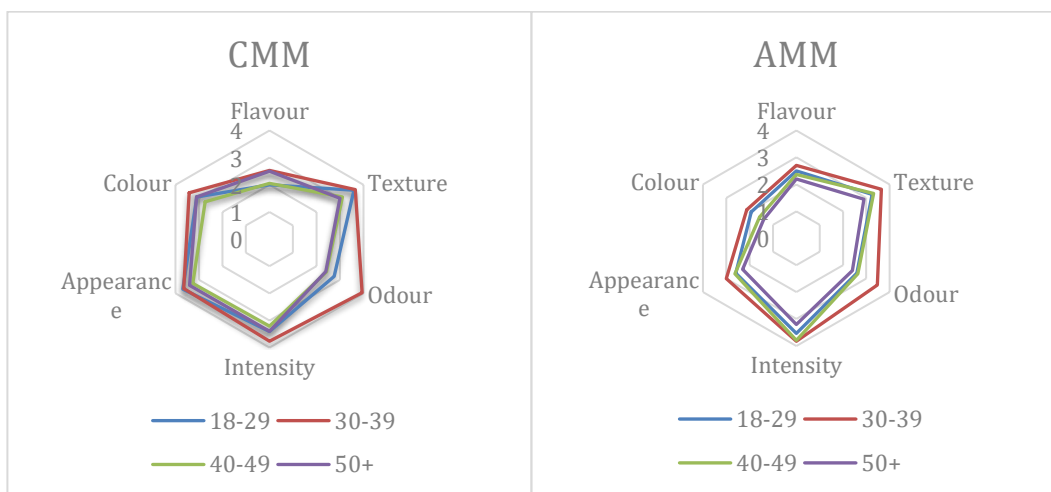
Participants’ sensory evaluations of the milk types were also analysed according to their demographic characteristics. Participants’ sensory evaluations of milk according to their demographic characteristics were also analysed in the study. Mann Whitney U and Kruskal Wallis tests were used to measure the level of significance between demographic characteristics and sensory evaluations. The results are presented in Table 4.

Table 4. Comparison of Demographic Characteristics and Sensory Evaluation

	CMM				AMM			
	Age	Educatio n	Gende r	Consumptio n	Age	Educatio n	Gender	Consump tion
Flavour	,262	,495	,482	,000*	,693	,937	,507	,000*
Texture	,390	,723	,182	,037*	,373	,666	,971	,026*
Odour	,007*	,844	,951	,047*	,140	,787	,116	,011*
Intensity	,567	,260	,858	,084	,439	,476	,954	,025*
Appearance	,737	,585	,732	,545	,584	,053	,422	,404
Colour	,459	,961	,436	,211	,256	,813	,743	,771

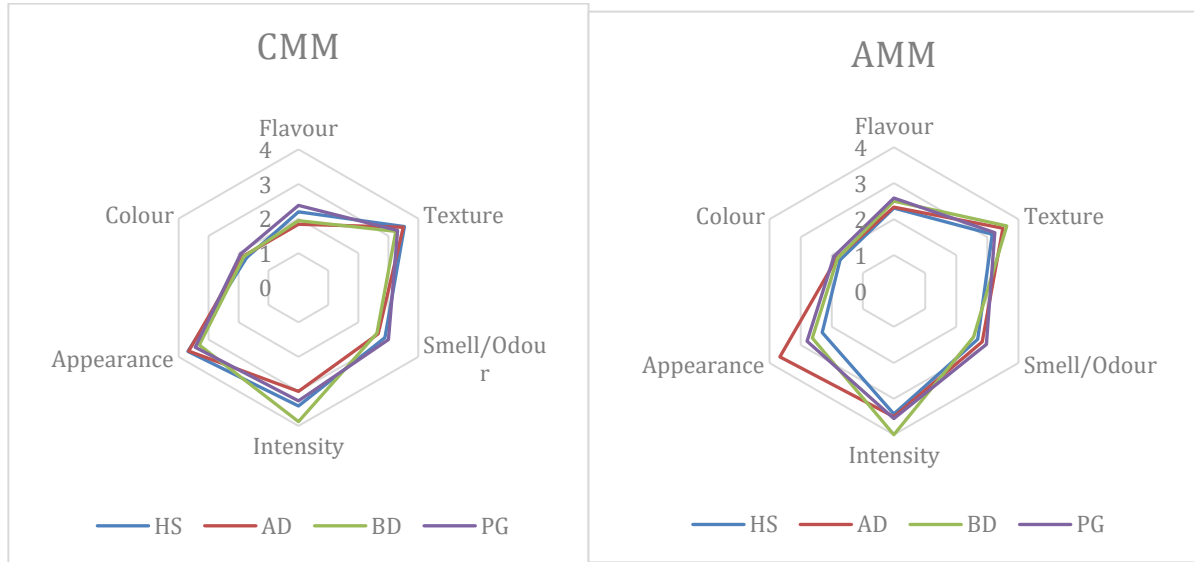
According to the results of the analyses, a significant difference was found between the odour variable and age in CMM: flavour, texture, and odour variable, and consumption in CMM, flavour, texture, odour, and intensity variable and consumption in AMM. However, the results regarding the significance difference could not be obtained. At this point, the graphs comparing the CMM and AMM were examined for some evaluations that could not be determined by statistical analysis (see Figures 3 to 6).

Fig. 3. Similarity results by age



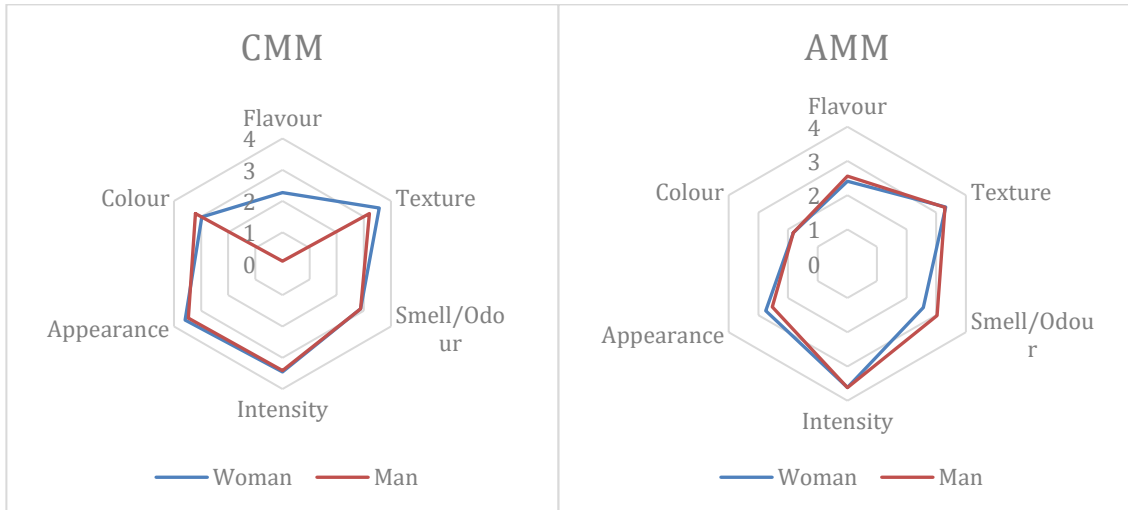
As shown in Figure 3, participants in the 30–39 age group liked CMM to the original muhallebi more than those in the other groups. The odour perception of the same group was also high for AMM. There were no significant differences in the other sensory variables between the groups. In the comparison of CMM and AMM, it can be said that the colour of CMM is more similar to the original, whereas AMM is more similar in taste.

Fig. 4. Similarity results from education



As shown in Figure 4, the appearance of AMM was perceived as being more similar to the original among associate degree graduates. For CMM, all education groups likened their appearance to that of the original. However, none of the groups detected significant similarities in taste or colour, whereas university graduates detected a greater resemblance to the original in terms of density.

Fig. 5. Similarity results by gender

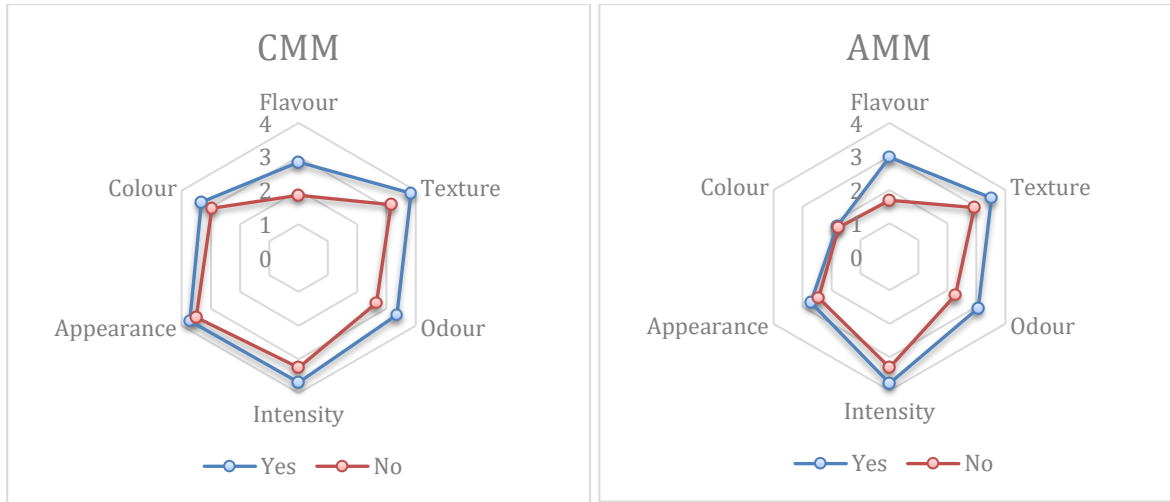


According to the graphs in Figure 5, there is a significant difference in the taste of the CMM from the original. Male participants could not compare the CMM to the original in terms of taste. In terms of colour and general appearance, both men and women found the CMM to be more similar to the original.

Finally, in line with the purpose of the study, participants were asked whether they would consume one of the options offered instead of the original muhallebi. While 33.3% of the participants stated that they would consume CMM, 66.6% stated that they would not prefer it. According to Drake (2009), this rate is not considered sufficient for an alternative product. In the case of AMM, 61.3% of the participants stated that they would consume it, whereas 38.6% stated that they would not consume it. As this response was given by more than 50 participants, it can be considered an alternative product. In the similarity comparisons made thus far, it has been seen that CMM is more similar to the original muhallebi in terms of various sensory characteristics; however, according to this result, the number of people who prefer to consume AMM is higher than for CMM.

At this point, since AMM was found to be more similar to the original in terms of taste, taste may be a more decisive factor in consumption preference. This is consistent with the results shown in Figure 1. Additionally, when the significant differences in consumption according to sensory characteristics were analysed (Table 5), this result was supported. Notably, AMM showed significant differences in taste, texture, odour, and intensity. An analysis of the averages of the results reveals that the consumption preference is higher in these dimensions. In CMM, there is a significant difference in the taste, texture, and odour variables; however, the preference remains proportionally low.

Fig. 6. Consumption preference and similarity results



As shown in Figure 6, the perception of those who did not prefer to consume CMM based on taste similarity was quite low. For AMM, consumption preference and taste similarity were high. In addition to these analyses, an open-ended question was asked in the sensory evaluation form, and participants were asked to evaluate the CCM and AMM in general. In the answers given to the open-ended questions, it was noted that the taste of CMM was insufficient, the sugar level was low, the taste of rice was excessive, and consistency was not at the desired density. Additionally, it was perceived as artificial because it was too light in colour. It was observed that AMM was more similar to the original muhallebi in terms of taste and texture. Although not similar in colour, it was found to be more positively regarded than CMM, especially in terms of taste and consistency.

When the answers were evaluated in general, it was observed that there were explanations that were in line with the sensory evaluation results. The analysis showed that the rate of those who stated that they would consume CMM was low, whereas the rate of those who stated that they would consume AMM was within acceptable limits. In the evaluations, it was evident that there were more negative comments on CMM, while there were more positive comments on AMM. In this case, it can be interpreted that AMM can be considered an alternative to muhallebi based on cow's milk. On the other hand, some people did not prefer anything other than the original muhallebi under any circumstances. It is estimated that muhallebi made with alternative types of milk will not be satisfactory for people who are estimated to have a traditional structure in terms of taste. At this point, muhallebi prepared with alternative milk can be flavoured with traditional flavours such as vanilla or gum drops to bring them closer to the normal perception.

Discussion and Conclusion

In this study, muhallebi were created with alternative dairy products, and AMM stands out as an acceptable alternative in the context of consumption preferences. The present study contributes to the field from different perspectives. Creating new products from recipes with alternative materials will be important for reducing the effects of environmental problems caused by dietary habits that may arise today and in the future. Trying alternative artificial meat and plant-based milk in different recipes and making these dishes suitable for people's tastes will enable individuals to prefer these products. This study also showed that dairy-based desserts, such as muhallebi, can be consumed by vegans when using milk alternatives. As noted in the literature, plant-based milks are used not only for the optional vegan diet but also for specific reasons such as food allergies. The muhallebi proposed in this study is also important in terms of providing an alternative product for people who do not consume dairy products due to health concerns. Although the study was limited to a single dairy dessert product, other studies can be conducted on alternative desserts. Such studies, which will provide diversification in the product range, will also contribute to businesses.

Another contribution of this study, which may seem less relevant than previous topics but will increase in importance over the coming years, is the economic dimension of milk alternatives. To date, cow's milk has been more affordable than plant-based milk in Turkey, making it more economical. However, in recent years, with the decline in animal husbandry, cow's milk prices have increased significantly. With rapidly rising prices, cow milk has approached the prices of plant-based milk alternatives. When agricultural and livestock policies are considered, it can be predicted that this trend will continue for cow milk. In this case, plant-based milk, which is considered a luxury in Turkey may be an alternative to cow milk. Therefore, the number of studies on the use of plant-based milk in different recipes may increase.

Implications for Gastronomy

As the human population continues to grow, alternative diets and raw materials are being developed to ensure the sustainability of nutrition and its benefits to human health. In recent years, plant-based drinks have gained popularity because of the impact of animal-based drinks on the environment and the health problems experienced by individuals. This study sought to determine the similarities between the use of plant-based dairy alternatives as raw materials in existing recipes, and the consumption potential of these products.

This study, which is intended to open new avenues for kitchens to reduce their environmental impact, will have important results in terms of promoting the country's cuisine to the public, especially when the concept of sustainability is being discussed. In particular, the preparation of recipes using alternative raw materials increases kitchen sustainability. This will also attract the attention of individuals with health problems. However, the methods and results of this study offer new opportunities for food and beverage companies in terms of recipe development.

The results of this study can be used for traditional dishes by businesses such as restaurants and cafés that support environmental consumption. This will inspire in terms of interpreting recipes for these products, and at the same time, it will increase the potential for chefs to make traditional kitchen products sustainable. In recent years, an increase in lifestyle and food-related diseases has negatively affected food consumption. The main complaint of individuals is the lack of access to healthy menus.

Declaration of Competing Interest

The authors declare that they did not use any financial outsourcing in this study, and they do not have relationships with individuals and organisations that will obtain financial benefits.

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