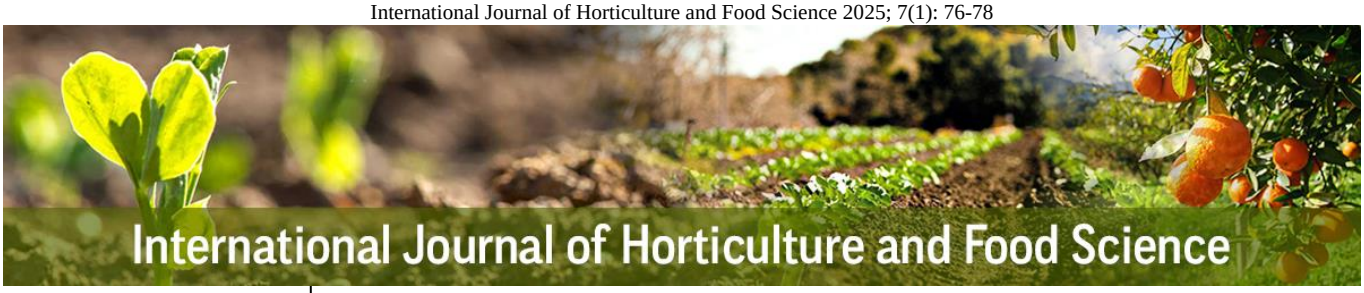

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Effect of microwave heating on the chemical composition of paneer

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Abstract
This study investigates the changes in the chemical composition of paneer subjected to microwave heating at different power levels: 180 W (T_1), 360 W (T_2), 540 W (T_3), and 720 W (T_4) for 1 minute each. The chemical and sensory qualities of the microwave-treated samples were compared with fresh paneer (T_5) and fried paneer (T_6). The analysis focused on parameters such as fat content, acidity, total solids, water activity, and moisture loss. The results showed that T_1 (180 W for 1 minute) maintained a chemical composition and sensory profile similar to fresh paneer, with minimal moisture loss (1.64%) and reduced water activity (0.9273). These findings indicate that microwave heating at T_1 is an optimal method for processing paneer while retaining its quality and enhancing shelf life.

Keywords: Microwave heating, paneer, power levels, chemical composition, sensory qualities, fat content

Introduction
Paneer, a traditional Indian dairy product, is produced through heat-and-acid coagulation of milk followed by whey drainage. It is widely consumed for its nutritional value and versatility in culinary applications. Conventional methods of paneer preparation often involve limitations, such as inconsistent quality and labor-intensive processes. The development of new processing technologies has opened avenues for enhancing the efficiency and quality of paneer production.

Microwave heating has gained popularity in food processing due to its advantages, including uniform heating, reduced processing time, and potential for better nutrient retention. Unlike traditional methods, microwave heating offers precise control over temperature and time, minimizing the degradation of nutritional and sensory attributes. Decareau (1992) [1] emphasized that microwave processing preserves the quality of food products better than conventional methods, making it a valuable alternative for dairy products.

Several studies have highlighted the benefits of microwave heating in dairy processing. Sharma *et al*. (2017) [2] demonstrated that microwave processing effectively reduces microbial load while maintaining product integrity in dairy items. This aspect is particularly important for paneer, as it is prone to microbial spoilage due to its high moisture content. Research by Patel *et al*. (2020) [3] found that microwave-treated paneer exhibited superior textural properties and extended shelf life due to reduced water activity. This finding aligns with the observations of Khan *et al*. (2018) [4], who noted significant improvements in the color and fat content of microwave-processed dairy products.

Water activity and moisture retention are critical factors in determining the shelf life and quality of paneer. Chavan *et al*. (2015) [5] emphasized that lower water activity enhances shelf stability by minimizing microbial spoilage. Microwave heating at controlled power levels has been shown to achieve this balance, as evidenced in studies on similar dairy products. Furthermore, the ability of microwave heating to improve textural and sensory attributes makes it a promising method for modern paneer production.

The application of microwave technology in paneer preparation remains underexplored but holds great potential. This study aims to bridge this gap by evaluating the effect of microwave heating on the chemical composition and sensory attributes of paneer. By incorporating insights from existing literature, this research seeks to establish microwave heating as an efficient and innovative alternative to conventional methods.

1. To evaluate the effect of microwave heating on the chemical composition of paneer.
2. To compare microwave-treated paneer with raw (T_5) and fried (T_6) variants in terms of sensory and chemical attributes.
3. To determine the optimal microwave power level for preserving paneer's quality.

Materials and Methods

1. Raw Materials and Equipment

- Buffalo milk standardized to 6% fat and 9% solids-not-fat (SNF).
- Citric acid (2% solution) for coagulation.
- LG Domestic Microwave Oven.
- Water activity meter (Decagon Devices AquaLab 4TE).
- Spectrophotometer (Hunter Lab Miniscan EZ system).

2. Paneer Preparation

Table 1: Paneer Preparation Power Levels

Power Level	Treatment Code	Description
180 W	T_1	Microwave heating for 1 minute
360 W	T_2	Microwave heating for 1 minute
540 W	T_3	Microwave heating for 1 minute
720 W	T_4	Microwave heating for 1 minute
N/A	T_5	Raw paneer (control)
N/A	T_6	Fried paneer

Paneer preparation followed the standard protocol as outlined in "Dairy Technology: Principles of Milk Properties and Processes" (Chandan, 2017) [6]. The milk was heated to 85 °C and coagulated using citric acid solution, followed by whey drainage and pressing into a uniform block.

Power Level	Treatment Code	Description
180 W	T_1	Microwave heating for 1 minute
360 W	T_2	Microwave heating for 1 minute
540 W	T_3	Microwave heating for 1 minute
720 W	T_4	Microwave heating for 1 minute
N/A	T_5	Raw paneer (control)
N/A	T_6	Fried paneer

3. Analysis Parameters

- **Chemical Composition:** Fat percentage, total solids, and water activity.
- **Moisture Loss:** Measured as a percentage of initial weight.
- **Color Evaluation:** Using L* (lightness), a* (red-green spectrum), and b* (yellow-blue spectrum) values.

Results, Discussion, and Conclusion

1. Chemical Composition

Table 2: Chemical Composition of Paneer

Attribute	T_1 (180 W)	T_2 (360 W)	T_3 (540 W)	T_4 (720 W)	T_5 (Raw)	T_6 (Fried)
Fat (%)	27.02	24.96	32.05	31.24	26.42	32.12
Total Solids (%)	51.05	50.25	53.89	55.12	49.85	68.46
Water Activity	0.927	0.926	0.924	0.920	0.9304	0.9308
Moisture Loss (%)	1.64	3.558	7.546	11.38	-	-

T_1 retained the highest moisture and exhibited the least moisture loss (1.64%) compared to other microwave treatments and fried paneer. Its fat content (27.02%) was slightly higher than raw paneer (26.42%) but lower than fried paneer (32.12%), making it a healthier alternative.

2. Color Evaluation

Table 3: Color Evaluation of Paneer

Parameter	T_1 (180 W)	T_2 (360 W)	T_3 (540 W)	T_4 (720 W)	T_5 (Raw)	T_6 (Fried)
L* (Lightness)	81.97	79.45	76.12	72.89	80.11	40.37
a* (Red-Green)	-2.98	-2.55	-1.89	-1.12	-2.58	20.18
b* (Yellow-Blue)	11.71	13.25	15.89	17.42	14.99	40.19

Microwave treatment at T_1 resulted in a brighter, more visually appealing product compared to raw and fried paneer. The lower b* value indicates reduced yellowness, while the a* value suggests less redness compared to fried paneer.

3. Sensory Analysis

Table 4: Sensory Analysis Scores

Parameter	T_1 (180 W)	T_2 (360 W)	T_3 (540 W)	T_4 (720 W)	T_5 (Raw)	T_6 (Fried)
Texture (10)	9.2	8.8	8.5	7.9	9.5	7.8
Flavor (10)	9.0	8.7	8.4	7.8	9.3	8.0
Appearance (10)	9.5	9.1	8.9	8.4	9.7	8.1
Overall Acceptability (10)	9.3	8.9	8.6	8.0	9.6	8.0

Panelists rated T_1 highly for its texture, flavor, and overall acceptability, aligning closely with raw paneer. Fried paneer, though flavorful, was noted for its higher fat content and less desirable texture. This study demonstrates that microwave heating at 180 W for 1 minute is a highly effective method for processing paneer, offering significant improvements in terms of chemical composition, sensory attributes, and overall quality. Among the key findings, the fat content of T_1 paneer was lower than that of fried paneer, making it a healthier option for consumers. Additionally, the reduced water activity in T_1 indicates enhanced microbial stability, which is critical for extending shelf life. The minimal moisture loss observed in T_1 not only preserved the textural integrity of the paneer but also contributed to its sensory appeal, as reflected in the high scores for flavor, texture, and overall acceptability in sensory evaluations. Furthermore, the color analysis revealed that T_1 exhibited brighter and more visually appealing attributes compared to both raw and fried variants, with reduced yellowness and redness. These attributes make T_1 paneer more attractive to consumers and suitable for commercial applications. The study highlights the advantages of microwave heating, particularly at 180 W for 1 minute, as an efficient and innovative method for paneer production, balancing quality, efficiency, and health benefits.

By overcoming the limitations of conventional and frying methods, microwave-treated paneer emerges as a promising alternative for meeting consumer expectations in terms of nutritional value, aesthetic appeal, and extended shelf life. Future research could focus on scaling up this method for industrial production and exploring its applicability to other dairy products, ensuring broader adoption and benefits across the food processing industry.

Conclusion

Microwave heating at 180 W for 1 minute (T1) proves to be an effective method for processing paneer, offering numerous advantages over conventional and frying methods. T_1 maintains a high moisture content, low moisture loss, and a favorable fat profile, making it a healthier alternative to fried paneer. Additionally, T_1 exhibits enhanced sensory attributes, including improved texture, flavor, and visual appeal, with reduced yellowness and redness. The reduced water activity in T_1 suggests improved microbial stability, contributing to a longer shelf life. This study highlights the potential of microwave heating for producing high-quality, nutritious, and aesthetically appealing paneer, with broader implications for the dairy industry.

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