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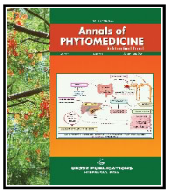

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Examining the sensory and cooking qualities of noodles enriched with lentils and investigating the physical and functional attributes of composite flours

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Abstract

The current research aimed to develop extruded noodles with enriched nutritional content while maintaining acceptable physical and sensory properties of the noodles and composite flour. Five formulations; namely, C (100% wheat), T1 (90% wheat + 10% lentils), T2 (80% wheat + 20% lentils), T3 (70% wheat + 30% lentils), and T4 (60% wheat + 40% lentils), were assessed for cooked noodles using Hedonic scale. Among them, T3 (70% wheat + 30% lentils) and the control noodles (C-100% wheat) exhibited the highest acceptance in the study. The selected T3-Lentil-incorporated noodles composite flour (LINCF) had a lower bulk density (0.87 g/ml) compared to the control (0.89 g/ml). T3-LINCF also demonstrated superior water absorption capacity (121.33 ml/g) and swelling power (5.61%) in contrast to the C-control wheat noodles composite flour (CWNCF) (110.67 ml/g, 4.60%), while solubility was significantly higher for T3-LINCF (22.53) than the C-CWNCF (16.67). The cooking time for T3-Lentil-incorporated noodles (LIN) and C-control wheat noodles (CWN) were 12.00 and 10.33 min, respectively. Additionally, T3-LIN showed higher cooked weight (76.86 g/25 g), cooking yield (307.46%), lower bulk density (0.52 g/ml), higher swelling index (2.22), and increased total solid loss in gruel (7.49%) compared to control noodles (71.06 g/25 g, 284.10%, 0.55 g/ml, 1.94%, 2.43% by mass, respectively). In conclusion, the study successfully developed lentil-incorporated extruded noodles with superior sensory attributes, functional properties and nutritional richness as evidenced by the higher acceptance of T3 formulation. These findings contribute valuable insights for producing healthier and well-accepted noodle products through extrusion processing.

1. Introduction

The rising global demand for instant food, particularly noodles, is driven by factors like cost-effectiveness and appealing taste (Gulia *et al.,* 2014). Forecasts suggest that the output of noodles is expected to hit 145.8 million packs by 2020, with approximately half of the wheat consumption allocated to noodle manufacturing across Asian countries (Hou, 2011). Noodle formulations have explored diverse ingredients to enhance nutritional value, aligning with consumer health preferences. The utilization of extrusion technology in the food industry is a promising avenue for processing a diverse range of products with varied shapes, tastes, sizes and textures (Hundal *et al*., 2017). Worldwide, extrusion cooking is widely utilized in the manufacturing of noodles, fulfilling the significant need for convenient and nutritious instant products among consumers of all age groups. Enhancing product quality is accomplished through the regulation of extrusion conditions, such as feed extrusion temperature, moisture content and screw speed (Rathod and Annapure, 2016).

On a global scale, an astonishing 116.5 billion servings of instant noodles were consumed, equating to an average of approximately 319 million servings per day. Notably, between 2016 and 2020, there was a significant upsurge in instant noodle consumption, with an increase of 162.7% in Saudi Arabia and 166.7% in Egypt. In 2020, estimates from the World Instant Noodles Association indicated that consumption reached 830 million servings in Saudi Arabia and 350 million servings in Egypt. Instant noodles are universally embraced regardless of geographical location, age, or gender, despite their limited nutritional value. Chowdhury *et al.* (2020) uncovered a protein content spanning from 8.5% to 12.5%. However, they also highlighted shortcomings in crucial nutrients such as dietary fiber and vitamins.

Composite flours are comprised of combinations of starch-rich tuber flours (such as yam, cassava, and sweet potato), protein-rich flours (like peanut and soy), and/or cereals (such as millet, maize, buckwheat and rice), with or without wheat flour. Essentially, composite flour denotes a blend of non-wheat flours, sometimes including wheat, utilized in the production of baked goods or snacks, traditionally made from wheat flour, to augment the essential nutrient content in the human diet. Functional properties encompass crucial physicochemical characteristics that reflect the intricate interplay among the composition, structure, molecular conformation, and physicochemical attributes of food components, taking into account

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the environmental conditions under which they are evaluated (Kinsella and Melachouris, 1976). These properties are vital for evaluating and potentially predicting the behaviour of new proteins, fats, fibers, and carbohydrates in specific systems. They also determine whether such proteins can effectively substitute or simulate conventional proteins (Mattil, 1971).

The demand for pulses among the World's population has significantly increased recently (Pandey *et al.*, 2022). Due to their high protein, dietary fiber, and carbohydrate content.

Lentils (*Lens culinaris*) have emerged as a dietary staple in numerous regions, offering a broad spectrum of both micronutrients and macronutrients (Rathod and Annapure, 2016). The composition and nutritional profile of lentils display considerable diversity among different varieties. Grusak (2009) compiled data from various studies, indicating protein content ranging from 15.9% to 31.4%, carbohydrates from 43.4% to 74.9%, fat from 0.3% to 3.5%, total fiber from 5.1% to 26.6%, and ash from 2.2% to 6.4%. Lentils also serve as abundant sources of bioactive phytochemicals, encompassing flavonoids (flavanols and flavonols), extractable and insoluble-bound phenolics, carotenoids, tocopherols, saponins, phytic acid, and phytosterols, all of which confer various health benefits. Notably, among legumes, lentils exhibit notably high phenolic content, which correlates with potent antioxidant activity. Particularly, the seed coat or hull of red lentils boasts rich phenolic compounds with demonstrated antioxidant properties. Contributing to a lower glycemic index, lentils owe this effect to their elevated protein and dietary fiber content, which facilitate slower digestion of available carbohydrates. A one-cup (197 g) serving of cooked lentils supplies approximately 15.6 g of fiber, meeting 62% of the daily requirement, and offers a commendable mineral content (Dhull *et al.*, 2023).

Consistent consumption of lentils has been linked to enhanced human nutrition and the mitigation of chronic diseases such as diabetes, obesity, heart disease, cancer, and metabolic disorders (Pathak and Singh, 2022). Particularly in regions where access to meat and dairy products may be limited due to ethical concerns or allergenicity, lentils serve as a primary source of protein for human nutrition. Given the widespread availability of processed, high-calorie foods, which contribute to increased food consumption and decreased energy expenditure, ultimately leading to obesity, the importance of maintaining a balanced energy intake and expenditure for weight management is underscored (Sharma and Sarwat, 2022).

Scholars emphasize that include items made from legumes in daily meals is important for promoting general health and well-being (Boye *et al.*, 2010; Tharanathan and Mahadevamma, 2003). A vital component in the prevention of metabolic disorders such as obesity, diabetes mellitus, renal disease, growth retardation, and coronary heart disease, lentils also provide vital vitamins and micronutrients (Rathod and Annapure, 2016; Boye *et al.*, 2010; De Almeida Costa *et al.*, 2006; Simpson, 1981). In the meanwhile, rice noodles a popular type of Asian noodles are consumed extensively in Southeast Asia and are usually produced with rice flour or a mix of starches and hydrocolloids (Bhattacharya *et al.*, 1999; Hormdok and Noomhorm, 2007).

In today's consumer landscape, a heightened awareness of health prompts individuals to prioritize nutritionally dense foods, particularly those abundant in protein and dietary fiber, all while maintaining an eye on affordability. This emphasis on health stems from the understanding that consumption of low-calorie and reduced-fat products can mitigate the risk of ailments such as cancer and heart disease (Patel *et al.*, 2022). As a result, there's a notable surge in the popularity of products enriched with natural antioxidants, as opposed to synthetic counterparts, which are associated with adverse health effects (Aggarwal *et al.*, 2022). While research extensively explores the integration of fiber sources into wheat-based noodles, there remains a notable gap in knowledge regarding noodles that are simultaneously enriched with both protein and fiber (Boye *et al.*, 2010). This void presents an opportunity for further exploration and innovation in the realm of food science and product development, catering to the evolving preferences and health-conscious choices of consumers. This study aimed to evaluate the sensory and cooking qualities of lentil-enriched noodles, delving into the physical and functional characteristics of composite flours, emphasizing the potential of combining cereals and legumes to create nutritionally rich products.

2. Materials and Methods

2.1 Raw materials

The components, comprising locally sourced lentil grains, wheat flour (Aashirvaad Brand), and salt (Tata Brand), were procured from the Pantnagar local market in India. The noodle binding agent, guar gum (Weissmill Brand), was supplied by Bossan Pvt. Ltd., Bangalore, India. All chemicals utilized in the research were of analytical grade and were acquired from Allied Chemicals in Pantnagar, Uttarakhand.

2.2 Grain processing for lentils

After thoroughly cleaning the grains to remove any dust, they were dried for three hours at 60°C in a hot air oven until the moisture content was about 8%. Subsequently, the dehydrated grains were crushed in a Wiley apparatus and were sieved *via* a 60-micron (0.25-mm) mesh screen.

2.3 Formulation of composite flours

Experimental composite flours, incorporating lentils, were formulated alongside a control wheat flour, resulting in five formulations (C and T1 to T4), as outlined in Table 1.

Table 1: Composite flours formulation

Ingredients	Formulations for composite flours				
	Control	Experimental (Lentil incorporated)			
	C	T1	T2	T3	T4
Wheat flour (g)	100	90	80	70	60
Lentil flour (g)	0	10	20	30	40
Salt (g)	2	2	2	2	2
Guar gum (g)	2	2	2	2	2

2.4 Noodles making procedure

Experimental, *i.e.*, lentil incorporated noodles (LIN- T_1 to T_4) along with control noodles (CWN) were formulated by the procedure given by Dixit and Chaudhary (2017) .Utilize properly sieved lentil flour (g), wheat flour (g), salt (g), guar gum (g), and water (ml) for distinct formulations, including control and experimental ones:

C(0:100:2:2:52), T1 (90:10:2:2:53), T2 (80:20:2:2:53), T3 (70:30:2:2:53), and T4 (60:40:2:2:55). Combine all ingredients to form a dough, kneading deliberately for 15 min. Allow the dough to rest for 1 h at room temperature. Using a Q2 noodle extruder that is handled by hand, form the bails into strips of noodles. Dry the noodles at 80°C for 3 h or until they reach a consistent weight. Package the noodles in low density poly ethylene (LDPE) pouches for later use (Dixit and Chaudhary, 2017).

2.5 Assessment of the sensory attributes of cooked noodles (LIN and CWN)

The sensory characteristics of experimental noodles, *i.e.,* lentil incorporated noodles (LIN-T1 to T4), along with control wheat noodles (CWN), were assessed using a hedonic scale (Amerine *et al.*, 1965).

2.6 Characterization of the physical and functional attributes of composite flours.

The bulk density of composite flours was assessed following the methodology outlined in Okaka and Potter's (1979) work. Water absorption capacity was determined using the procedure detailed by Smith and Circle (1972). Swelling power and solubility of composite flours were evaluated based on the method described by Schoch (1964).

2.7 Cooking quality of selected lentil incorporated and control noodles

20 g noodles were boiled in 120 ml of water with 2 g of salt for duration of 12 min. The noodles were boiled, the extra water drained out and then they were immediately put through a sensory analysis process that lasted 5 min. The process used to determine the ideal cooking time was that described by Singh *et al.* (1989). The method of measuring cooked weight as outlined by Prabhasankar *et al.* (2007) was employed. The formula for cooking yield was calculated using the AACC (2000) method. Noodles made from cooked lentils were measured for bulk density using the techniques of Okaka and Potter (1979) and Shobha *et al.* (2015). The technique outlined by Mestres *et al.* (1988) was used to determine the cooked noodles' swelling index. The gruel's total solid loss was calculated using ISI (1993) guidelines.

3. Results

3.1 Sensory evaluation

The sensory evaluation of the lentil flour-made noodles showed substantial modifications ($p<0.05$) in several measures (Table 2). Regarding appearance, a decrease in scores was noted with increasing lentil flour incorporation, attributed to the intensified dark color from higher lentil content. Despite this trend, all appearance scores fell within the liked range on the hedonic scale. In terms of color, significant differences were observed, with T1 obtaining the highest score along with the control, indicating favourable coloring. Flavour scores exhibited a decreasing trend with higher lentil substitution, except for T3, which resembled the control in terms of flavor, suggesting 30% lentil flour incorporation yielded the most acceptable flavor. When lentil replacement increased, texture scores trended downward, but no discernible change was seen up to 30%. Taste decreased with lentil flour addition, except for T3, which had a taste comparable to the control, implying 30% lentil flour incorporation led to better taste. Overall acceptability showed significant differences, with 100% wheat noodles and 70:30 wheat-lentil ratio noodles being the most acceptable, mirroring the findings of individual parameters. The highest average score was observed for T3 (30% lentil flour), indicating its high acceptability and similarity to the control noodles.

3.2 Physical and functional properties of composite flours

3.2.1 Physical property: Bulk density

In the assessment of composite flours, the physical characteristic of bulk density was measured in triplicates for a 30% lentil incorporated noodles composite flour T3 (LINCF) and compared with the control wheat noodles composite flour (CWNCF) (Table 3). Bulk density, reflecting the heaviness of flour samples and influenced by particle size, is a crucial factor in noodle production. A substantial ($p<0.05$) difference was seen in the measured bulk densities of LINCF(T3) and CWNCF (C) flour, which were 0.87 and 0.90 g/ml, respectively, when compared to control and lentil-incorporated noodle flour.

3.2.2 Functional properties

For 30% lentil-incorporated noodles composite flour T3 (LINCF), the functional properties of the flour water absorption capacity (WAC), swelling power and solubility were examined in triplicate and contrasted with the control wheat noodle composite flour (CWN) (Table 3). The amount of water required to achieve the proper dough consistency or water absorption capacity (WAC), was much higher in LINCF (T3) (121.33 ml/100 g) than in CWNCF(C) (110.67 ml/100 g). Swelling power, indicative of the water absorption index during heating, showed non-significant differences between LINCF (T3) (5.63 g/g) and CWNCF (C) (4.65 g/g). Solubility, representing the amount of solute that dissolves in a solvent, was significantly higher in LINCF (T3) (22.53 g/100 g) compared to CWNCF (C) (16.67 g/100 g).

Table 2: Hedonic scores of sensory evaluation of cooked noodles

Sample	Appearance	Colour	Flavour	Mouthfeel	Taste	Overall acceptability	Average score
C	8.50 ± 0.53^{a}	8.40 ± 0.52^{a}	8.60 ± 0.52^{a}	8.50 ± 0.53^{a}	8.67 ± 0.50^{a}	8.60 ± 0.52^{a}	8.55
T1	7.81 ± 0.43^{b}	7.80 ± 0.42^{b}	6.70 ± 0.67^{c}	7.40 ± 0.52^{b}	6.80 ± 0.42^{c}	7.10 ± 0.57^{b}	7.27
T2	7.60 ± 0.52^{b}	7.50 ± 0.53^{b}	7.20 ± 0.42^{b}	7.30 ± 0.48^{b}	7.30 ± 0.48^{b}	7.20 ± 0.42^{b}	7.35
T3	7.60 ± 0.52^{b}	7.60 ± 0.52^{b}	8.50 ± 0.53^{a}	8.20 ± 0.42^{a}	8.40 ± 0.52^{a}	8.30 ± 0.48^{a}	8.10
T4	7.40 ± 0.52^{bc}	7.10 ± 0.32^{bc}	6.60 ± 0.52^{c}	6.60 ± 0.52^{c}	6.70 ± 0.48^{c}	7.00 ± 0.47^{b}	6.90
CD 5%	0.403	0.361	0.482	0.443	0.465	0.413	-
CV	5.716	5.190	7.097	6.431	6.787	5.966	-

The values reflect the mean ± standard deviation of 10 independent assessments.

Table 3: The chosen lentil-incorporated composite flour's physical and functional qualities are compared to the control composite flour.

Properties	Sample attributes	LINCF (T3)	CWNCF(C)	t-value
Physical property	Bulk density (g/ml)	0.87 ± 0.004	0.90 ± 0.005	(NS)
Functional Property	Water absorption capacity (ml/ 100 g)	121.33 ± 2.31	110.67 ± 1.15	7.155 (S)
	Swelling power (g/g)	5.63 ± 0.023	4.65 ± 0.461	NS
	Solubility (g/100 g)	22.53 ± 0.462	16.67 ± 0.611	4.237 (S)

Values are mean ± SD of three independent observations.
LINCF= Lentil incorporated noodles composite flour (30% lentil flour + other ingredients).
CWNCF= Control wheat noodles composite flour (100% wheat flour + other ingredients).
At $p<0.05$, S is significant; NS is non-significant.

3.3 Cooking quality of T3-LIN versus C-control

The ideal characteristics of cooked noodles include elasticity, firmness, resilience and non-stickiness, which contribute to optimal consumer satisfaction. The cooking attributes of T3-lentil incorporated noodles (LIN) and C-control wheat noodles (CWN) are detailed in Table 4.

3.3.1 Cooking time

The variance in cooking duration for noodles may stem from variations in the gelatinization temperatures of their respective flours. C-Control wheat noodles (CWN) exhibited a shorter cooking time of 10.33 min in contrast to T3-Lentil incorporated noodles (LIN), which required 12.03 min. This notable distinction in cooking times between the two types of noodles was statistically significant ($p<0.05$), indicating a substantial variation in their properties.

3.3.2 Cooked weight

The weight of the noodles after cooking, known as the cooking weight, increases due to water absorption. The cooked weight of C-control wheat noodles (CWN) (76.86 g/25 g) is lower compared to T3-lentil incorporated noodles (LIN) (71.06 g/25 g). A significant difference ($p<0.05$) between Lentil incorporated noodles and control noodles was observed.

3.3.3 Cooking yield

The ability of the noodles to absorb water while cooking is indicated by the cooking yield, which is measured as the proportion of the cooked noodles' weight compared to their raw weight. Superior alkaline noodles are often indicated by higher cooking yield values and lower cooking loss. Due of lentil flour's special ability to hold onto more water, T3-LIN (307.46 g) produced more noodles after cooking than C-CWN (208.42 g). There was a noticeable distinction ($p<0.05$) between the noodles with lentil incorporation and the control group.

3.3.4 Bulk density

The weightiness of a flour sample is indicated by bulk density, which is generally impacted by particle size. Compared to C-CWN (0.54), T3-LIN has a lower bulk density (0.52). There was a noticeable distinction ($p<0.05$) between the noodles with lentil incorporation and the control group.

Figure 1: Images of cooked noodles with different formulation (Control, T_1, T_2, T_3 and T_4).

3.3.5 Swelling index

The noodles' ability to swell is indicated by their relative hydration rate. T3-LIN has a larger swelling capacity (222%) than C-CWN (194%). There was a noticeable distinction ($p<0.05$) between the noodles with lentil incorporation and the control group. The main element influencing the lentil husk's ability to retain water and expand is its fiber content.

3.3.6 Total solid loss in gruel

The term "cooking loss" describes the particles that seep into the cooking medium during the cooking process from the noodles. This attribute is a reflection of the noodles' surface qualities as reported by Shiau and Yeh (2001). Because of the high starch content in the cooking medium and the restricted heating tolerance of the noodles, Chakraborty *et al.* (2003) state that a bigger cooking loss indicates a stickier noodle surface, which is undesirable. Wu *et al.* (1987), on the other hand, recommend that the cooking loss not exceed 10% of the dry weight. By mass, C-CWN's cooking loss (2.43%) was less than T3-LIN's (7.49%). The gruel in our investigation had the appropriate level of total solid loss and the values of the two noodles differed significantly. There was a noticeable distinction ($p<0.05$) between the noodles with lentil incorporation and the control group.

Table 4: Cooking properties of T3-LIN and C-CWN (mean ± SD) N=3

Properties	T3-LIN	C- CWN	t-value
Cooking time (min)	12.00 ± 0.00	10.33 ± 0.29	10.000 (S)
Cooked weight (g/25 g)	76.86 ± 0.19	71.06 ± 0.55	51.628 (S)
Cooking yield (%)	307.46 ± 0.75	284.10 ± 0.002	50.981 (S)
Bulk density (g/ml)	0.52 ± 0.005	0.55 ± 0.00	6.800 (S)
Swelling index (%)	2.22 ± 0.00	1.94 ± 0.006	73.317 (S)
Total solid loss in gruel (per cent by mass)	7.49 ± 0.50	2.43 ± 0.210	15.898 (S)

Values are mean ± SD of three independent observations.
LIN = Lentil incorporated noodles formed by T3 formulation.
CWN = Control wheat noodles formed by C formulation.
At $p<0.05$, S is significant; NS is non-significant.

4. Discussion

Several studies have corroborated the findings of our current research on lentil flour-infused noodles through sensory evaluations. For instance, Bae *et al.* (2016) determined that noodles containing 30% red lentil powder (RLP) exhibited superior scores in smell, taste, chewiness, and overall preference, suggesting their potential as substitutes for wheat flour to enhance noodle quality. Similarly, Bayomy and Alamri (2022) found that instant noodles incorporating 25% lentil flour displayed the highest sensory ratings for taste, appearance, flavor and overall acceptance, although texture scores declined with increasing substitution ratios. Bilgiçli *et al.* (2011) observed enhanced odor and taste in Eriote, a traditional Turkish food, with the inclusion of coarse lentil flour, resembling the taste improvement noted in lentil-substituted noodles. Yoshimoto *et al.* (2020) demonstrated superior texture in noodles made entirely from chickpea and lentil flour compared to commercial legume-containing products, consistent with our findings on lentil-substituted noodles. Moreover, they highlighted taste variations among legume-based noodles, supporting our observations on lentil-substituted noodles. Rathod and Annapure (2017) emphasized lentil-rice blended noodles' overall acceptability, aligning with our study's significant differences in overall acceptability scores. Ritika *et al.* (2016) further reinforced these findings by demonstrating the highest sensory acceptability in noodles blended with malted cowpea and refined wheat flour. Collectively, these studies offer valuable parallels and insights into the sensory attributes and acceptability of legume-incorporated noodles.

With respect to physical property, *i.e.,* bulk density, previous studies by Rathod and Annapure (2017) indicated a decrease in bulk density with the addition of lentil flour in lentil: rice noodle formulations. The optimal ratio of lentil to rice (40:60) resulted in a bulk density of 0.51g/ml, making it the most acceptable for noodle production. By contrast, Akubor and Taibat (2018) found that bulk densities were not significantly impacted by the addition of soybean flour to wheat flour. Furthermore, Ritika *et al.* (2016) discovered that the addition of legumes had no effect on the bulk density of wheat flour mixed with malted/fermented cowpea flour. Hence, we can conclude that the bulk density of lentil incorporation is recommendable for making noodles. The study demonstrated how bulk density affects the texture and compactness of noodles, which has consequences for package design and should be taken into account in contexts like baby feeding where a lower bulk density is preferred (Iwe and Onalope, 2001).

In case of functional property, the water absorption capacity values of our results are in consistent with the results of Bouhlal *et al.* (2019), wherein they found that adding lentil flour to wheat flour ratios led to a considerable increase in water absorption. Similar to this, Ritika *et al.* (2016) found that adding legume fractions to flour blends increased WAC, mostly due to the legumes' higher fiber content. Ashraf *et al.* (2012) reported similar trends, noting a dramatic increase in swelling power with the gradual addition of lentil flour. Ratnawati (2019) highlighted the impact of legume inclusion on solubility by reporting variable solubility percentages for various bean flours. The observed variations in these functional attributes can be ascribed to several reasons, including the quantity of protein present, the degree of damaged and undamaged starch and the intrinsic hydrophilic and hydrophobic characteristics of the proteins in the flours. These results are important for the development of ready-to-eat meals as they may enhance the cohesiveness of the final product due to their high water absorption capacity (Ogunlakin *et al.*, 2012)

Comparing the cooking quality of T3-lentil incorporated noodles (LIN) with control noodles, Shobha *et al.* (2015) found that control noodles required less cooking time (8.8 min) compared to regular noodles (10.5 min) and quality protein maize noodles (10.6 min). Rathod and Annapure (2017) reported variations in cooking time ranging from 5.42 to 8.42 min among different formulations of lentil-incorporated noodles. Vani and Manimegalai (2004) noted that noodles made with blended legume flour exhibited increased water uptake, weight gain after cooking and extended cooking time. High protein content in lentils may contribute to longer cooking durations. Prabhasankar (2007) observed that the cooked weight of control vermicelli was 82.5 g/25 g, while three other vermicelli formulations fell within the range of 84.00 to 88.00 g/25 g. Ronge *et al.* (2017) reported mean cooking weights of skim milk vermicelli treatments ranging from 274.95 to 353.10 g for different treatments. Additionally, Park and Baik (2004) found a positive correlation between protein content and amylose content with cooking time in noodles, suggesting that higher protein content in lentils could lead to increased cooking duration in T3-Lentil incorporated noodles (LIN).

As per findings by Shobha *et al.* (2015), the yield of noodles after cooking was higher for normal noodles (234 g) and quality protein maize noodles (220 g) compared to the control (201 g). Eman *et al.* (2012) observed cooking yields ranging from 180 to 207 g for different formulated noodles fortified with whole lupine meal. Similarly, Chin *et al.* (2012) noted variations in cooking yield for noodles with different levels of added surumi powder. Shobha *et al.* (2015) also reported bulk density values for control noodles, normal noodles and quality protein maize noodles as 0.55, 0.58 and 0.42, respectively. Bulk density serves as an indicator of a product's porosity, influencing package design and aiding in the selection of appropriate packaging materials. For noodles, a lower bulk density is crucial and desirable. The bulk density is directly impacted by the moisture content of the raw material and extrusion temperature, with higher moisture content leading to lower density. Consequently, T3-LIN can be considered superior to C-CIN as outlined by Rathod and Annapure (2017). As per Mestres *et al.* (1988), the swelling index was reported to be 450 for rice flour noodles and 850 for mung bean starch vermicelli. Ronge *et al.* (2017) found the swelling indices of skim milk vermicelli for different treatments ranged from 3.67 to 3.36%. Shobha *et al.* (2015) reported cooking losses within the range of 6.3 to 7.76 per cent by mass for control noodles, normal noodles and quality protein maize noodles.

Extensive research has been conducted on the cooking loss of noodles, assessed through total solid loss in gruel. Purnima *et al.* (2012) observed cooking loss ranging from 5.6 to 9.1 per cent by mass for various pasta products with added ingredients, while Rathod and Annapure (2017) noted a variation in cooking loss from 3.3 to 22.9 per cent by mass among different formulations of lentil-incorporated noodles. Furthermore, Ronge *et al.* (2017) reported an average solid gruel loss of cooked skim milk vermicelli treatments ranging from 2.18% to 5.10%. Odabas *et al.* (2022) observed an increase in cooking loss of gluten-free noodles with the addition of quinoa flour (QF) or Yellow lentil flour (YLF), although all noodles remained within acceptable limits. Geng *et al.* (2021) explored various noodle types and found that the addition of lentil protein significantly influenced cooking quality, particularly evident in the highest cooking loss observed in rice lentil noodles due to the crude fiber in red lentil coat. Additionally, Vatansever *et al.* (2020) noted that increasing the ratio of lentil flour in extruded instant noodles resulted in higher cooking loss and water absorption values. Similarly, Bayomy and Alamri (2022) reported significant influences on cooking loss with the addition of chickpea or lentil flour to instant noodles. According to Feillet and Dexter (1996), who stipulated that noodle-leached components should not exceed 10% during cooking, all percentages remained within acceptable limits for consumers and industry standards. These findings imply that while the incorporation of legume flours may negatively affect cooking loss, the effects are controllable and remain within satisfactory thresholds for both consumers and industry standards.

5. Conclusion

The noodles prepared using the T3 formulation (70:30:2:2:53) received favorable feedback from the majority of panelists. Subsequently, the cooking quality of the chosen noodles was compared to the control noodles. Distinct differences were observed in cooking attributes, including cooking time, cooked weight, cooking yield, bulk density, swelling index and total solid loss in the gruel between T3-LIN and C-CWN. While the physical and functional properties such as bulk density and swelling power did not exhibit a significant difference, there was a notable contrast in water absorption capacity and solubility. The introduction of lentils into regular wheat noodles not only enhances their nutritional profile but also results in favourable physical and functional properties suitable for proper packaging facilities. This indicates the potential for producing noodles with improved qualities by incorporating lentils, offering both nutritional benefits and practical packaging consideration.

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Conflict of interest

The authors declare no conflict of interest relevant to this article.

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