International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Sustainable Valorization of Muskmelon (Cucumis *melo*) Fruit Pulp in Functional Cookie Development

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Abstract:
The bakery sector is continually evolving to create innovative products that satisfy consumer preferences for both taste and improved nutritional quality. Muskmelon is a delicious fruit popular for its nutritive and medicinal properties. This study aimed to incorporate muskmelon fruit pulp into cookies formulations to enhance their nutritional profile while maintaining desirable texture and quality. Five different formulations were prepared using wheat flour (variety – Lokwan) with muskmelon fruit pulp at 90:10, 80:20, 70:30, 60:40 and 50:50 levels respectively. The impact of substitution was evaluated through physical, chemical and sensory analyses. Results indicated that the energy content ranged from 324.59 to 349.30 kcal per 100 g, while protein levels varied between 7.24% and 17.02%. Carbohydrate content was observed in the range of 45.28% to 65.94%, and moisture content ranged from 6.31% to 19.98%. Additionally, total sugar and added sugar contents were recorded between 32.99%–36.25% and 30.14%–33.80%, respectively. The calcium content was found to vary from 505 mg to 625 mg. With respect to physical characteristics, the cookies exhibited minimal variation in weight, ranging from 22.22 g to 22.45 g. However, more noticeable differences were observed in dimensional attributes, where the diameter ranged from 48.79 mm to 67.35 mm and thickness varied between 17.30 mm and 26.77 mm. Sensory evaluation indicated that the cookies were generally well accepted by the panelists. The colour scores ranged from 7.24 to 8.05, texture from 7.40 to 8.55, taste from 8.10 to 8.87, and overall acceptability from 7.11 to 8.89, reflecting a favorable perception across all quality parameters. Value-added cookies products were prepared by incorporating muskmelon fruit pulp and wheat flour (variety–Lokwan) at different incorporation levels. The development of cookies using fruit-derived ingredients provides a practical strategy to simultaneously enhance nutritional quality while promoting environmentally sustainable food practices. Thus, muskmelon fruit pulp could be processed into value-added nutritive products.

Keywords: cookies formulations, wheat flour, muskmelon fruit pulp, sustainable food practices.

Introduction:

The bakery sector continues to expand rapidly, driven by increasing consumer demand for diverse, ready-to-eat, and palatable food options. Among bakery products, cookies are one of the most widely consumed snack items. Their long shelf life, ease of handling, and wide acceptability among all age groups make them a preferred product for nutritional modification and functional food development. The 3 important

points that are usually taken into account regarding the development of an innovative food product are: convenience of the food product, healthy dietary choices, and sustainable food systems (Horvat *et al*., 2019).

Fruits and vegetables play a significant role in human nutrition and are rich sources of vitamins (A, B complex and C) and minerals (calcium, iron and phosphorus) in diets to keep human health in good state (Tucker, 1993). The muskmelon is an important source of dietary fiber, minerals, provitamin A (beta carotene) and vitamin C (Burns *et al*., 2003). Muskmelon can be regarded as a distinctive, economical, safe, and palatable fruit with medicinal value (Parle M. *et al*., 2011).

Perishable fruits are gaining significant importance in cookie formulation, especially in the production of functional, value-added, and nutritionally enhanced bakery products. Adding fruit pulp to cookie formulations enhances their overall nutritional value by supplying naturally occurring sugars, fiber, essential vitamins, and beneficial phytochemicals. Beyond improving the health profile, the use of perishable fruits also promotes sustainable processing practices, as it allows the utilization of excess or overripe fruits that might otherwise be discarded. This approach helps to reduce post-harvest losses and limit food waste. Therefore, developing cookies with fruit-based ingredients offers a practical way to achieve both improved nutrition and greater environmental sustainability.

Muskmelon is also a member of the Cucurbitaceae family and is recognized for its pleasant aroma, refreshing flavour, and sweet pulp. These appealing attributes depend upon the variety and cultivar of the muskmelons. Muskmelon is a beautiful, juicy, tasty and delicious fruit popular for its nutritive and medicinal properties.

Materials and Methods:

Procurement of Raw Materials:

The raw materials required for cookie preparation comprised wheat flour (variety-Lokwan), muskmelon fruit pulp, baking powder, baking soda, brown sugar, ghee, salt, and milk, along with appropriate packaging materials. All ingredients were sourced from the local market of Chalisgaon, located in Jalgaon district, Maharashtra, India. The materials were selected based on their availability and suitability for developing nutritionally enhanced cookies.Composite flour was formulated by blending wheat flour (variety-Lokwan) with muskmelon fruit pulp according to the specified treatment combinations. Initially, brown sugar and ghee were creamed together until a light and uniform consistency was achieved. Subsequently, muskmelon fruit pulp was incorporated into the mixture, followed by the addition of wheat flour, baking powder, baking soda, salt, and milk to obtain homogeneous dough. The prepared dough was then shaped into the desired forms and baked at 180 °C for 15 minutes. After baking, the cookies were allowed to cool at room temperature and were then packed in low-density polyethylene (LDPE) pouches. The packaged samples were stored under ambient conditions (28–32 °C) for stability assessment. Five treatment combinations, namely M1 (90:10), M2 (80:20), M3 (70:30), M4 (60:40), and M5 (50:50), were formulated to evaluate the effect of partial substitution of wheat flour (variety-Lokwan) with muskmelon fruit pulp at different levels. These treatments were analyzed to determine their influence on the chemical, physical, and sensory properties of the developed cookies.Further chemical analysis of the developed cookies was carried out at SHHLOK Food Laboratories Pvt. Ltd., Chhatrapati Sambhajinagar.

Chemical Analysis of Cookies:

The chemical composition of the developed cookies was evaluated by determining parameters such as

energy value, protein content, carbohydrate content, moisture content, ash content, total sugar content, added sugar content and calcium. These analyses were performed to assess the nutritional quality of cookies enriched with banana fruit pulp. All chemical estimations were conducted at a certified food testing facility. The analysis of cookie samples was carried out at SHHLOK Food Laboratories Pvt. Ltd., located in Chhatrapati Sambhajinagar, Maharashtra, India.

Physical analysis of cookies:-

The diameter and thickness of cookies were determined using a Vernier caliper.

Sensory Evaluation of Cookies:-

Sensory evaluation of the developed cookies was carried out to determine their overall acceptability among consumers. A panel of ten untrained members, selected from various academic disciplines with general familiarity with food products, participated in the evaluation. The assessment was conducted using the nine-point hedonic scale (Larmond, 1977), where a score of 9 indicated "like extremely" and 1 indicated "dislike extremely." The panelists evaluated key sensory attributes, including color, flavor, texture, taste, and overall acceptability. The collected data were statistically analyzed using standard deviation and other appropriate methods to identify significant differences among the treatment groups.

Statistical Analysis:

All experimental measurements were performed in triplicate, and the results are presented as mean ± standard deviation.

Observations:

Nutrient Analysis of Muskmelon Fruit:-

Table 1. Chemical Composition of Muskmelon Fruit and Wheat Flour (Variety:Lokwan)

Sr. No.	Parameters	Muskmelon Fruit	Wheat Flour (Variety:Lokwan)
1	Energy (kcal/100g)	43.70	390.2
2	Protein (g/100g)	0.75	12.6
3	Carbohydrates (g/100g)	9.82	80.75
4	Moisture (g/100g)	88.72	6.44
5	Ash (g/100g)	0.65	0.42
6	Total Sugar (g/100g)	8.95	0.0
7	Added Sugar (g/100g)	0.0	0.0
8	Calcium (mg/100g)	9.4	412

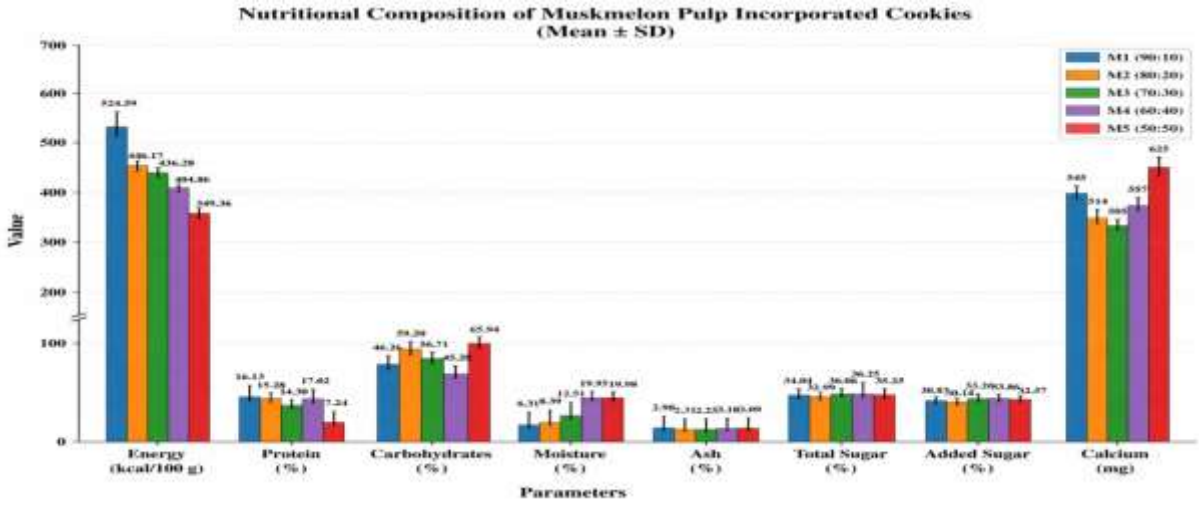
Chemical Composition of cookies:-

Table 2. Proximate Composition of Cookies Prepared Using Muskmelon Fruit Pulp and Wheat Flour (Variety:Lokwan)

Sr.No.	Parameters	M_1 90:10	M_2 80:20	M_3 70:30	M_4 60:40	M_5 50:50
1	Energy	524.59±1.12	446.17±0.12	436.28±0.24	404.86±0.05	349.36±0.30
2	Protein	16.13±0.53	15.28±0.86	14.30±0.30	17.02±0.11	7.24±0.99
3	Carbohydrates	46.26±0.30	59.20±0.62	56.71±1.16	45.28±0.75	65.94±0.30

4	Moisture	6.31±0.55	8.39±0.60	12.51±1.03	19.95±0.33	19.98±0.25
5	Ash	2.98±0.08	2.31±0.54	2.25±0.50	3.18±0.40	3.09±0.34
6	Total Sugar	34.04±0.27	32.99±0.08	36.06±0.13	36.25±0.40	35.25±0.41
7	Added Sugar	30.87±0.24	30.14±0.38	33.26±0.39	33.86±0.70	32.57±0.44
8	Calcium	545±1.00	514±1.00	505±1.00	557±1.00	625 ±1.00

(Values are means of 3 determinations ± Standard deviation)

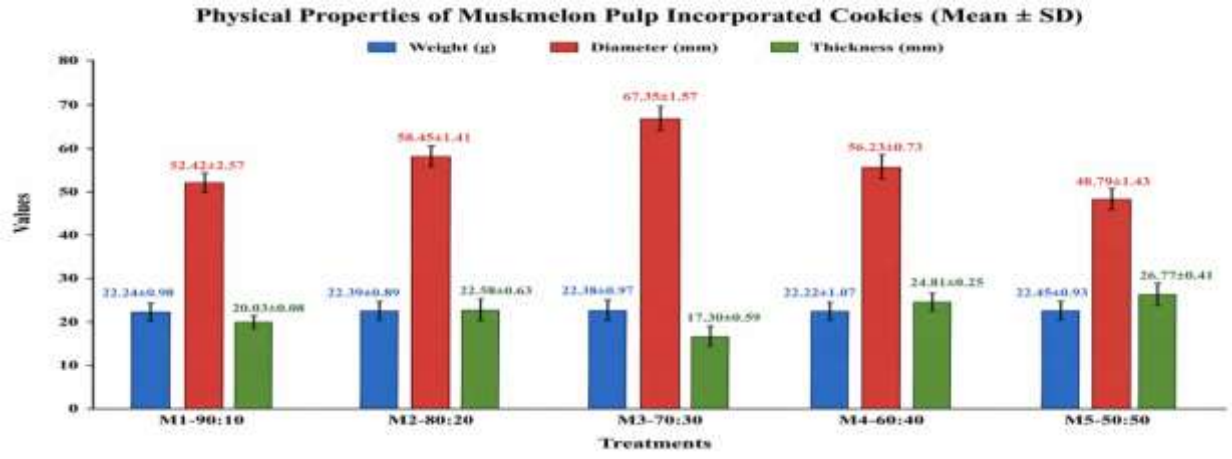


Physical analysis of cookies:-

Table 3. Physical analysis of cookies using Muskmelon Fruit Pulp and Wheat Flour (Variety:Lokwan)

Sr.No	Treatment	Weight (g)	Diameter (mm)	Thickness (mm)
1	M_1-90:10	22.24±0.98	52.42±2.57	20.03±0.08
2	M_2-80:20	22.39±0.89	58.45±1.41	22.58±0.63
3	M_3-70:30	22.38±0.97	67.35±1.57	17.30±0.59
4	M_4-60:40	22.22±1.07	56.23±0.73	24.81±0.25
5	M_5-50:50	22.45±0.93	48.79±1.43	26.77±0.41

(Values are means of 3 determinations ± Standard deviation)

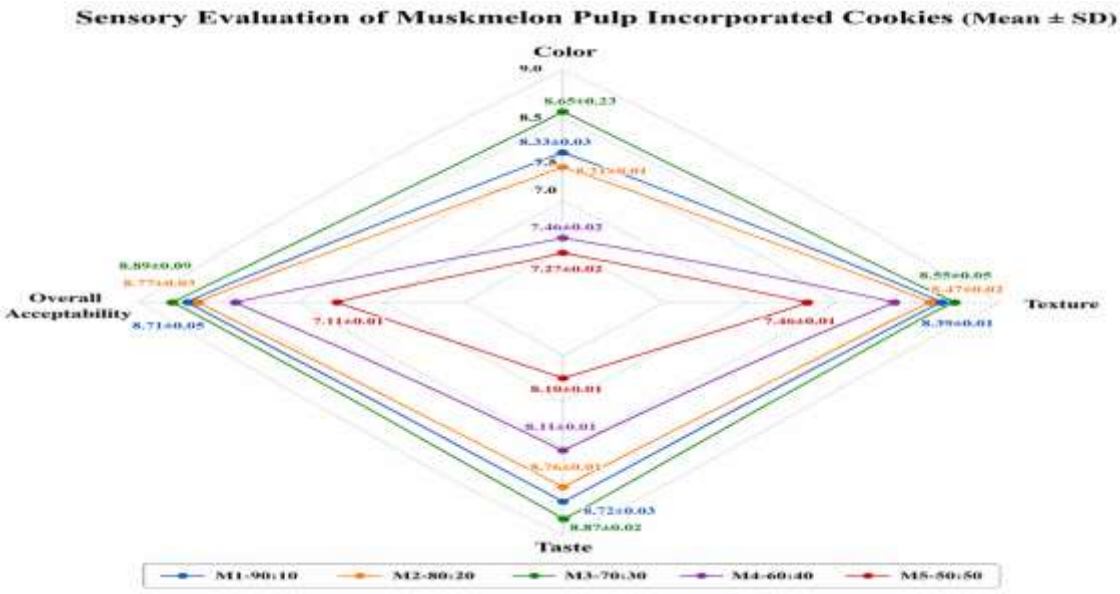


Sensory evaluation of cookies:-

Table 4. Sensory evaluation of cookies using Muskmelon Fruit Pomace and Wheat Flour (Variety:Lokwan)

Sr.No	Parameters	Treatments				
		M_1-90:10	**M_2- 80:20**	**M_3-70:30**	**M_4-60:40**	**M_5- 50:50**
1	Color	8.33±0.03	8.21±0.01	8.65±0.23	7.46±0.02	7.27±0.02
2	Texture	8.39±0.01	8.47±0.02	8.55±0.05	7.62±0.02	7.46±0.01
3	Taste	8.72±0.03	8.76±0.01	8.87±0.02	8.11±0.01	8.10±0.01
4	Overall Acceptability	8.71±0.05	8.77±0.03	8.89±0.09	7.70±0.01	7.11±0.01

(Values are means of 3 determinations ± Standard deviation)



Results and Discussion:

Earlier research on muskmelon-based cookies has predominantly utilized muskmelon flour and seed flour as primary ingredients, as reported by Manika Mehra *et al,.* (2023) and Sangamithra Asokapandian *et al,.* (2015). In contrast, the present study proposes the use of fresh muskmelon fruit pulp as an alternative, offering a different approach to cookie formulation. The formulated cookies exhibited notable variations in nutritional composition, with energy ranging from 324.59 to 349.30 kcal/100 g, protein from 7.24% to 17.02%, carbohydrates from 45.28% to 65.94%, and moisture from 6.31% to 19.98%. Total sugar, added sugar, and calcium contents were recorded between 32.99–36.25%, 30.14–33.80%, and 505–625 mg, respectively. Physical properties showed minimal differences in weight (22.22–22.45 g), while diameter (48.79–67.35 mm) and thickness (17.30–26.77 mm) varied more noticeably. Sensory evaluation indicated good acceptability, with scores for colour (7.24–8.05), texture (7.40–8.55), taste (8.10–8.87), and overall acceptability (7.11–8.89), reflecting a favorable consumer response. The findings of the present study are in agreement with those reported by Najila Al Masoud *et al.,* (2024), Prachi K. Bhoi *et al.,* (2025), and Akshata Gombi (2017).

Conclusion:

The present study confirms that incorporating muskmelon fruit pulp into cookie formulations can improve their nutritional value while preserving desirable physical qualities and sensory appeal. Differences in substitution levels were found to influence important characteristics such as texture, flavour, and overall acceptability, making formulation optimization essential. An appropriate combination can achieve a balance between enhanced nutrition and consumer satisfaction. Thus, cookies enriched with muskmelon pulp offer promising potential as a functional and value-added bakery product for broader utilization.

Declaration of AI Statement:

AI-assisted tools were employed during manuscript preparation exclusively to improve grammar and enhance language clarity.

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