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Preparation and evaluation of noodles from some legumes powder

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ABSTRACT

Instant noodles, renowned for their affordability, convenience, and diverse flavors, represent a popular global cereal product. This study explored the potential of incorporating unconventional ingredients, specifically lentil, pea, and bean powders, to enhance the nutritional profile and sensory attributes of instant noodles. The objective was to investigate the feasibility of coloring wheat flour-based instant noodles using these legume powders while assessing their impact on chemical composition, color characteristics, and overall acceptability. Instant noodles were fortified with 15-30% red lentil powder (RLP), green pea powder (GPP), red kidney bean powder (RKBP), or a combination thereof, employing lamination technology. The incorporation of kidney bean powder significantly elevated dietary fiber, ash, protein, and essential amino acid content, including lysine. Total essential amino acid content increased from 33.35% to 37.75% with a 30% RLP replacement and to 36.22% with a 30% mixed legume powder replacement. Legume flour addition imparted distinct color variations to the noodles, with red lentil powder proving most effective as a natural colorant. Sensory evaluation revealed that noodles enriched with 30% red lentil powder garnered the highest consumer preference and exhibited the most intense color.

1. Introduction

Instant noodles have captured the palates of people worldwide, particularly among children. According to the World Instant Noodles Association's 2021 report, global consumption continues to surge, reaching a staggering 116.5 billion servings annually, equivalent to approximately 319 million servings daily. Saudi Arabia and Egypt witnessed particularly rapid growth in instant noodle consumption between 2016 and 2020, with increases of 162.7% and 166.7%, respectively. Despite their universal appeal, instant noodles often fall short in terms of nutritional value. While they boast a relatively high protein content of 8.5% to 12.5%, they are deficient in essential vitamins and dietary fiber. Recognizing the need to enhance the nutritional profile of such popular products, researchers (Onyema et al., 2014; Rodríguez DeMarco et al., 2018; Chowdhury et al., 2020) have advocated for incorporating nutrient-rich ingredients into noodles. Legumes, known for their health benefits associated with the Mediterranean diet (Rebello et al., 2014), emerge as promising candidates. These plant-based foods are packed with proteins, dietary fiber, oligosaccharides, phytosterols, and bioactive peptides, making them ideal for fortifying instant noodles (Singh et al., 2017; Sonta and Rekiel, 2020). However, legumes contain anti-nutrients that can hinder nutrient absorption and digestion (Samtiya et al., 2020). Fortunately, these compounds can be mitigated through various processing techniques, including heat treatments, soaking, sprouting, and fermentation (Thakur et al., 2019; Abbas and Ahmad, 2018; Kamalasundari et al., 2019).

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Legumes possess natural defense mechanisms, including chemical compounds that deter pests and diseases. However, many of these anti-nutritional factors can be significantly reduced or eliminated through proper processing. Techniques such as soaking, sprouting, boiling, and fermentation have been shown to enhance the nutritional value of legumes by breaking down these compounds.

Common household preparation methods, like boiling and frying beans, can also contribute to reducing anti-nutrient levels (Abbas and Ahmad, 2018). Traditional culinary practices involving soaking, boiling, and cooking legumes have effectively lowered anti-nutritional components, making them safe and nutritious for consumption (Kamalasundari et al., 2019). Lentils (*Lens culinaris*) are a rich source of protein (20.6-31.4%), minerals, fiber (11% in green, 31% in red varieties), and essential amino acids, with the exception of cystine and methionine (Bayomy and Alamri, 2022; Hajas et al., 2022). Their balanced nutritional profile and functional properties, such as solubility, gelation, emulsification, and foaming, have made lentil powder a popular ingredient among food manufacturers and consumers alike. Applications span diverse food categories, including dairy, meat, and bakery products (Argel et al., 2020; Romano et al., 2021).

Peas (*Pisum sativum L.*) are a highly nutritious legume valued for their protein, dietary fiber, complex carbohydrates, and essential vitamins and minerals. Beyond their core nutritional profile, peas are also rich in phytochemicals, antioxidants, flavonoids, tannins, and other phenolic compounds. The dietary fiber in peas, derived from seed coats, pods, and cell walls, promotes gut health by supporting beneficial bacteria. Peas' intermediate amylose content helps regulate blood sugar levels by reducing starch digestibility and lowering the glycemic index.

Pea proteins have potential applications in nutraceuticals, while their non-α-galactooligosaccharides can alleviate digestive discomfort (Kumari and Deka 2021). Processed peas, particularly dehulled varieties, are prized globally for their concentrated antioxidants and fiber content. Pea vine haulm, a byproduct, has been explored for its chloroplast-rich fractions through centrifugation (Torcello-Gómez et al., 2019). Red kidney beans (*Phaseolus vulgaris L.*), a heat-loving legume, are renowned for their exceptional nutritional profile. Rich in soluble and insoluble fiber, essential minerals, and vitamins, they contribute significantly to overall health and well-being (Worku and Sahu, 2017; Mullins and Arjmandi, 2021). As members of the Fabaceae family, these beans are also a valuable source of phenolic compounds, which act as antioxidants to protect cells from oxidative damage (Sarker et al., 2020).

This study aimed to determine the optimal incorporation levels of red lentil powder (RLP), green pea powder (GPP), red kidney bean powder (RKBP), and their combinations into instant noodles. The research focused on assessing anti-nutrient content, sensory properties, chemical composition, energy value, amino acid profile, and color attributes of the resulting noodle products.

2. Materials and Methods

Materials

Red lentil (*Lens culinaris*) seeds, green peas (*Pisum sativum L.*) seeds, red kidney beans (*Phaseolus vulgaris L.*) seeds, wheat flour and the rest ingredients used in the preparation were obtained from El-Abed hypermarket, Banha Governorate - Egypt. The was stored immediately in the refrigerator until used in preparing products.

Methods

Preparation and addition of components to make instant noodles

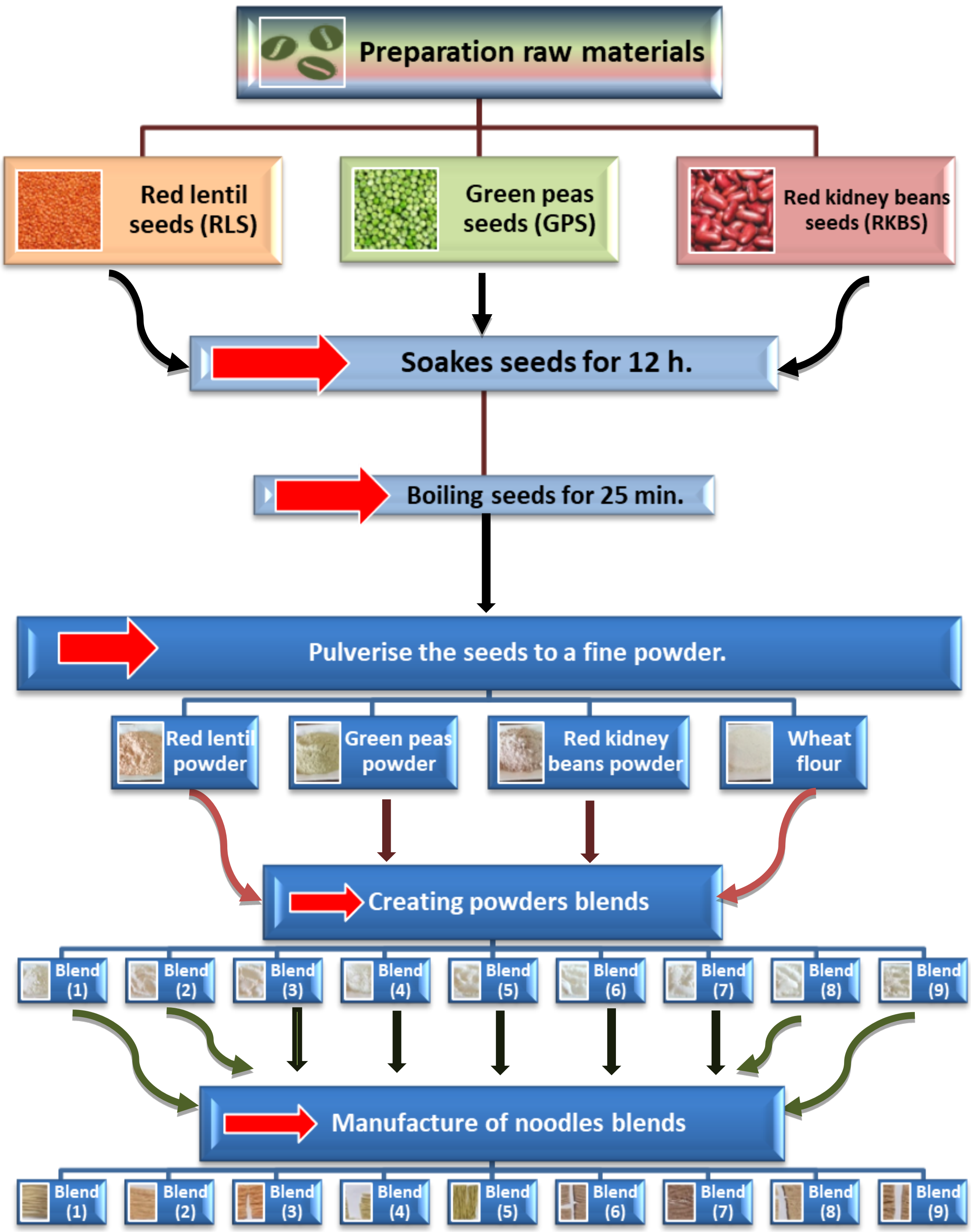
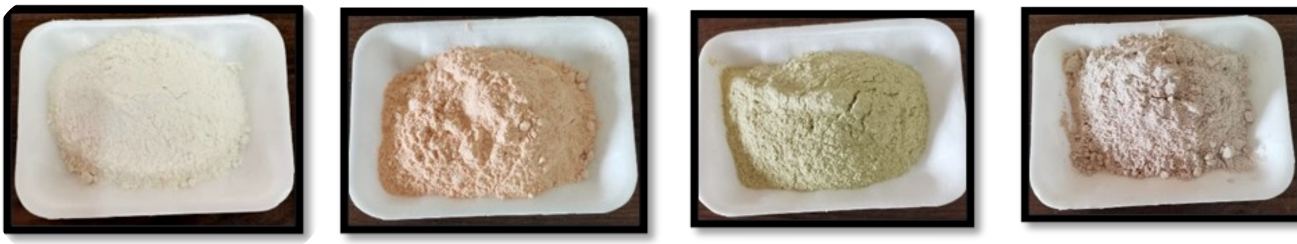


Figure 1. Preparation and addition of components to make instant noodles

Preparation of pulse seeds to obtain powder

Making powder A grinder (model GVX212, Krupps, Essen, Germany) was used to crush red lentil seeds, green pea seeds, and red kidney bean powder several times. The powder that was obtained was placed in an airtight container and sieved using an electric screen with a 30-mesh size until testing.



Wheat (72% ext.) flour (WF) **Red lentil Powder (RLP)** **Green peas Powder (GPP)** **Red kidney beans powder (RKBP)**

Figure 2. Raw material flour and powders.

Preparation of instant noodles

As outlined by Kuen et al., (2017), instant noodles were prepared as follows. Salt was dissolved in water before gradually adding flour, powder, and other ingredients to a Kenwood kitchen mixer at low speed. Once mixed, the beater and bowl were scraped clean. The mixing speed was then increased for four minutes, followed by a two-minute break to scrape the bowl and beat again. The dough was covered with plastic wrap and rested for 15 minutes. The dough was rolled out into a smooth sheet, avoiding contact with the chopping board. Using a pasta machine, the dough was rolled into uniform sheets with a thickness of 1.5 mm. After folding the sheets in half, leaving a center gap, they were rolled again. The dough sheet was then passed through the pasta maker's slitter to form long noodle strands. These were cut into smaller pieces to prevent sticking during steaming. The noodles were steamed for ten minutes before being dried in a tray dryer at 50°C until reaching a moisture content of 5-7%. Once cooled to room temperature, the noodles were packaged in polythene bags and stored at 12-14°C until testing.

Table 1. preparation and addition of components to make instant noodles

Components	WF (gm)	RLP (gm)	GPP (gm)	RKBP (gm)	MIX (15%) (gm)	MIX (30%) (gm)	Salt (gm)	Water (ml)
B1	100	**	**	**	**	**	1	30
B2	85	15	**	**	**	**	1	31
B3	70	30	**	**	**	**	1	32
B4	85	**	15	**	**	**	1	31
B5	70	**	30	**	**	**	1	32
B6	85	**	**	15	**	**	1	32
B7	70	**	**	30	**	**	1	33
B8	85	**	**	**	15	**	1	31
B9	70	**	**	**	**	30	1	33

WF= Wheat flour RLP= Red lentil powder GPP= Green peas powder RKBP= Red kidney beans powder

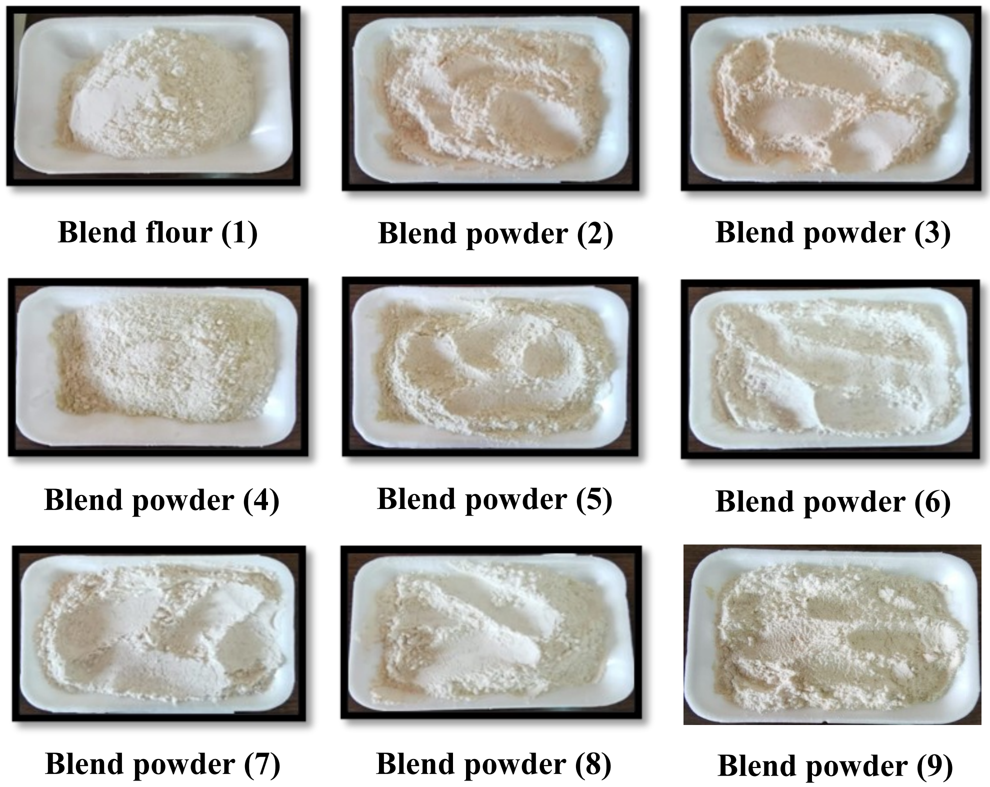


Figure 3. Blends the flour and powder used to make noodles

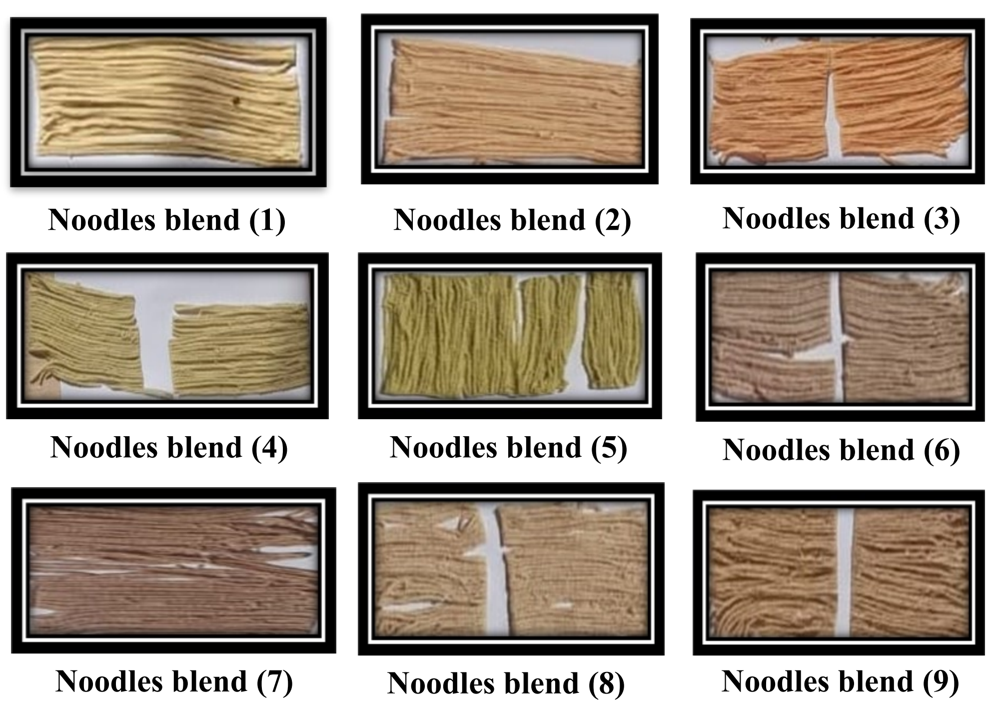


Figure 4. Noodles blends

Proximate analysis of moisture, crude protein, ether extract, ash, and crude fiber content in both noodles and raw materials was conducted according to AOAC (2012) methods. Available carbohydrates were determined by difference. Crude protein was calculated as nitrogen content multiplied by 5.7 for wheat flour (WF) and WF noodles, or 6.25 for other blends. Energy value (kcal/100 g) was calculated based on crude protein, fat, and available carbohydrate content using the formulaas outlined in AOAC (2012).

Energy value (kcal/100 g) = (Crude protein × 4.1) + (carbohydrates × 4.1) + (Crude fat × 9.1)

Determination of ß-carotene

The analysis of carotene was conducted using a modified method from AOAC (2012).

Determination of Vitamins

The vitamin B content, including thiamin (B1), riboflavin (B2), niacin (B3), and folic acid (B9), of various food samples was determined using HPLC according to AOAC (2012) methodology.

Anti-nutritional factors analysis

Phytic acid content was determined in raw, soaked, and boiled bean samples according to the method of Wheeler and Ferrel (1971). Trypsin inhibitor activity was assessed in the same samples using the method of Kakade et al. (1969), with benzoyl-DL-arginine-p-nitroanilide hydrochloride as the substrate.

Amino acid analysis

The calculation of amino acids was done using the protocol outlined in AOAC (2012).

Color Measurements of instant noodles

Color measurements were obtained using a handheld Chroma Meter (Model CR-400, Konica Minolta, Japan) according to the methodology described by McGurie (1992).

Sensory evaluation of noodles

Sensory evaluation was conducted by a panel of 20 experienced judges at the Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. Panelists rated various quality attributes, including color, softness, stickiness, taste, odor, and overall acceptability, using a 10-point hedonic scale. Subsequent statistical analysis of the scores was performed according to the method of Chan and Cavaletto (1982).

Statistical analysis

Analysis of variance (ANOVA) was conducted to determine significant differences among groups, using a Duncan's multiple range test at the 5% significance level. Data for all variables except amino acid content are presented as mean ± standard deviation.

3. Results and Discussion

Chemical composition raw materials

Table 2 presents the results of the proximate analysis of RLP, GPP, RKBP, and WF, including crude protein, ash, ether extract, crude fiber, available carbohydrates, and caloric value. Crude protein content was highest in RLP (26.60%) and GPP (24.33%), followed by RKBP (18.28%) and WF (12.00%). Ether extract content was higher in RLP, GPP, and RKBP compared to WF. Ash and crude fiber contents were highest in RKBP compared to RLP, GPP, and WF.

Available carbohydrate content was highest in WF compared to GPP, RLP, and RKBP. Caloric value was highest in WF (413.88 kcal/100g) compared to the other raw materials. The obtained results align with previous studies by EL-Derny and El-Hadidy (2018), Nassef et al. (2022), El-Hadidy et al. (2023), and Shaban et al. (2023), which reported crude protein content in wheat flour ranging from 11.69 % to 12%, crude ether extract from 1.40% to 1.90%, and ash from 0.50% to 0.60%. Furthermore, El-Hadidy (2020) reported wheat flour composition as 11.81% crude protein, 0.45% ash, 0.84% crude fiber, and 86.13% carbohydrates.

Table 2 also presents the mineral and vitamin content of RLP, GPP, RKBP, and WF. Mineral content was significantly higher in RLP, GPP, and RKBP compared to WF, with these materials demonstrating greater concentrations of calcium, potassium, phosphorus, magnesium, zinc, manganese, and iron.

Vitamin analysis revealed that GPP exhibited the highest vitamin content, surpassing RLP and RKBP in vitamin A and B1 levels. While GPP also contained higher niacin (B3) content, WF demonstrated the presence of B1 (0.40), B2 (0.12), B3 (0.70), and folate (0.05).These findings align with previous research by El-Hadidy et al., (2022), Mospah et al., (2023), and El-Hadidy[2] et al., (2023) on the mineral and chemical composition of wheat flour and lentil powder.

Table 2. Proximate composition of raw materials

Chemical composition g/100g samples (on dry weight)				
Raw materials	RLP	GPP	RKBP	WF
Crude protein%	26.60^{a}±0.07	24.33^{b}±0.08	18.28^{c}±0.053	12.00^{e}±0.06
Ether extract%	2.60^{a}±0.02	1.67^{c}±0.01	1.54^{d}±0.01	1.80^{b}±0.02
Ash%	3.20^{b}±0.05	3.22^{b}±0.04	5.44^{a}±0.04	0.55^{c}±0.01
Crude fiber%	4.50^{b}±0.07	8.85^{a}±0.15	3.33^{c}±0.05	0.80^{d}±0.02
Available carbohydrates%	63.10^{c}±0.05	61.93^{d}±0.07	71.41^{b}±0.09	84.95^{a}±0.08
Energy (kcal/100g)	391.43^{b}±0.15	368.86^{d}±0.20	381.74^{c}±0.45	413.88^{a}±0.55
Minerals (mg/ 100g)				
Ca	90.11^{b}±0.05	89.62^{b}±0.04	115^{a}±1.53	17.50^{c}±1.03
P	520^{a}±2.03	312.11^{c}±2.33	435^{b}±1.73	141.00^{d}±1.55
Na	70^{a}±0.50	4.00^{d}±0.03	41.50^{b}±0.20	5.10^{c}±0.04
K	980^{b}±2.53	869.52^{c}±3.33	1250^{a}±3.50	120.50^{d}±1.03
Mg	135^{c}±1.07	152.32^{a}±2.07	141.35^{b}±1.05	105.00^{d}±1.00
Zn	4.00^{c}±0.03	4.71^{b}±0.05	6.34^{a}±0.06	4.00^{c}±0.01
Mn	2.6^{c}±0.02	6.32^{a}±0.04	3.33^{b}±0.01	0.90^{d}±0.01
Fe	9.43^{a}±0.08	4.47^{c}±0.05	7.42^{b}±0.04	1.80^{d}±0.01
Vitamins (mg/100g)				
Vitamin (A)	1.87^{b}±0.02	31.83^{a}±0.05	0.67^{c}±0.01	ND
Thiamine (B1)	0.54^{b}±0.01	0.86^{a}±0.02	0.25^{d}±0.01	0.40^{c}±0.02
Riboflavin (B2)	0.34^{b}±0.02	0.31^{c}±0.01	2.37^{a}±0.03	0.12^{d}±0.01
Niacin (B3)	3.12^{c}±0.02	3.23^{b}±0.03	127.53^{a}±0.05	0.70^{d}±0.02
Folic acid (B9)	5.23^{b}±0.07	46.78^{a}±0.05	0.67^{c}±0.04	0.05^{d}±0.01

Influence of soaking and boiling procedures on levels of anti-nutritional factors

Table 3 presents the effects of soaking and boiling on phytic acid and trypsin inhibitor activity in RLS, GPS, and RKBS. A 12-hour soaking period significantly reduced phytic acid levels in all samples compared to their raw counterparts, with RLS, GPS, and RKBS showing reductions to 3.11%, 2.40%, and 2.25%, respectively. Boiling after soaking further decreased phytic acid content to 2.12% and 1.50% in RLS and GPS, respectively, while it was undetectable in boiled RKBS. Trypsin inhibitor activity was also significantly reduced in RLS, GPS, and RKBS samples after a 12-hour soaking period, with values of 1.54, 3.68, and 1.73 U/mg, respectively. Subsequent boiling led to further decreases in trypsin inhibitor activity, reaching 0.95 and 2.90 U/mg for RLS and GPS, respectively, while becoming undetectable in RKBS. In comparison, raw RLS, GPS, and RKBS exhibited trypsin inhibitor activities of 2.85, 5.43, and 2.41 U/mg, respectively. Both soaking and boiling processes effectively reduced anti-nutritional factors in RLS, GPS, and RKBS. Phytic acid content decreased by 24.57%, 48.42%, 34.96%, 59.33%, and 35.89%, while trypsin inhibitor activity reduced by 45.96%, 66.66%, 32.23%, 4.59%, and 26.87% in RLS, GPS, and RKBS, respectively, following soaking and boiling.

The data revealed significant variations in anti-nutrient levels among raw RLS, GPS, and RKBS, as well as in response to soaking and boiling. Both soaking and boiling effectively reduced phytic acid and trypsin inhibitor levels in all samples. These findings corroborate those of Haileslassie et al., (2019), who reported decreased phytate content after soaking, attributing this reduction to the leaching of anti-nutrients into the soaking water. These findings align with previous research by Laurena et al., (1986), who demonstrated a decrease in phytic acid content when cowpeas were soaked in alkaline and acidic solutions. Adebayo (2014) suggested that the reduction of tannins during soaking is attributed to the leaching of polyphenols into the soaking water. Our results are consistent with those of Huma et al., (2008), who reported phytic acid reduction through leaching during soaking and boiling. Additionally, pressure cooking soaked pulses for 15 minutes led to a significant reduction (25.2-50.1%) in anti-nutritional factors, as reported in other studies.

Table 3. Extents of anti-nutritional parameters in Raw, Boiled and soaked of RLS, GPS and RKBS of different processes.

Samples	Method	Time	Phytic acid (%)		Trypsin inhibitor (TIU*/mg)	
			Mean ± SD	RD %	Mean ± SD	RD %
RLS	Raw seeds	0	4.11^{a}±0.01	0.00	2.85^{b}±0.03	0.00
	Soaked	12h	3.11^{a}±0.2	24.57	1.54^{c}±0.03	45.96
	Boiling after soaking	25min	2.12^{a}±0.1	48.42	0.95^{b}±0.01	66.66
GPS	Raw seeds	0	3.69^{b}±0.03	0.00	5.43^{a}±0.02	0.00
	Soaked	12h	2.40^{b}±0.02	34.96	3.68^{a}±0.04	32.23
	Boiling after soaking	25min	1.50^{b}±0.01	59.35	2.90^{a}±0.01	4.59
RKBS	Raw seeds	0	3.65^{b} ± 0.04	0.00	2.41^{c}± 0.23	0.00
	Soaked	12h	2.25^{c}± 0.05	35.89	1.73^{b}± 0.02	26.87
	Boiling after soaking	25min	N.D.	100	N.D.	100

-Means in the same column with different letters are significantly different (p≤ 0.05) in raw seeds.
-Means in the same column with different letters are significantly different (p≤ 0.05) in soaked seeds.
-Means in the same column with different letters are significantly different (p≤ 0.05) in boiling seeds.
-Data was expressed using Mean ± SD. Statistically significant at p ≤ 0.05 (n = 5) ∗ TIU = Trypsin inhibited unit. RD=Reduction

Color of raw materials

The incorporation of RLP, GPP, and RKBP into WF significantly (p ≤ 0.05) altered the color characteristics of the resulting instant noodles, as detailed in Table 4. A notable decrease in lightness ($L*$ value) from 78.51 to 73.14-50.30 was observed in the flour mixes containing RLP, GPP, and RKBP, respectively, compared to the control (WF). This reduction in $L*$ value is likely attributed to the higher protein content of RLP, GPP, and RKBP, which has been previously reported to negatively correlate with $L*$ value (Bhise and Kaur, 2013). Additionally, the elevated polyphenolic compounds present in these ingredients may have undergone oxidation reactions, further contributing to the decreased $L*$ value of the blended instant noodles. The incorporation of RLP, GPP, and RKBP powders into wheat flour (WF) significantly enhanced (p ≤ 0.05) the $a*$ value of the flour blends, ranging from 0.66 to 5.33 compared to the control (1.58). Concurrently, the $b*$ value, indicative of yellowness, increased significantly (p ≤ 0.05) to 9.32-14.95 for the blended instant noodles compared to the control (9.20). These changes in $a*$ and $b*$ values resulted in a noticeable shift towards a golden-brown color as the proportion of RLP, GPP, and RKBP powders increased in the blends.

Table 4. Raw materials and its blends colors of instant noodles prepared with different levels of GPP, RLP and RKBP by substituting WF.

Materials		*L**	*a**	*b**	*c**	*h**
Raw material	GPP	63.14^{f}± 0.01	1.03^{j}± 0.01	13.09^{d}± 0.01	13.13^{d}± 0.01	85.51^{b}± 0.01
	RLP	50.35^{k}± 0.01	12.48^{a}± 0.01	16.38^{a}± 0.01	20.59^{a}± 0.01	52.70^{k}± 0.01
	RKBP	55.68^{g}± 0.01	3.66^{d}± 0.01	7.99^{L}± 0.01	8.78^{L}± 0.01	65.39^{j}± 0.01
Blends flour material	WF (B1)	78.51^{a}± 0.01	1.58^{h}± 0.01	9.20^{k}± 0.01	9.33^{k}± 0.01	80.28^{d}± 0.01
	B2	73.14^{b}± 0.01	0.67^{L}± 0.01	12.77^{e}± 0.01	12.79^{e}± 0.01	87.01^{a}± 0.01
	B3	50.60^{i}± 0.01	0.66^{k}±0.01	12.62^{f}± 0.01	12.64^{f}± 0.01	87.00^{a}± 0.01
	B4	54.73^{h}± 0.01	4.30^{c}± 0.01	14.95^{b}± 0.01	15.56^{b}± 0.01	73.97^{b}± 0.01
	B5	65.36^{e}± 0.01	5.33^{b}± 0.01	13.74^{c}± 0.01	14.74^{c}± 0.01	68.79^{i}± 0.01
	B6	70.28^{c}± 0.01	1.87^{g}± 0.01	9.32^{j}± 0.01	9.50^{j}± 0.01	78.67^{e}± 0.01
	B7	69.66^{d}± 0.01	2.23^{f}±0.01	10.33^{g}± 0.01	10.57^{g}± 0.01	77.80^{c}± 0.01
	B8	50.47^{j}± 0.01	1.33^{i}± 0.01	10.15^{i}± 0.01	10.24^{i}± 0.01	82.54^{f}± 0.01
	B9	50.30^{L}± 0.01	2.31^{e}± 0.01	10.30^{b}± 0.01	10.55^{h}± 0.01	77.37^{g}± 0.01

-Means in the same column with different letters are significantly different (p≤ 0.05).
-Each mean value is followed by ± SE (standard division).

Sensory analysis of instant noodles

The sensory properties of blended instant noodles were significantly influenced ($p < 0.05$) by the incorporation of RLP, GPP, and RKBP into wheat flour (WF). Compared to the control (appearance score of 8), blending WF with RLP, GPP, RKBP, 15% mix, and 30% mix resulted in significant increases ($p \leq 0.05$) in appearance scores, ranging from 8 to 9.5. Similarly, the color of the blended noodles was significantly enhanced ($p \leq 0.05$), with scores rising from 8 in the control to 7.5-9 for the blends. The incorporation of RLP, GPP, and RKBP into wheat flour significantly enhanced ($p \leq 0.05$) the odor, texture, and taste of the instant noodles. Compared to the control (odor score of 8.5), the blended noodles exhibited higher odor scores ranging from 8 to 9.5. Texture and taste scores also increased progressively with higher levels of RLP, GPP, and RKBP in the blends. As the level of integration of RLP, GPP, RKBP, mix (15%) and mix (30%) powder blends increased, so did the general acceptability of instant noodles preparation with these powder blends (Figure 5). These findings align with the work of Bayomy and Alamri (2022).

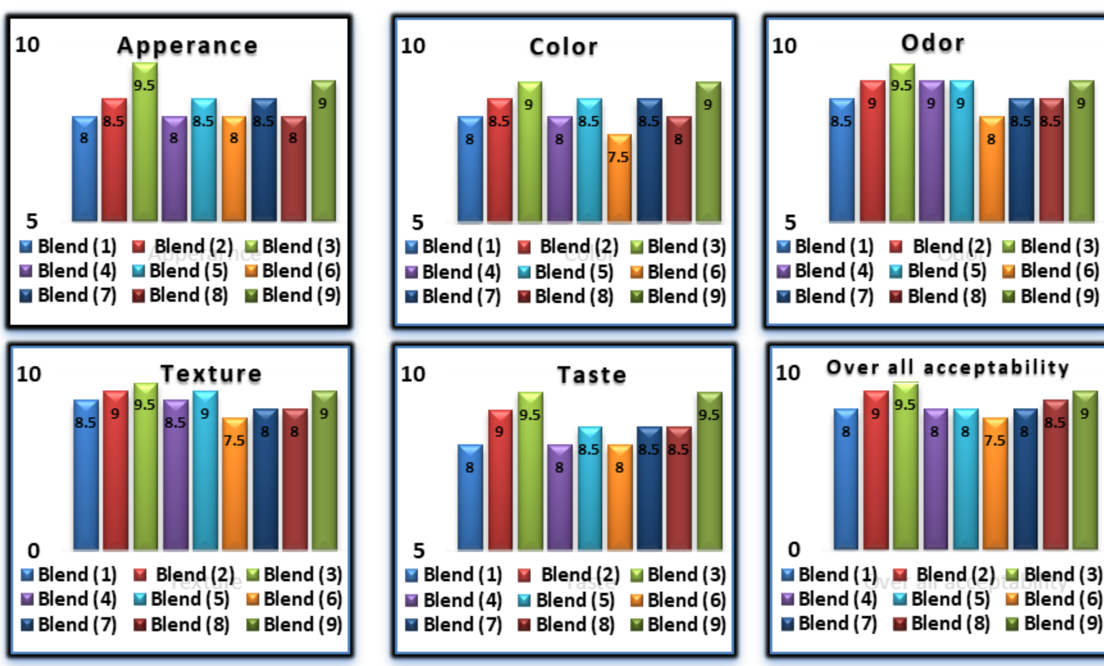


Figure 5. Sensory analysis for noodles blends

-Means in the same row with different letters are significantly different (p≤ 0.05) - Each mean value is followed by ± SE (standard division).

Chemical composition of noodles

Table 5 presents the proximate chemical composition of control instant noodles (B1) and those substituted with 30% RLP (B3), 30% GPP (B5), 30% RKBP (B7), and a 30% blend (B9) consisting of 10% each of RLP, GPP, and RKBP, and 70% wheat flour. Notably, instant noodles incorporating 30% RLP, GPP, or RKBP exhibited significantly higher protein levels compared to the control (B1). This enhancement is attributed to the inherently higher protein content of these flours relative to wheat flour. The incorporation of RLP, GPP, RKBP, or the blended mix (B9) at the 30% substitution level resulted in protein content increases of 16.38%, 15.70%, 13.88%, and 15.35%, respectively, compared to the control's 12%. The ether extract content exhibited slight variations across the samples. While a slight increase was observed in B3 (1.80%) compared to the control (1.80%), a modest decrease was noted in B5, B7, and B9, ranging from 1.72% to 1.76%. Conversely, the ash content was significantly higher in instant noodles containing the three seed powders (B3, B5, B7, and B9) compared to the control. This increase is directly attributed to the elevated ash content of these powders relative to wheat flour. A notable benefit of incorporating RLP, GPP, RKBP, and their blend (B9) into the instant noodles was the significant increase in fiber content compared to the control. Instant noodles fortified with 30% GPP and 70% WF exhibited a substantial increase in fiber content, reaching 3.22% compared to the control's 0.80%. Concurrently, available carbohydrate content decreased significantly from 81.55% to 77.97% due to the elevated protein and fiber levels. While these enhancements contributed to a modest reduction in caloric content, the overall nutritional profile of the instant noodles was improved. These findings align with the work of Bayomy and Alamri (2022), who demonstrated that lentil powder enrichment increased protein, ash, and fiber content in instant noodles.

Table 5. Proximate composition of instant noodles

Chemical composition g/100g samples (on dry weight)					
Raw materials	NB1	NB3	NB5	NB7	NB9
Crude protein%	$12.00^{e}\pm0.03$	$16.38^{a}\pm0.15$	$15.70^{b}\pm0.25$	$13.88^{d}\pm0.10$	$15.35^{c}\pm0.20$
Ether extract%	$1.80^{b}\pm0.01$	$2.04^{a}\pm0.02$	$1.76^{b}\pm0.04$	$1.72^{b}\pm0.01$	$1.76^{b}\pm0.02$
Ash%	$0.55^{c}\pm0.03$	$1.35^{a}\pm0.02$	$1.35^{a}\pm0.01$	$1.29^{a}\pm0.02$	$2.02^{a}\pm0.05$
Crude fiber%	$0.80^{e}\pm0.04$	$1.9^{c}\pm0.05$	$3.22^{a}\pm0.01$	$1.56^{d}\pm0.05$	$2.23^{b}\pm0.03$
Available carbohydrates%	$84.95^{a}\pm0.03$	$78.32^{c}\pm0.05$	$77.97^{d}\pm0.01$	$81.55^{b}\pm0.06$	$78.64^{c}\pm0.10$
Energy (kcal/100g)	$413.88^{a}\pm0.20$	$406.83^{b}\pm0.25$	$400.06^{d}\pm0.05$	$406.92^{b}\pm0.20$	$401.38^{c}\pm0.15$
Minerals (mg/100g)					
Ca	$17.50^{d}\pm0.25$	$39.53^{c}\pm0.15$	$39.39^{c}\pm0.20$	$47.00^{a}\pm0.30$	$43.72^{b}\pm0.40$
P	$141.00^{e}\pm1.20$	$254.70^{a}\pm2.50$	$192.33^{d}\pm1.40$	$229.20^{b}\pm2.30$	$225.41^{c}\pm1.70$
Na	$5.10^{d}\pm0.30$	$24.57^{a}\pm0.75$	$4.77^{e}\pm0.10$	$16.20^{b}\pm0.15$	$15.07^{c}\pm0.10$
K	$120.50^{e}\pm1.40$	$378.35^{c}\pm2.30$	$345.21^{d}\pm3.50$	$459.35^{a}\pm4.20$	$394.80^{b}\pm3.90$
Mg	$105.00^{e}\pm0.20$	$114.00^{d}\pm0.30$	$119.10^{a}\pm0.25$	$115.80^{c}\pm0.10$	$116.30^{b}\pm0.20$
Zn	$4.00^{c}\pm0.01$	$4.00^{c}\pm0.01$	$4.21^{b}\pm0.02$	$4.70^{a}\pm0.01$	$4.31^{b}\pm0.02$
Mn	$0.90^{e}\pm0.03$	$1.41^{d}\pm0.02$	$2.53^{a}\pm0.04$	$1.63^{c}\pm0.01$	$1.86^{b}\pm0.03$
Fe	$1.80^{d}\pm0.01$	$4.09^{a}\pm0.01$	$2.60^{c}\pm0.05$	$3.49^{b}\pm0.02$	$3.39^{b}\pm0.03$

-Means in the same row with different letters are significantly different ($p\leq 0.05$).
-Each mean value is followed by ± SE (standard division). -NB = (Noodles Blends).

Table 5 presents the mineral composition of control instant noodles (B1) and those formulated with 30% RLP (B3), 30% GPP (B5), 30% RKBP (B7), and a blend of 10% RLP, GPP, and RKBP with 70% WF (B9). All instant noodle formulations incorporating RLP, GPP, or RKBP exhibited significantly higher mineral content compared to the control (B1).

A positive correlation was observed between the amount of pulse seed flour incorporated and the overall mineral content of the instant noodles. However, the final mineral composition was primarily influenced by the intrinsic mineral profile of the individual legume seed powders. Notably, calcium content was substantially elevated in all formulations containing RLP, GPP, or RKBP. Calcium content was significantly elevated by 2 to 3 times in instant noodles formulated with 30% RLP, GPP, RKBP, or the blended mix (B9) compared to the control. A similar enhancement was observed for other essential minerals, including manganese, phosphorus, potassium, zinc, and magnesium. While sodium content was primarily influenced by added salt during production rather than by the inclusion of RLP, GPP, RKBP, or B9, the blend (B9) demonstrated relatively higher levels of calcium, phosphorus, manganese, iron, zinc, and magnesium compared to individual RLP, GPP, and RKBP additions. These findings align with the work of Pâucean et al., (2018), who reported similar changes in the chemical composition of noodles fortified with mustard and garden cress seed flours.

Amino acid analysis

Wheat protein is notably deficient in tryptophan, threonine, and lysine, limiting its nutritional value (Šramková et al., 2009). This study aimed to enhance the nutritional profile of instant noodles by incorporating RLP, GPP, and RKBP, which are rich sources of essential amino acids including valine, threonine, methionine, lysine, phenylalanine, and tryptophan. By supplementing wheat flour with these legume-based ingredients, we sought to address protein-calorie malnutrition, a prevalent issue in developing countries. Table 6 presents the amino acid profiles of instant noodles formulated with varying levels of RLP, GPP, and RKBP replacements. The amino acid profile of wheat noodles revealed relatively low levels of lysine (2.80 g/100 g protein), isoleucine (3.70 g/100 g protein), leucine (6.50 g/100 g protein), phenylalanine (3.50 g/100 g protein), methionine (1.20 g/100 g protein), and threonine (2.30 g/100 g protein). The incorporation of 30% RLP significantly enhanced these amino acid levels to 4.03 g/100 g protein for lysine and isoleucine, 6.89 g/100 g protein for leucine, 4.34 g/100 g protein for phenylalanine, 1.31 g/100 g protein for methionine, and 2.78 g/100 g protein for threonine. While 30% GPP substitution also improved the amino acid profile, it resulted in lower isoleucine (2.96 g/100 g protein) and leucine (5.61 g/100 g protein) compared to RLP. The inclusion of 30% RKBP yielded intermediate results, with amino acid levels generally falling between those of wheat noodles and RLP-enriched noodles. The total essential amino acid content increased from 36.96 g/100 g protein in the control group to 39.01 g/100 g protein in instant noodles containing 25% chickpea. This trend of increasing essential amino acids and decreasing non-essential amino acids was consistent with higher substitution ratios. Lentils (*Lens culinaris Medik.*), a significant protein source (20.6-31.4%), are rich in essential amino acids, except for methionine and cysteine (Urbano et al., 2007; Jarpa-Parra, 2018; Rozan et al., 2018; El-Hadidy et al., 2022).

Color characteristics of instant noodles

Food color significantly impacts product acceptability (El-Hadidy et al., 2023). Table 7 presents the color characteristics of instant noodles prepared using RLP, GPP, and RKBP blends. Color development in these noodles is primarily attributed to Maillard reactions, $a*$ non-enzymatic browning process involving amino acids and reducing sugars (Vidal-Valverde et al., 2003). The incorporation of RLP, GPP, and RKBP blends significantly decreased ($p \leq 0.05$) the lightness ($L*$ value) of instant noodles from 62.47 (control, NB1) to 38.02 (NB8). This reduction in $L*$ value is likely due to the higher protein content of RLP, GPP, and RKBP, as previous research has established a negative correlation between $L*$ value and protein content (Bhise and Kaur, 2013).

Table 7. Blends colors of instant noodles prepared with different levels of GPP, RLP and RKBP by substituting WF.

Blends noodles	*L**	*a**	*b**	*c**	*h**
NB1	62.47^{a}±0.02	4.09^{i}±0.03	15.09 ^{i}±0.01	15.63^{i}±0.03	74.84^{c}±0.04
NB2	50.15^{f}±0.02	4.71^{h}±0.03	19.45^{e}±0.01	20.01^{e}±0.01	76.35^{b}±0.01
NB3	57.86^{b}±0.02	4.73^{g}±0.03	20.29^{d}±0.01	20.84^{d}±0.04	76.54^{a}±0.04
NB4	47.36^{g}±0.02	12.99^{b}±0.03	24.44^{b}±0.01	27.68^{b}±0.03	62.01^{g}±0.01
NB5	52.87^{c}±0.02	17.55^{a}±0.03	25.54^{a}±0.01	30.65^{a}± 0.05	55.50^{i}±0.02
NB6	50.33^{e}±0.02	12.91^{c}±0.03	22.73^{c}±0.01	26.21^{c}±0.01	61.09^{h}±0.04
NB7	50.87^{d}±0.02	8.69 ^{d}±0.03	17.59^{g}±0.01	19.62^{g}±0.01	63.72^{f}±0.02
NB8	38.02^{i}±0.02	7.36 ^{f}±0.03	16.97^{h}±0.01	18.50^{h}±0.02	66.55^{d}±0.05
NB9	44.23^{h}±0.02	8.24^{e}±0.03	17.81^{f}±0.01	19.63^{f}±0.02	65.18^{e}±0.03

-Means in the same column with different letters are significantly different ($p \leq 0.05$).
-Each mean value is followed by ± SE (standard division).

The observed decrease in L* value may also be attributed to the oxidation of polyphenolic compounds present in RLP, GPP, and RKBP powders, aligning with the findings of Grigelmo-Miguelet et al. (1999). Incorporation of RLP, GPP, and RKBP powders significantly increased ($p \leq 0.05$) the *a* value of instant noodles from 4.09 (control, NB1) to 12.91 (NB6), indicating enhanced redness. Similarly, the *b* value, representing yellowness, was significantly elevated ($p \leq 0.05$) from 15.09 (NB1) to 25.54 (NB5) due to the addition of these powders. These changes in *a* and *b* values resulted in a noticeable shift towards a golden-brown color profile for the instant noodles.

4. Conclusions

The incorporation of RLP, GPP, and RKBP into instant noodles successfully enhanced their nutritional profile, resulting in products with significantly higher protein, fiber, and amino acid content while reducing overall carbohydrate and energy values per 100g. As the proportion of RLP, GPP, and RKBP increased, so did the essential amino acid content. Sensory evaluation revealed a strong preference ($p \leq 0.05$) for instant noodles containing red lentil powder and the 30% RLP, GPP, and RKBP blend. Importantly, these modifications did not compromise color, taste, or overall sensory quality. The findings suggest that up to 30% of wheat flour can be replaced with RLP, GPP, and RKBP to create nutritionally improved instant noodles without negatively impacting consumer acceptability.

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