DEVELOPMENT AND NUTRITIONAL CHARACTERIZATION OF COMPOSITE FLOURS OF WHEAT, RED LENTILS, RED KIDNEY BEANS, SOYBEAN, CHICKPEAS, MAIZE AND MORINGA LEAF

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Abstract

The aim of the study was to utilize the composite flour technology to prepare protein and micronutrient rich flours to address the protein-micronutrient deficiencies amongst the vulnerable segments of the population. In this context, varied flours including red lentils, red kidney beans, soybeans, chickpeas and maize were incorporated in wheat flour at the rate of 5, 10, 15 and 20%. However, moringa leaf powder was included in the wheat flour in the range of 1, 2, 3 and 4%. Afterwards, the composite flours were tested for proximate composition and mineral profiling. The outcomes of the study indicated significant difference amongst the treatments in terms of moisture, ash, crude-protein, fiber fat, NFE, sodium, potassium, calcium, magnesium, phosphorous, iron, zinc, manganese and copper. Protein content of composite flours was ranged from 13.25±0.81 to 20.48±1.02% that was higher than wheat flour 12.01±0.54%. On the other hand, ash content of composite flours was ranged between 1.81±0.08 and 5.31±0.24% i.e. more than wheat flour (1.77±0.07%). Furthermore, moringa leaf powder based composite flour @4% indicated highest levels of Na (13.50±0.61 mg/100g), K (191.85±8.65 mg/100g), Fe (17.27±0.79 mg/100g), Zn (21.91±0.99 mg/100g), Mn (11.03±0.49 mg/100g) and Cu (7.05±0.34 mg/100g). In addition, maximum Ca (67.82±2.11 mg/100g) content was determined in 20% chickpea based composite flour whereas maximum Mg (61.54±2.76 mg/100g) and P (431.12±19.39 mg/100g) levels were measured in 20% soybean based composite flour. These nutritional properties portrayed that the presence of healthy legumes, pulses and plants as composite flours could uplift the protein and micronutrient scarcity if replaced with staple food.

1. Introduction

Pakistan is at 11th position with respect to malnutrition, as studied by Global Hunger Index. The malnutrition is based on protein-caloric deficiency as well as micronutrient scarcity that have become common amongst children and women in Pakistan (NNS, 2011). The primary symptoms of protein-energy scarcity are marasmus and kwashiorkor that under severe conditions may leads to co-morbidities or mortality. Pakistanis are attaining 60% of their total protein and energy requirement from wheat as their staple food that is culprit of PEM hence dietary diversifications technologies are needed at government level to

overcome PEM (Batool *et al.*, 2015; Saadat *et al.*, 2020).

In this context, composite flour technology offers a cost-effective means to create high-quality foods. Many countries have initiated efforts to explore the feasibility of using locally available flours in lieu of wheat flour. The development of composite flours, which involve replacing a portion of wheat flour with regional cereals and legumes, has been a subject of extensive research (Olaoye *et al.*, 2006). Composite flours come into being through the amalgamation of diverse non-wheat flours sourced from legumes, pulses, tubers, and leaves with conventional wheat flour (Banu et al., 2021).

Legumes play a pivotal role in providing humans with essential protein, micronutrients like calcium, iron, and the vitamin B complex needs particularly in developing nations hence stand out as invaluable sources of affordable protein. Further, pulse crops (such as soybeans, peas, lentils, and beans) comprise of 18-38% protein and 15-26% dietary fiber. Nonetheless, they play a pivotal role in augmenting the protein quality of cereals. Food products arising from the combination of cereals and legumes exhibit superior nutritional and caloric value when compared to those solely derived from either cereals or legumes hence blending of cereals with legumes addresses protein energy malnutrition (Igbabul *et al.* 2015; Peluola-Adeyemi *et al.*, 2021; Mullins and Arjmandi, 2021; Adeyanju *et al.*, 2022; Goldstein and Reifen, 2022). In this regard, there is a dire need to develop composite flour using legumes to optimize their utilization and consumer acceptance (Zia *et al.*, 2011).

Currently, the advantages offered by composite flours, such as augmented protein and fiber content, prompt continuous research in the scientific fraternity. This advocate a shift towards increased usage of flours derived from non-wheat sources, replacing the traditional wheat flour in an amount to enhance the nutritional composition of flatbread (Chandra *et al.*, 2015; Urigacha, 2020; Ezegbe *et al.*, 2023).

2. Materials and Methods

The research work was carried out in the Department of Food Science and Technology located at Jinnah University for Women, Karachi. This study was designed to explore the potential of locally available raw materials rich in protein, including red lentils, kidney beans, soybean, chickpeas, maize and moringa leaves, for their total protein content. The objective of the study was to develop several formulations of protein-enriched wheat flour using protein enriched sources, preceded by their characterization. All the materials used in the current research and the corresponding protocols are thoroughly detailed herein to ensure transparency and reproducibility of the work.

2.1. Procurement of raw materials and chemicals

All raw materials, including flour, red lentils, kidney beans, soybean, chickpeas, maize and moringa leaves, were procured from the local market, ensuring that they meet quality standards concerning uniformity in size, color, and cleanliness. Analytical grade reagents necessary for the study were attained from Nawaid Scientific Traders in Karachi, ensuring the accuracy and reliability of the experimental procedures.

2.2. Preparation of samples

The entire set of raw materials, including red lentils, kidney beans, soybean, and chickpeas and maize were cleaned to eliminate any foreign materials like dust, dirt, straw, and stones. Subsequently, the raw materials were soaked and washed with water to eliminate soluble impurities.

Similarly, moringa leaves were carefully selected, sorted, and thoroughly washed.

To ensure consistent quality, all the samples were subjected to oven drying at 60-70°C till constant weight. Subsequently drying, the samples were crushed to fine powder and stored in polythene zip-lock bags to ensure their integrity for consequent investigations.

2.3. Preparation of composite flours

The composite flours were prepared by substituting the all-purpose flour as mentioned in Table 1.

Table 1. Composite flour formulations

2.4. Compositional analysis of composite flour

The raw legumes were evaluated for moisture, crude- protein, -fat & -fiber, and ash content as mentioned in detail below:

2.4.1. Moisture content

In the selected samples, moisture content was by following Method no "44-15A Moisture-Air-Oven Methods" (AACC, 2000). Intentionally, exactly 5 g of sample was taken in a pre-weighed china dish and dried at 105°C in a hot air oven until weight becomes constant. Subsequently, the dried sample was shifted to a desiccator and let it cool then moisture content was measured following the mathematical expression herein:

$$\text{Wt. of evaporated moisture (g)} = \text{Wt. of original sample (g)} - \text{Wt. of sample after drying (g)}$$

Equation # 1

Formulations	Description
W_C	Wheat flour (control) 100%
W_{R5}	Wheat flour 95% + Red lentil flour 5%
W_{R10}	Wheat flour 90% + Red lentil flour 10%
W_{R15}	Wheat flour 85% +Red lentil flour 15%
W_{R20}	Wheat flour 80% +Red lentil flour 20%
W_{K5}	Wheat flour 95% + Red kidney bean flour 5%
W_{K10}	Wheat flour 90% + Red kidney bean flour 10%
W_{K15}	Wheat flour 85% +Red kidney bean flour 15%
W_{K20}	Wheat flour 80% +Red kidney bean flour 20%
W_{S5}	Wheat flour 95% + Defatted soybean flour 5%
W_{S10}	Wheat flour 90% + Defatted soybean flour 10%
W_{S15}	Wheat flour 85% + Defatted soybean flour 15%
W_{S20}	Wheat flour 80% + Defatted soybean flour 20%
W_{C5}	Wheat flour 95% + Chickpea flour 5%
W_{C10}	Wheat flour 90% + Chickpea flour 10%
W_{C15}	Wheat flour 85% +Chickpea flour 15%
W_{C20}	Wheat flour 80% + Chickpea flour 20%
W_{M5}	Wheat flour 95% +Maize flour 5%
W_{M10}	Wheat flour 90% + Maize flour 10%
W_{M15}	Wheat flour 85% + Maize flour 15%
W_{M20}	Wheat flour 80% +Maize flour 20%
W_{ML1}	Wheat flour 99% + Moringa leaf powder 1%
W_{ML2}	Wheat flour 98% + Moringa leaf powder 2%
W_{ML3}	Wheat flour 97% +Moringa leaf powder 3%
W_{ML4}	Wheat flour 96% + Moringa leaf powder 4%

$$\text{Moisture (\%)} = \frac{\text{Wt. of evaporated moisture (g)}}{\text{Wt. of original sample (g)}} \times 100$$

Equation # 2

2.4.2. Ash content

The ash content of the samples was assessed by following "Ash-Basic Method; 08-01" (AACC, 2000). Exactly, 5 g of sample was placed in a pre-weighted porcelain crucible followed by charring until the sample became flameless. After that, the sample was placed in muffle furnace for ignition at 550-600°C for 5 hrs. till greyish white deposits attained. Afterwards, the sample was cooled in a desiccator, weighed and ash content was determined as stated herein:

$$\text{Ash content (\%)} = \frac{\text{Wt. of ash in sample (g)}}{\text{Wt. of sample (g)}} \times 100$$

Equation # 3

2.4.3. Crude protein

In all samples, nitrogen was assessed by employing Kjeldahl apparatus (model: D-40599) "30-25b Crude Protein-Improved Kjeldahl Method" (AACC, 2000). Purposely, 50 g of sample (was accurately taken in a Kjeldahl digestion tube, and digestion was done utilizing 25 mL of conc. H_2SO_4 along with digestion tablets till light green color is attained. After then, the subsequent sample was diluted to 250 mL. This digested, diluted sample (10 mL) along with 40% NaOH (10 mL) was taken in the distillation apparatus trailed by release of ammonia (NH_3) that was took by solution of boric acid + methyl red (indicator). Resultantly, ammonium borate was formed and titrated through 0.1 N H_2SO_4. Lastly, acid volume utilized during titration was recoded for nitrogen quantification.

$$\text{Nitrogen (\%)} = \frac{\text{Vol. of 0.1 N } H_2SO_4 \text{ used (mL)} \times 0.0014 \times \text{diluted Vol. (250 mL)}}{\text{Wt. of original sample (g)} \times \text{Vol. of digested, diluted sample (10 mL)}} \times 100$$

Equation # 4

$$\text{Crude protein (\%)} = \text{Nitrogen (\%) x factor}$$

Equation # 5

2.4.4. Crude fiber

The flour samples were evaluated for crude fiber, adopting Method no. 32-10 (AACC, 2000). Specifically, 10 g of sample was treated with 150 mL of 1.25% H_2SO_4 for 30 min to solubilize all acid fractions followed by filtration and washing. Further, this sample was treated with alkali to digest alkali fractions trailed by washing with hot water. Finally, the sample was dried in oven at 110°C for 24 hrs, and the ensuing sample was cooled in a desiccator prior weighing (w_1). Later, the sample was shifted in a muffle furnace for 2 hrs at 550-600°C trailed by cooling in a desiccator and re-weighed (w_2) followed by subtraction ($w_1.w_2$) to achieve loss in weight on ignition. The percentage crude fiber was assessed as stated in the equation herein:

$$\text{Crude fiber (\%)} = \frac{\text{Loss in wt. on ignition (g)}}{\text{Wt. of original sample (g)}} \times 100$$

Equation # 6

2.4.5. Crude fat

Each flour sample was confirmed for crude fat by adopting Soxtec System HT2, Extraction Unit, Tecator, Hoganas, Sweden (AACC, 2000). As a result, precisely 5 g dried sample was placed in extraction thimble whereas, 50 mL of petroleum ether was taken in a pre-weighed flask. Later, attaching both extraction thimble and flask to Soxhlet system, followed by five siphoning to accomplish extraction and solvent evaporated via rotary apparatus. The removed fat was then dried in oven at 110°C for 1 hr and crude fat was calculated by adopting ensuing equation.

$$\text{Crude fat (\%)} = \frac{\text{Wt. of fat (g)}}{\text{Wt. of original sample (g)}} \times 100$$

Equation # 7

2.4.6. Nitrogen Free Extracts (NFE)

The nitrogen free extract was estimated as stated by the formula shown herein:

$$\text{NFE (\%)}=100-[\text{moisture (\%)}+\text{crude protein(\%)}+\text{crude fat(\%)}+\text{crude fiber(\%)}+\text{ash(\%)}]$$

Equation # 8

2.5. Mineral analysis

Mineral composition of all flour blends was determined according to procedures described by Althwab et al. (2021). Expressly, 0.5 g dried sample was wet digested using di-acid mixture of 7:3 of nitric acid (HNO_3) and perchloric acid ($HClO_4$) on hot plate till 1 to 2 mL solution left trailed by dilution up to 100 mL. To measure calcium, sodium and potassium, Flame Photometer-410 (Sherwood Scientific Ltd., Cambridge, UK) was employed whereas, other minerals were assessed through Atomic Absorption Spectrophotometer (Varian AA240, Victoria Australia).

2.6. Data analysis

The obtained outcomes were subjected to a completely randomized design (CRD) and analyzed using IBM STATISTICS SPSS 20. Analysis of variance (ANOVA) was applied to estimate the significance levels (Mason *et al.*, 2003).

3. Results and Discussion

3.1. Proximate composition

The proximate composition facilitates in determining the nutritive value of foods. According to Table 2, the moisture, ash, crude protein, crude fiber, crude fat and Nitrogen Free Extract (NFE) were found to be varying significantly amongst the treatments. The current study portrayed highest ash and crude fiber contents in moringa powder incorporated samples (W_{ML4} 5.31±0.24 and 7.61±0.35 g/100g, respectively) along with minimum moisture content (W_{ML4} 8.29±0.32 g/100g). Further, maximum crude protein content was reported in soybean based samples (W_{S20} 23.26±1.05 g/100g). However, defatted soybean based composite flour samples demonstrated minimum fat content (W_{S20} 1.67±0.07 g/100g). Moreover, highest crude fat was found in chickpea carrying formulations (W_{C20} 4.19±0.19 g/100g). Furthermore, wheat sample (W_C) elucidated minimum ash (1.77±0.07 g/100g), crude, protein (12.01±0.54 g/100g) and crude fiber contents (1.78±0.08 g/100g) along with maximum moisture content (13.85±0.69 g/100g). The NFE of composite flours indicated a range between 56.87±2.56 (W_{S20}) to 70.18±3.15 (W_{C5}) g/100g.

Table 2. Proximate composition (g/100g) of composite flours

Formulations	Moisture	Ash	Crude Protein	Crude Fiber	Crude Fat	NFE
W_C	13.85±0.69a	1.77±0.07o	12.01±0.54l	1.78±0.08n	2.93±0.14cde	67.66±2.77a
W_{R5}	12.67±0.54ab	2.22±0.10jklm	13.65±0.76jkl	2.47±0.11lm	2.48±0.12ghi	66.51±2.78ab
W_{R10}	11.89±0.51bcd	2.57±0.12ghi	15.72±1.00ghi	2.96±0.12jk	2.31±0.11ij	64.55±2.83bcd
W_{R15}	11.37±0.50bcde	2.84±0.15def	17.87±1.00def	3.21±0.18hijk	2.26±0.11ij	62.45±2.80bcde
W_{R20}	11.13±0.48cdef	2.98±0.19de	20.48±1.02bc	3.64±0.19gh	2.10±0.08jk	59.67±2.84cdef
W_{K5}	11.16±0.51cdef	1.79±0.08o	14.67±0.94hijk	2.81±0.10kl	1.83±0.08lm	67.74±2.92cdef
W_{K10}	10.48±0.43defg	2.40±0.11hij	15.99±0.95gh	3.06±0.11jk	1.87±0.08klm	66.20±2.78defg

W_{K15}	10.37±0.41efg	2.62±0.12fgh	17.92±1.00de	3.17±0.15ijk	1.90±0.09klm	64.02±2.91efg
W_{K20}	9.81±0.39fghi	2.75±0.13efg	19.24±1.01bcd	3.32±0.17hij	1.95±0.09kl	62.93±2.83fghi
W_{S5}	10.52±0.43defg	2.10±0.11lmn	16.09±1.00fgh	2.78±0.11kl	2.74±0.15ef	66.84±2.77defg
W_{S10}	10.36±0.43efg	2.31±0.11jkl	18.78±1.01cd	3.56±0.18hi	2.25±0.10ij	63.16±2.76efg
W_{S15}	10.14±0.40efgh	2.74±0.15efg	20.91±1.03b	4.02±0.20fg	1.83±0.08lm	59.94±2.72efgh
W_{S20}	9.87±0.39fghi	3.08±0.17d	23.26±1.05a	4.18±0.22f	1.67±0.07lm	56.87±2.56fghi
W_{C5}	10.50±0.42defg	1.81±0.08o	12.11±0.77l	2.93±0.10jk	2.47±0.15hi	70.18±3.15defg
W_{C10}	9.84±0.37fghi	1.88±0.08no	13.25±0.81kl	3.61±0.19gh	3.81±0.17b	67.61±2.90fghi
W_{C15}	9.67±0.35ghij	1.93±0.09no	15.12±0.93ghij	4.37±0.25ef	4.02±0.19ab	64.89±2.85ij
W_{C20}	8.46±0.34ij	1.99±0.09mno	16.57±1.00efg	4.68±0.27e	4.19±0.19a	64.11±2.82bcd
W_{M5}	12.51±0.54abc	2.07±0.10lmn	13.46±0.82jkl	1.92±0.10n	2.67±0.12fgh	68.06±2.97bcd
W_{M10}	12.45±0.53abc	2.19±0.10jklm	13.79±0.85jkl	2.06±0.11mn	2.83±0.14def	66.76±2.92bc
W_{M15}	12.37±0.53bc	2.28±0.10jkl	14.16±0.86ijk	2.13±0.13mn	3.05±0.16cd	65.93±2.95abc
W_{M20}	11.82±0.51bcd	2.36±0.11ijk	14.34±0.91hijk	2.46±0.17lm	3.14±0.16c	65.19±2.84abc
W_{ML1}	11.43±0.51bcde	2.12±0.09klmn	14.78±0.93ghijk	5.22±0.29d	2.65±0.14fgh	63.72±2.93bcde
W_{ML2}	9.84±0.39fghi	3.86±0.21c	15.12±0.94ghij	6.03±0.31c	2.68±0.14efgh	62.47±2.81fghi
W_{ML3}	8.76±0.35hij	4.60±0.22b	16.57±1.00efg	6.47±0.34b	2.73±0.15efg	60.87±2.80hij
W_{ML4}	8.29±0.32j	5.31±0.24a	18.09±1.01de	7.61±0.35a	2.80±0.15def	57.90±2.67j
F value	9.62**	336.06**	73.42**	343.55**	213.45**	3.88**

Data values represent mean±SD (n = 3); One-way ANOVA followed by Tukey's HSD multiple comparison tests; ** = Highly significant ($p<0.01$)

The instant study depicted moisture and ash contents in wheat sample as 13.85±0.69 and 1.77±0.07 g/100g $i.e.$ in close harmony with Khan $et\ al.$ (2012) who found the moisture and ash of wheat flour as 11.50 and 1.62 g/100g, correspondingly. However, as the proportions of red lentils, kidney beans, soybeans, chickpea, maize, and moringa leaf powder exceeds; the moisture content of composite flours showed a declining trend, owing to less inherent moisture levels as compared to wheat flour, ranged between 6 and 11 g/100g. On the other hand, incorporation of aforementioned composite flours resulted in increase of ash content based on higher

ash levels of the selected composite flours, varying between 1.94 and 9.80 g/100g. Further, the current study demonstrated crude-protein and -fiber in wheat flour as 10.77±0.01-12.01±0.54 and 1.78±0.08- 2.65±0.06 g/100g, respectively that was in accordance with Khan *et al.* (2012) who found it as 13.24 and 2.16 g/100g. However, incorporation of red lentils, kidney beans, soybeans, chickpea, maize, and moringa leaf powder resulted in increase in protein and fiber content, ranging from 15 to 29 and 3 to 10 g/100g, accordingly. Moreover, crude fat content in wheat flour was found as 1.87 g/100g (Khan *et al.*, 2012) however, kidney beans, soybeans, chickpea, maize, and moringa leaf powder incorporated composite flours depicted higher crude fat content as compared to wheat, varying between 1.92 and 5.70 g/100g whereas, red lentil based composite flour indicated lower fat level as 1.04 g/100g than wheat flour. In context to NFE, the previous researchers have found the values varying between 43 and 69 as observed in the present study (Masood *et al.* 2014; Stevens *et al.* 2015; Lamidi *et al.* 2017; Ciurescu et al., 2018; Abimbola et al., 2020; Gulukun *et al.* 2020; Afify *et al.* 2022; Levent *et al.* 2023; Mpili *et al.* 2024).

3.2. Mineral Profiling

Statistical study reported that minerals encompassing Na, K, Ca, Mg, P, Fe, Zn, Mn and Cu differed momentously amongst the samples (Table 3). In this context, maximum Na, Fe, Zn, Mn and Cu contents were reported in moringa based flour (W_{ML4} 13.50±0.61, 17.27±0.79, 21.91±0.99, 11.03±0.49 and 7.05±0.34 mg/100g) however wheat flour (W_C) showed minimum Na content (4.13±0.17 mg/100g). Furthermore, maximum K content was found in red lentils (W_{R20} 395.87±18.17 mg/100g) with minimum K level in moringa composite flour (W_{ML4} 191.85±8.65 mg/100g). Chickpea based flours indicated maximum Ca content (W_{C20} 67.82±2.11 mg/100g) however, minimum Ca, Fe, Zn, Mn proportions were noted in maize incorporated flour (W_{M20} 14.97±0.69, 1.87±0.08, 1.56±0.07 and 0.83±0.04 mg/100g). Soybean enriched flour demonstrated highest Mg and P contents (W_{S20} 61.54±2.76 and 431.12±19.39 mg/100g) whilst, minimum Mg level was testified in red lentil based composite flour; W_{R20} 22.06±1.02 mg/100g. However, the lowest P and Cu levels were viewed in chickpea based composite flour W_{C20} (296.30±13.48 and 0.11±0.01 mg/100g).

Formulations	Na	K	Ca	Mg	P	Fe	Zn	Mn	Cu
W_C	4.13±0.17m	239.24±11.25fgh	27.52±1.39i	32.49±1.44kl	342.81±14.68defghi	2.56±1.03ghijk	1.740.07±e	1.28±0.08e	0.26±0.01ijklm
W_{R5}	5.95±0.26hij	256.06±13.82ef	30.71±1.47hi	30.13±1.42l	331.64±14.15efghij	2.71±1.09ghij	1.92±0.09e	1.29±0.08e	0.29±0.01hijklm
W_{R10}	7.12±0.38def	278.91±14.93de	38.93±1.50f	27.54±1.30lm	320.03±13.67ghij	2.85±1.10ghi	2.03±0.09e	1.30±0.09e	0.33±0.01ghijkl
W_{R15}	8.90±0.41c	354.62±16.49b	41.26±1.74ef	25.11±1.13mn	316.17±13.54hij	3.03±1.12gh	2.08±1.01e	1.32±0.09e	0.37±0.01ghijk
W_{R20}	11.67±0.58b	395.87±18.17a	45.82±1.78d	22.06±1.02n	309.93±13.17ij	3.10±1.12gh	2.12±1.03e	1.35±0.09e	0.42±0.02ghij
W_{K5}	4.94±0.25klm	228.74±10.48fghij	28.05±1.36i	36.51±1.48ijk	361.09±16.05cdefg	3.14±1.15fg	1.63±0.07e	1.23±0.07ef	0.27±0.01ijklm
W_{K10}	5.18±0.27ijkl	214.05±9.84ghijk	29.16±1.36hi	40.77±1.71fghi	369.11±16.12cdef	3.73±1.16ef	1.71±0.07e	1.24±0.07ef	0.29±0.01hijklm
W_{K15}	6.02±0.31ghi	203.32±7.96ijk	30.49±1.44hi	46.93±1.76de	374.27±16.54cde	4.04±1.19e	1.76±0.09e	1.33±0.09e	0.31±0.02hijklm
W_{K20}	6.39±0.33efgh	197.51±6.83jk	32.45±1.51gh	53.69±1.83bc	381.03±16.72bcd	4.22±1.23e	1.81±0.09e	1.39±0.09e	0.49±0.03gh
W_{S5}	5.67±0.29hijk	230.16±10.33fghi	30.93±1.48hi	35.90±1.54ijk	357.07±16.07cdefgh	2.49±1.03hijk	1.62±0.07e	1.21±0.08ef	0.45±0.03ghi
W_{S10}	6.22±0.34fgh	244.59±12.75fgh	41.58±1.73ef	48.03±1.81d	390.51±16.97abc	2.31±1.02ijkl	1.67±0.07e	1.34±0.09e	0.53±0.03g
W_{S15}	6.94±0.35defg	249.82±12.81ef	46.07±1.79d	55.21±1.78b	418.36±18.45ab	2.20±1.01jkl	1.73±0.07e	1.40±0.09e	0.76±0.03f
W_{S20}	5.72±0.25hijk	257.07±13.58ef	39.19±1.65f	61.54±2.76a	431.12±19.39a	2.11±1.01jkl	1.75±0.08e	1.44±0.09e	1.12±0.05e
W_{C5}	5.82±0.27hijk	332.18±14.72bc	45.91±1.78d	36.92±1.71ijk	330.82±15.21fghij	2.57±1.13ghijk	1.69±0.07e	1.26±0.08e	0.24±0.01jklm
W_{C10}	6.15±0.32gh	340.63±14.90b	57.11±1.96c	39.73±1.66ghij	315.09±13.11hij	2.38±1.09ijkl	1.75±0.09e	1.29±0.09e	0.18±0.01klm
W_{C15}	6.92±0.35defg	347.45±15.63b	63.54±2.02b	42.31±1.74efg	309.75±13.06ij	2.24±1.04ijkl	1.82±0.09e	1.30±0.09e	0.16±0.01lm
W_{C20}	7.21±0.39de	353.92±15.79b	67.82±2.11a	45.18±1.80def	296.30±13.48j	2.16±1.01jkl	1.87±0.09e	1.32±0.09e	0.11±0.01m
W_{M5}	4.25±0.26lm	240.02±12.43fgh	21.73±1.03j	35.91±1.58ijk	345.82±15.86defghi	2.32±1.05ijkl	1.71±0.09e	1.15±0.07ef	0.25±0.01ijklm
W_{M10}	5.01±0.26jklm	253.10±12.89ef	18.10±0.95k	42.07±1.74efgh	337.11±15.94efghij	2.16±0.09jkl	1.67±0.08e	1.09±0.06ef	0.21±0.01klm
W_{M15}	5.59±0.26hijk	279.67±11.54de	15.42±0.72k	49.52±1.73cd	321.56±15.41ghij	2.09±0.09kl	1.62±0.08e	1.02±0.06ef	0.17±0.01klm
W_{M20}	5.82±0.28hijk	303.91±14.75cd	14.97±0.69k	55.63±1.87b	314.73±14.23hij	1.87±0.08l	1.56±0.07e	0.83±0.04f	0.14±0.01lm

W_{ML1}	7.75±0.39d	212.71±10.05hijk	34.73±1.12g	35.81±1.61jk	337.53±16.77efghij	6.44±0.32d	12.63±0.65d	3.17±0.24d	1.92±0.06d
W_{ML2}	9.04±0.43c	205.83±9.87ijk	38.92±1.56f	37.33±1.62hijk	321.84±15.64ghij	9.08±0.47c	15.59±0.81c	5.92±0.28c	3.15±0.13c
W_{ML3}	11.88±0.59b	195.62±8.93k	43.60±1.63de	45.92±1.67de	315.97±14.11hij	13.59±0.56b	18.72±0.94b	8.38±0.41b	5.86±0.29b
W_{ML4}	13.50±0.61a	191.85±8.65k	45.95±1.65d	49.40±1.70cd	309.78±13.87ij	17.27±0.79a	21.91±0.99a	11.03±0.49a	7.05±0.34a
F value	188.12**	104.05**	417.92**	120.88**	19.55**	1142.44**	1111.78***	1051.01***	2201.23**

Table 3. Mineral profiling (mg/100g) of composite flours
Data values represent mean±SD ($n = 3$); One-way ANOVA followed by Tukey's HSD multiple comparison tests; ** = Highly significant ($p < 0.01$)

The conclusions of the current study are comparable to the outcomes of earlier researchers that reported Na, K, Ca, Mg, P, Fe, Zn, Mn and Cu in wheat flour as 5, 405, 34, 138.33, 345.83, 3.92, 2.92, 3.83 and 0.42 mg/100g, respectively (Khan *et al.*, 2012). Various minerals in the selected raw materials were different from one another. Na content in red lentils, kidney beans, defatted soybean, chickpea, maize, and moringa leaf powder was 63, 35, 17, 11, 5, and 214 mg/100g, respectively *i.e.* more than wheat flour and similar demonstration was observed in the present study results. With the increase in composite flour proportion, Na content was increasing in red lentil from 5.95±0.26 to 11.67±0.58, kidney bean from 4.94±0.25 to 6.39±0.33, soybean from 5.67±0.29 to 5.72±0.25, chickpea from 5.82±0.27 to 7.21±0.39, maize from 4.25±0.26 to 5.82±0.28 and moringa leaf powder from 7.75±0.39 to 13.50±0.61 mg/100g, correspondingly. Earlier scrutiny documented that K content in red lentils, kidney beans, defatted soybean, chickpea, maize, and moringa leaf powder was found to be 890, 17, 360, 730, 300 and 23 mg/100g, respectively *i.e.* less in case of kidney bean and moringa leaf powder than wheat flour. These findings are supporting the results of the present study, indicating change of K levels as the quantity exceeds from 256.06±13.82 to 395.87±18.17, from 228.74±10.48 to 197.51±6.83, from 230.16±10.33 to 257.07±13.58, from 332.18±14.72 to 353.92±15.79, from 240.02±12.43 to 303.91±14.75 and from 212.71±10.05 to 191.85±8.65 mg/100g, accordingly. The current results are in close agreement with the work of earlier researchers, who calculated the Ca content of the selected flour formulations to be 114, 51, 271, 260, 7, and 720 mg/100g, indicating less Ca level in maize flour only as compared to wheat. The present study portrayed comparable Ca level (mg/100g) depending on the quantity of the selected raw materials in wheat flour, modifying between 30.71±1.47 and 45.82±1.78 (red lentils), 28.05±1.36 and 32.45±1.51 (kidney beans), 30.93±1.48 and 39.19±1.65 (defatted soybean), 45.91±1.78 and 67.82±2.11 (chickpea), 21.73±1.03 and 14.97±0.69 (maize), and 34.73±1.12 and 45.95±1.65 (moringa leaf powder). Nevertheless, Mg level in the selected flours was 15, 762, 250, 70, 90, and 670 mg/100g, *i.e.* less for red lentils as compared to wheat flour, this trend was endorsed in the present study results. As the quantity progresses, the change in Mg level (mg/100g) was found to be varying between 30.13±1.42 and 22.06±1.02 (red lentils), 36.51±1.48 and 53.69±1.83 (kidney beans), 35.90±1.54 and 61.54±2.76 (defatted soybean), 36.92±1.71 and 45.18±1.80 (chickpea), 35.91±1.58 and 55.63±1.87 (maize), and 35.81±1.61 and 49.40±1.70 (moringa leaf powder). Minor variations in particular minerals depend on the variety or the quantity incorporated to design composite flour. In addition, P content was significantly high in defatted soybean flour (654 mg/100g) in contrast to wheat flour (342.81

mg/100g) as stated by previous researchers Khan and his coworkers, 2012 and Etiosa and his followers, 2018. Further, previous scientists determined that all the other selected flours showed less P content than wheat flour, ranging between 4-270 mg/100g and the similar trend was viewed by the current study outcomes. Earlier researchers mentioned that Fe content of wheat flour (2.56 mg/100g) was comparable with maize and chickpea flours (2.4 mg/100g) however all other flours indicated a reasonably higher value, varying between 6.5 and 187 mg/100g. These findings were in corroboration with the current study results. Likewise, the present study depicted comparable results of Zn content in wheat and maize flours, however, the existence of other selected flours demonstrated higher zinc content as the quantity of the selected flours increases in wheat flour, this trend was endorsed by the previous scientists, who found wheat and maize flour having Zn value in the range of 1.70 to 1.74 mg/100g, whereas red lentils, kidney beans, defatted soybean, chickpea, maize and moringa leaf presented the zinc content in the range of 2.1 to 540 mg/100g. Additionally, Mn and Cu showed momentously higher values in moringa leaf as compared to wheat flours and the same tendency was viewed in the current research nonetheless Mn and Cu in the remaining composite flours was comparable to that of wheat (Gharibzahedi *et al.*, 2012; Khan *et al.*, 2012; Sodamade *et al.*, 2013; Hayat *et al.*, 2014; Etiosa *et al.*, 2017; Dandachy *et al.*, 2019; Filho *et al.*, 2020).

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