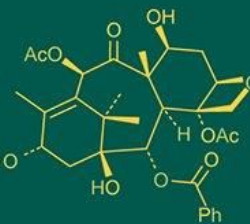
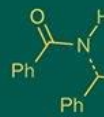
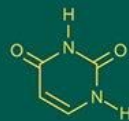
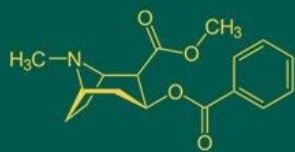


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Influence of Microencapsulation on Organoleptic Quality of Probiotic-Fortified Oat Milk

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Abstract

The growing demand for plant-based functional beverages has encouraged the development of value-added oat milk products enriched with probiotics. However, direct incorporation of probiotic cultures may adversely affect sensory quality and stability. The present study aimed to evaluate the sensory characteristics of oat milk fortified with microencapsulated probiotic formulations prepared at different composition levels (T₁-T₂₀). Sensory attributes, including colour, taste, texture, flavour, appearance, and overall acceptability, were assessed using a nine-point hedonic scale, and statistical analysis was performed to determine significant differences among treatments ($p \leq 0.05$).

Results revealed that microencapsulation significantly influenced the organoleptic properties of oat milk. Sensory scores varied across treatments, with colour ranging from 5.9 to 8.5, taste from 5.3 to 8.2, texture from 5.8 to 8.5, flavour from 5.1 to 8.1, and appearance from 5.9 to 8.8. Among all formulations, treatments T₁₃ and T₁₈ demonstrated superior sensory performance, recording the highest overall acceptability scores (8.4 and 8.0, respectively). These treatments showed balanced flavour perception, improved mouthfeel, and enhanced visual appeal, suggesting optimal microcapsule incorporation. In contrast, formulations with comparatively higher encapsulating matrix concentration exhibited reduced sensory preference.

The findings indicate that appropriate optimisation of microencapsulation parameters enables successful incorporation of probiotics into oat milk without compromising consumer acceptability. The study highlights the potential of microencapsulation technology in improving the sensory quality of plant-based functional beverages while maintaining product appeal.

Keywords: Oat milk, Microencapsulation, Probiotic, Sensory evaluation, Functional beverage, Consumer acceptability

Introduction

The demand for non-dairy functional beverages has increased due to the growing trend toward plant-based diets. Oat milk's mild flavour, balanced nutritional makeup, and consumer-friendly sensory profile have made it a promising substitute for traditional dairy milk. It is naturally high in vitamins, dietary fiber, β -glucan, and bioactive substances that support good health. Oat milk makes an excellent carrier matrix for functional ingredients like probiotics because of its neutral flavour and creamy texture.

Probiotics are live microorganisms that confer health benefits when consumed in adequate amounts^[3].

However, their incorporation into beverage systems presents technological challenges, including reduced viability and potential effects on sensory quality. Microencapsulation has been explored as an effective strategy to enhance probiotic survival and stability by forming protective matrices around probiotic cells^[10].

The present study aimed to evaluate the sensory characteristics of oat milk incorporated with different levels of microencapsulated probiotics and to identify the most acceptable formulation based on organoleptic evaluation.

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Table 1: Nutritional composition of raw oats (per 100 g)

Component	Amount (per 100 g)
Energy	389 kcal
Protein	16.9 g
Total Fat	6.9 g
-Saturated Fat	1.22 g
-Monounsaturated Fat	2.18 g
-Polyunsaturated Fat	2.54 g
Carbohydrates	66.3 g
-Dietary Fiber	10.6 g
-Total Sugars	0 g
Moisture	8.2 g
Ash	1.7 g
Calcium	54 mg
Iron	4.72 mg
Magnesium	177 mg
Phosphorus	523 mg
Potassium	429 mg
Sodium	2 mg
Zinc	3.97 mg
Thiamin (B1)	0.76 mg
Riboflavin (B2)	0.14 mg
Niacin (B3)	0.96 mg
Vitamin B6	0.12 mg
Folate	56 µg

Source: USDA FoodData Central (Standard Reference, raw oats)

2. Materials and Methods

2.1 Raw Materials

Roller oats were procured from a local retail market. Distilled water was used for beverage preparation. Probiotic cultures were maintained under appropriate laboratory conditions prior to encapsulation. All chemicals and reagents used were of analytical grade.

2.2 Preparation of Oat Milk

Oat milk was prepared using an enzymatic hydrolysis method. One kilogram of roller oats was ground into fine flour and mixed with 2.70 kg of water to form an oat slurry. The slurry was treated with α -amylase (77.78 mg per kg of roller oats) to facilitate starch hydrolysis. The mixture was filtered to separate the liquid fraction from the filter cake. The filtrate obtained was collected as oat milk (2.85 kg) and used for further fortification [11].

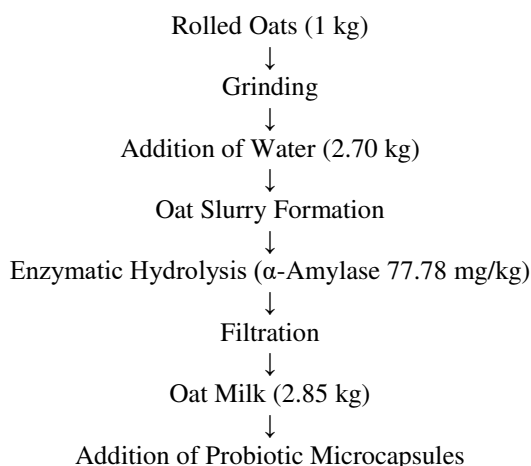


Fig 1: Illustrates the stepwise process involved in oat milk preparation, including mixing, enzymatic hydrolysis, filtration, and subsequent incorporation of probiotic microcapsules

2.3 Preparation of Microencapsulated Probiotics

Microencapsulation of probiotic cultures was carried out using a hydrocolloid-based encapsulating system. The probiotic culture was dispersed within the encapsulating matrix under aseptic conditions to obtain stable microcapsules. Different formulation combinations were prepared to obtain twenty treatments (T₁-T₂₀) [10].

2.4 Incorporation into Oat Milk

The prepared microcapsules were incorporated into freshly prepared oat milk under continuous stirring to ensure uniform distribution. Each formulation was prepared separately and stored under refrigerated conditions until sensory evaluation.

2.5 Sensory Evaluation

Sensory evaluation was conducted using a semi-trained panel. Samples were coded and presented in randomised order. Colour, taste, texture, flavour, appearance, and overall acceptability were evaluated using a nine-point hedonic scale (1 = dislike extremely; 9 = like extremely).

2.6 Statistical Analysis

All experiments were performed in triplicate, and results were expressed as mean±standard deviation. Data were analysed using analysis of variance (ANOVA) to determine significant differences among treatments at $p \leq 0.05$ [7].

Results and Discussion

3.1 Sensory Evaluation of Microencapsulated Probiotic Oat Milk

Sensory characteristics play a crucial role in determining the consumer acceptability of functional beverages. In the present investigation, oat milk incorporated with different levels of microencapsulated probiotic formulations (T₁-T₂₀) was evaluated for colour, taste, texture, flavour, appearance, and overall acceptability using a nine-point hedonic scale. The results are presented in Table 2.

A significant ($p \leq 0.05$) difference was observed among treatments for all sensory attributes, indicating that variation in microcapsule composition influenced organoleptic quality [5].

3.1.1 Colour

Colour scores ranged from 5.9 to 8.5. The highest colour score was recorded for T₁₈ (8.5±0.08) followed closely by T₁₃ (8.1±0.08), both belonging to statistical group "a". The improved colour in these treatments may be attributed to optimal microcapsule dispersion and minimal opacity changes in the oat milk matrix. In contrast, the lowest colour score was observed in T₇ (5.9±0.06), possibly due to higher encapsulant concentration affecting visual clarity [12].

3.1.2 Taste

Taste is one of the most critical parameters influencing product acceptance. The taste scores ranged from 5.3 to 8.2. Treatment T₁₈ (8.2±0.08) and T₁₃ (7.9±0.08) showed significantly higher taste scores ($p \leq 0.05$), indicating better flavor balance and absence of undesirable aftertaste. Lower taste scores in treatments such as T₇ (5.3±0.06) may be associated with excessive hydrocolloid concentration leading to slight bitterness or altered mouthfeel [2].

3.1.3 Texture

Texture scores varied between 5.8 and 8.5. The highest texture acceptability was again observed for T₁₈ (8.5±0.08) and T₁₃ (8.1±0.08). The improved texture in these treatments

suggests proper microcapsule integration without phase separation or sedimentation. Excessive encapsulating material in some treatments might have caused slight grittiness, reflected in lower scores for T_7 [4].

3.1.4 Flavour

Flavour scores ranged from 5.1 to 8.1. Treatment T_{18} (8.1 ± 0.08) achieved the highest score, followed by T_{13} (7.8 ± 0.08). The enhanced flavour profile may be due to effective encapsulation protecting probiotic viability while preventing off-flavour development. Treatments with lower scores possibly experienced minor flavour masking or textural interference [8].

3.1.4 Appearance

Appearance scores ranged from 5.9 to 8.8, with T_{18} recording the highest value (8.8 ± 0.08). The smooth dispersion and stable suspension of microcapsules likely contributed to superior visual appeal. Treatments showing moderate sedimentation tendencies exhibited comparatively lower appearance scores [6].

3.1.5 Overall Acceptability

The total perception of all sensory characteristics is known as overall acceptability. Scores varied significantly ($p \leq 0.05$) among treatments, ranging from 5.9 to 8.4.

T_{13} showed the highest overall acceptability (8.4 ± 0.08).

T_{18} (8.0 ± 0.08).

These treatments showed better sensory performance because they were in statistical group "a." The outcomes unequivocally show that optimal microencapsulation levels improve consumer acceptability without compromising organoleptic quality.

On the other hand, T_7 showed the lowest overall acceptability (5.9 ± 0.06), indicating that beverage palatability may be negatively impacted by an excessive amount of encapsulating matrix.

The results indicate that the successful production of a highly palatable functional oat milk beverage can be achieved through appropriately optimized microencapsulated probiotic incorporation [1].

Table 2: Sensory evaluation scores of microencapsulated probiotic oat milk beverages (Means $\pm$ SD; values with different superscripts within the same column differ significantly at $p \leq 0.05$)

Treatment	Colour	Taste	Texture	Flavour	Appearance	Overall Acceptability
T ₁	7.7 $\pm$ 0.08 ^b	7.8 $\pm$ 0.08 ^b	7.5 $\pm$ 0.08 ^b	7.9 $\pm$ 0.08 ^b	7.5 $\pm$ 0.08 ^b	7.6 $\pm$ 0.08 ^b
T ₂	6.3 $\pm$ 0.07 ^c	6.2 $\pm$ 0.07 ^c	6.5 $\pm$ 0.07 ^c	6.3 $\pm$ 0.07 ^c	6.7 $\pm$ 0.07 ^c	6.7 $\pm$ 0.07 ^c
T ₃	6.4 $\pm$ 0.07 ^c	6.2 $\pm$ 0.07 ^c	6.5 $\pm$ 0.07 ^c	6.1 $\pm$ 0.07 ^c	6.8 $\pm$ 0.07 ^c	6.8 $\pm$ 0.07 ^c
T ₄	6.9 $\pm$ 0.07 ^c	6.8 $\pm$ 0.07 ^c	7.1 $\pm$ 0.07 ^c	6.7 $\pm$ 0.07 ^c	7.0 $\pm$ 0.07 ^c	7.0 $\pm$ 0.07 ^c
T ₅	7.8 $\pm$ 0.08 ^b	7.5 $\pm$ 0.08 ^b	7.6 $\pm$ 0.08 ^b	7.2 $\pm$ 0.08 ^b	7.9 $\pm$ 0.08 ^b	8.1 $\pm$ 0.08 ^b
T ₆	6.9 $\pm$ 0.07 ^c	6.1 $\pm$ 0.07 ^c	6.5 $\pm$ 0.07 ^c	6.1 $\pm$ 0.07 ^c	6.5 $\pm$ 0.07 ^c	6.8 $\pm$ 0.07 ^c
T ₇	5.9 $\pm$ 0.06 ^d	5.3 $\pm$ 0.06 ^d	5.8 $\pm$ 0.06 ^d	5.1 $\pm$ 0.06 ^d	5.9 $\pm$ 0.06 ^d	5.9 $\pm$ 0.06 ^d
T ₈	6.5 $\pm$ 0.07 ^c	6.1 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	6.1 $\pm$ 0.07 ^c	6.3 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c
T ₉	6.4 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	6.2 $\pm$ 0.07 ^c	6.5 $\pm$ 0.07 ^c
T ₁₀	6.8 $\pm$ 0.07 ^c	6.2 $\pm$ 0.07 ^c	6.8 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	6.5 $\pm$ 0.07 ^c	6.8 $\pm$ 0.07 ^c
T ₁₁	6.4 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	6.2 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	6.5 $\pm$ 0.07 ^c
T ₁₂	6.6 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	6.5 $\pm$ 0.07 ^c	6.4 $\pm$ 0.07 ^c	6.8 $\pm$ 0.07 ^c	6.8 $\pm$ 0.07 ^c
T ₁₃	8.1 $\pm$ 0.08 ^a	7.9 $\pm$ 0.08 ^a	8.1 $\pm$ 0.08 ^a	7.8 $\pm$ 0.08 ^a	8.3 $\pm$ 0.08 ^a	8.4 $\pm$ 0.08 ^a
T ₁₄	6.5 $\pm$ 0.07 ^c	6.1 $\pm$ 0.07 ^c	6.7 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	7.4 $\pm$ 0.07 ^c	7.2 $\pm$ 0.07 ^c
T ₁₅	6.4 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	6.6 $\pm$ 0.07 ^c	6.0 $\pm$ 0.07 ^c	7.0 $\pm$ 0.07 ^c	7.0 $\pm$ 0.07 ^c
T ₁₆	6.9 $\pm$ 0.07 ^c	6.7 $\pm$ 0.07 ^c	7.2 $\pm$ 0.07 ^c	6.7 $\pm$ 0.07 ^c	7.5 $\pm$ 0.07 ^c	7.9 $\pm$ 0.07 ^b
T ₁₇	6.2 $\pm$ 0.07 ^c	6.1 $\pm$ 0.07 ^c	6.4 $\pm$ 0.07 ^c	6.2 $\pm$ 0.07 ^c	6.6 $\pm$ 0.07 ^c	6.6 $\pm$ 0.07 ^c
T ₁₈	8.5 $\pm$ 0.08 ^a	8.2 $\pm$ 0.08 ^a	8.5 $\pm$ 0.08 ^a	8.1 $\pm$ 0.08 ^a	8.8 $\pm$ 0.08 ^a	8.0 $\pm$ 0.08 ^a
T ₁₉	6.5 $\pm$ 0.07 ^c	6.1 $\pm$ 0.07 ^c	6.6 $\pm$ 0.07 ^c	6.5 $\pm$ 0.07 ^c	7.3 $\pm$ 0.07 ^c	6.9 $\pm$ 0.07 ^c
T ₂₀	6.9 $\pm$ 0.07 ^c	6.1 $\pm$ 0.07 ^c	6.5 $\pm$ 0.07 ^c	6.1 $\pm$ 0.07 ^c	6.5 $\pm$ 0.07 ^c	7.0 $\pm$ 0.07 ^c

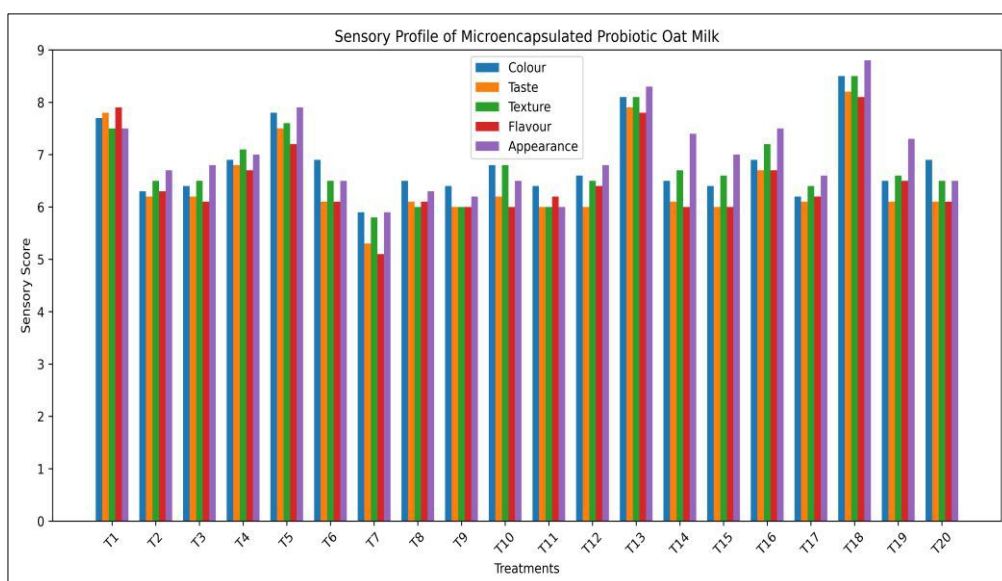


Fig 2: Sensory Profile of Microencapsulated Probiotic Oat Milk

Mean sensory scores for colour, taste, texture, flavour and appearance across treatments (T₁-T₂₀).

Conclusion

The current study showed that when formulation parameters are properly tuned, it is possible to incorporate microencapsulated probiotics into oat milk without sacrificing sensory quality. All assessed sensory qualities showed significant changes between treatments, indicating that the level and makeup of encapsulating materials are important factors in affecting the acceptability of a product. Colour, taste, texture, flavour, appearance, and general acceptance were the areas where T₁₃ and T₁₈ performed the best out of all the developed formulations. These treatments' enhanced organoleptic qualities imply that optimal microencapsulation enhances beverage stability and mouthfeel in addition to protecting probiotic organisms. Conversely, formulations containing relatively higher encapsulating matrix levels showed reduced sensory preference, indicating the importance of balanced formulation design. In general, the results show that all assessed sensory qualities showed significant changes between treatments, indicating that the level and makeup of encapsulating materials are important factors in affecting the acceptability of a product. Color, taste, texture, flavour, appearance, and general acceptance were the areas where T₁₃ and T₁₈ performed the best out of all the developed formulations. These treatments' enhanced organoleptic qualities imply that optimal microencapsulation enhances beverage stability and mouthfeel in addition to protecting probiotic organisms.

References

1. Alsado C, Lopez-Aldana L, Chen L, Wismer W. Consumer perception and sensory drivers of liking of fortified oat milks. *Foods*. 2023;12(22):4097.
2. Babolanmogadam N, Gandomi H, Akhondzadeh Basti A, Taherzadeh MJ. Nutritional, functional, and sensorial properties of oat milk produced by single and combined acid, alkaline, α -amylase, and sprouting treatments. *Food Sci Nutr*. 2022;11(1):28-40.
3. Food and Agriculture Organization of the United Nations & World Health Organization. Guidelines for the evaluation of probiotics in food: Report of a joint FAO/WHO working group. FAO/WHO; 2002.
4. Gupta S, Bisla G. Nutritional and sensory characteristics of oat milk based yoghurt. *Int J Appl Home Sci*. 2019;6(6-8):261-5.
5. Haro-González JN, Velásquez-Reyes DD. Sensory impact of probiotic incorporation in food matrices: A systematic review. *Crit Rev Food Sci Nutr*. 2025;1-22. Advance online publication.
6. McCarron R, Methven L, Grahl S, Elliott R, Lignou S. Oat-based milk alternatives: The influence of physical and chemical properties on the sensory profile. *Front Nutr*. 2024;11:1345371.
7. Montgomery DC. Design and analysis of experiments. 9th ed. EMEA ed. Wiley; 2020.
8. Sánchez-Rosales FE, Castellanos-Reyes KM, Macías-Bu LP, *et al*. Sensory acceptability of functional probiotic beverages made from underutilized tropical fruits rich in vitamins and minerals. *Beverages*. 2026;12(1):16.
9. U.S. Department of Agriculture, Agricultural Research Service. USDA National Nutrient Database for Standard Reference, Legacy. 2018.
10. Yao M, Xie J, Du H, McClements DJ, Xiao H, Li L. Progress in microencapsulation of probiotics: A review. *Compr Rev Food Sci Food Saf*. 2020;19(2):857-74.
11. Yu Y, Li X, Zhang J, Li X, Wang J, Sun B. Oat milk analogue versus traditional milk: Comprehensive evaluation of scientific evidence for processing techniques and health effects. *Food Chem X*. 2023;19:100859.
12. Zhou S, Jia Q, Cui L, Dai Y, Li R, Tang J, *et al*. Physical-Chemical and Sensory Quality of Oat Milk Produced Using Different Cultivars. *Foods*. 2023;12(6):1165.