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Valorization of Defatted Black Sesame Cake in Noodle Products: A Sensory Evaluation Study

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Abstract. Reducing food waste through the valorization of agro-industrial by-products has become an important challenge in sustainable food systems. At the same time, functional noodles have attracted increasing attention as a convenient staple food platform for delivering added nutritional and health-related benefits. In this study, defatted black sesame cakes, a by-product generated after oil extraction, was repurposed as an ingredient in noodle formulations to evaluate its sensory feasibility. Three different common carbohydrate-based noodle sources were studied to examine the applicability of defatted black sesame cake in different noodle matrices. Sensory evaluation was conducted with 15 panelists, and the data were analyzed using non-parametric statistical methods (Kruskal–Wallis test), followed by appropriate post hoc comparisons. Based on sensory evaluation, the preferred level of defatted sesame was 5% in wheat-based noodles, 10% in rice-based noodles, and 5% in semolina-based noodles, with mean liking scores of 7.67±0.98, 6.00±1.51, and 6.87±1.68, respectively, on a 9-point hedonic scale. Significant differences among formulations were observed for selected sensory attributes, with color ($P<0.01$) and overall liking ($P<0.05$) showing particularly strong variation across samples. Overall, the results suggest that defatted black sesame cake can be incorporated into noodle formulations without compromising sensory acceptability. The variation in optimal substitution levels across noodle types further highlights the importance of matrix-specific formulation strategies, supporting its potential application in sustainable and functional noodle products.

1 Introduction

With economic development, health problems such as overnutrition and high blood sugar have increased sharply. The latest data released by World Diabetes Day shows that the number of adult diabetes patients worldwide has exceeded 800 million. With the increase in global demand for healthy food, consumers are increasingly concerned about foods that are high in protein, low in fat, and rich in dietary fiber.

Noodles, as a popular staple food worldwide, has traditionally been made from wheat [1]. Therefore, its nutritional components are simple and lack other essential nutrients such as dietary fiber, protein, vitamins, and minerals, being just a source of energy. Regular noodles

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are high GI(50~70) foods that cause rapid blood sugar rise and are not a high-quality source of carbohydrates. Noodles still has room for improvement in texture and flavor [2]. The addition of defatted sesame cakes not only enhances its nutritional value but also potentially improves its texture and flavor. Nowadays, converting food industry waste into valuable dietary products is becoming a challenge. In the market, most sesame products are made from whole sesame seeds, while there are few studies on making healthy baked foods using defatted sesame cakes. The defatted sesame cakes are waste from the sesame oil industry, with a protein content of approximately 55%, 6.12% ash, 10.8% crude fiber, and 28.8% carbohydrates [3]. The defatted sesame cakes are rich in high-quality protein, unsaturated fatty acids, and bioactive components such as sesamin and sesamol. These components not only help improve the nutritional value of food but also enhance the antioxidant and texture properties of food [4].

This study aims to explore the impact of defatted sesame cakes addition on the consumer view of nutritional components and functional characteristics of different noodles-based ingredients. A sensory evaluation of consumer acceptance of different noodle-based enriched with defatted sesame cakes were conducted to inform future commercialization strategies. Through systematic analysis, the potential application of defatted sesame cakes in soybean noodles is evaluated to provide theoretical basis for developing new high-protein and high-fiber noodles products.

2 Material and methods

2.1 Materials

Wheat flour, rice flour and semolina flour were purchased from a local commercial supplier. Defatted black sesame powder (*Sesamum indicum* L.) was supplied by a local oil-processing manufacturer as a by-product of cold-press oil extraction [5].

The defatted black sesame powder was sieved through a 60-mesh sieve (250 μm) to obtain a uniform particle size and stored in airtight polyethylene bags at 25 °C until use. All flours were kept under dry and dark conditions at room temperature prior to noodle preparation. All samples were made with distilled water.

2.2 Sample preparation

The noodles were prepared following a standard laboratory procedure with slight modifications. Defatted black sesame (DBS) powder was incorporated into wheat flour, rice flour, and durum wheat semolina at substitution levels of 0%, 5%, 10%, and 15% (w/w). The dry ingredients were thoroughly mixed to ensure uniform distribution of DBS [6].

Distilled water was added at 50% (w/w, based on flour weight), and the mixture was kneaded until a homogeneous dough was formed. The dough was allowed to rest at room temperature (25°C) for 30 min to ensure proper hydration and gluten development in wheat-based formulations.

After resting, the dough was sheeted and cut into strands with a width of approximately 0.5 cm using a laboratory noodles roller. The noodles were prepared as fresh (wet) noodles.

Prior to sensory evaluation, the noodles were cooked in boiling water for 5 min [7], then immediately rinsed with cold water to stop further cooking and remove excess surface starch. The cooked noodles were drained and served with warm chicken broth for a 9-point hedonic evaluation.

Fig. 1. Appearance of wheat-based noodles with different levels of defatted black sesame cake: (A) 0%, (B) 5%, (C) 10%, and (D) 15% substitution.

2.3 Sensory evaluation

This research was certified by Assumption University Institution Review Board (certification no. 108/2025). Noodles samples were cooked with a pinch of salt at the optimum cooking time [6], randomly coded, and served warmly to 15 panelists. Participants were asked to rate the color, chewiness, softness, overall taste, and overall liking of the noodles on a Hedonic Scale (1 dislike extremely; 9 like extremely).

2.4 Statistical Analysis

Sensory data were statistically analyzed using one-way analysis of variance (ANOVA), followed by Tukey's honestly significant difference (HSD) test for post hoc comparisons with SAS 9.4 version from SAS Institute.

3 Results and discussion

For all three noodle matrices (wheat-, rice-, and semolina-based), sensory evaluation results indicated that there were no statistically significant differences among samples for color, chewiness, softness, overall liking, and taste ($p > 0.05$). Nevertheless, differences in mean scores were observed across substitution levels, particularly for overall liking, suggesting that certain formulations may be more preferred by panelists. Based on the observed mean liking scores, the preferred substitution levels were 5% for wheat noodles (Table 1), 10% for rice noodles (Table 2), and 5% for semolina noodles (Table 3), although these differences were not statistically significant.

Table 1. Mean sensory scores (9-point hedonic scale) of wheat noodles enriched with defatted black sesame at different substitution levels

	Color	Chewiness	Softness	Overall Taste	Overall Liking
W1	7.80±1.26	7.13±1.41	7.07±1.67	7.73±1.03	7.67±0.98
W2	6.40±1.72	6.87±2.13	7.20±1.78	7.33±1.50	7.20±1.78
W3	6.27±1.98	6.73±1.39	6.00±1.93	6.67±1.05	6.93±1.10
W4	6.20±1.82	6.40±2.09	6.73±1.90	6.80±1.74	6.60±2.10

Remark: Values were indicated as a mean ± standard deviation.

W1 (100 % wheat); W2 (95 % wheat, 5 % defatted black sesame flour); W3 (90 % wheat, 10 % defatted black sesame flour); W4 (85 % wheat, 15 % defatted black sesame flour).

Table 2. Mean sensory scores (9-point hedonic scale) of rice noodles enriched with defatted black sesame at different substitution levels

	Color	Chewiness	Softness	Overall Taste	Overall Liking
R1	6.00±2.07	5.27±2.31	5.00±2.14	5.13±2.13	5.53±2.17
R2	6.07±1.91	5.67±1.50	5.93±1.87	5.60±1.76	6.00±1.51
R3	6.07±1.91	5.87±1.77	5.33±1.84	5.80±1.93	5.67±1.76
R4	5.20±2.54	5.06±2.31	5.06±2.34	4.07±2.12	4.40±2.30

Remark: Values were indicated as a mean ± standard deviation.

R1 (100 % rice); R2 (95 % rice, 5 % defatted black sesame flour); R3 (90 % rice, 10 % defatted black sesame flour); R4 (85 % rice, 15 % defatted black sesame flour).

Table 3. Mean sensory scores (9-point hedonic scale) of semolina noodles enriched with defatted black sesame at different substitution levels

	Color	Chewiness	Softness	Overall Taste	Overall Liking
S1	6.33±2.06	6.07±1.58	6.13±1.55	6.40±1.55	6.13±2.03
S2	7.33±1.54	6.07±1.87	7.27±1.22	6.80±1.66	6.87±1.68
S3	6.07±2.09	5.67±2.06	5.87±2.07	5.80±2.11	5.67±1.88
S4	6.40±1.30	5.47±1.55	6.27±1.67	6.60±1.92	6.47±1.41

Remark: Values were indicated as a mean ± standard deviation.

S1 (100 % semolina); S2 (95 % semolina, 5 % defatted black sesame flour); S3 (90 % semolina, 10 % defatted black sesame flour); S4 (85 % semolina, 15 % defatted black sesame flour).

Previous studies have demonstrated that the incorporation of non-wheat or multigrain components into noodle formulations can significantly influence both physicochemical and sensory properties. For example, the addition of soy flour and sorghum flour in multigrain noodles has been reported to improve nutritional value and antioxidant capacity, while also affecting functional properties such as solubility and water absorption [8].

Overall, the impact of defatted black sesame incorporation was matrix-dependent. The defatted sesame cakes, which are high in protein (approximately 55%) and crude fiber (10.8%) [3], likely contribute to the increased coarseness and sandy mouthfeel of the noodles. Increasing the proportion of sesame cake substitution produced a clear decline in sensory acceptability scores, particularly for rice noodles, which contain the lowest gluten content among the three base flours. While color was consistently affected due to the inherent pigmentation of black sesame, overall liking was maintained in wheat noodles and only moderately influenced in rice and semolina noodles at higher substitution levels. These results suggest that incorporation levels up to 10% are feasible across different noodle matrices without substantial reduction in consumer acceptance.

Starch substitution is central to optimizing noodle quality, since replacing native starches with alternative ingredients directly alters structural features and thereby the functional properties that determine texture, cooking performance, and interactions with gluten proteins. Strategic starch substitution is especially important for starch-based noodles and can improve shelf life and dough integrity while potentially reducing strength and deformation resistance. Effective substitution decisions depend on raw material selection, processing methods, additives, and critical processing steps, all of which can modify starch functionality during production. Although starch substitution offers practical routes to enhance thermal, pasting, cooking, textural, nutritional, and sensory outcomes, technological, sensory, and nutritional trade-offs remain and must be managed to achieve optimal formulations for both conventional and functional noodle products [9-10].

4 Conclusion

Incorporation of defatted black sesame (DBS) at levels up to 15% in wheat, rice, and semolina noodles resulted in products with acceptable sensory quality, although matrix-dependent effects were observed. Wheat noodles maintained overall liking across substitution levels, despite significant changes in color and overall taste. In contrast, rice and semolina noodles showed reduced overall liking at higher substitution levels, indicating that these matrices may be more sensitive to elevated DBS incorporation.

The addition of DBS darkened the color of the noodles, which is consistent with the characteristic pigmentation of black sesame. However, this color change did not substantially compromise consumer acceptance, particularly in wheat-based formulations. Textural modifications were observed in semolina noodles, suggesting that structural differences among cereal matrices influence consumer perception.

Beyond sensory performance, DBS offers nutritional advantages due to its high protein, dietary fiber, and phenolic content. Therefore, incorporation levels up to approximately 10% appear feasible across different noodle matrices without significant reduction in overall acceptability, while potentially enhancing nutritional value.

Overall, the present findings support the application of defatted black sesame as a sustainable and value-added functional ingredient in cereal-based products. Future studies should further investigate the nutritional enhancement, including detailed compositional analysis and bioavailability assessment, to validate the potential health benefits of DBS-enriched noodles.

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