Hindawi
Journal of Food Processing and Preservation
Volume 2023, Article ID 2228745, 9 pages
https://doi.org/10.1155/2023/2228745

Research Article

Development and Quality Assessment of Ready-to-Cook Mixed Dal Powder

K. M. Mahdiuzzaman Sayed,[1] **Farzana Akter**,[1] **Md. Ahmadul Islam**,[2] **B. M. Khaled**,[3] **Lopa Aunsary**,[4] **Abdullah Iqbal**,[2] **and Md. Abdul Alim**[2]

[1]*Department of Nutrition and Food Engineering, Daffodil International University, Dhaka, Bangladesh*
[2]*Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh, Bangladesh*
[3]*Department of Agro Product Processing Technology, Jashore University of Science and Technology, Jashore, Bangladesh*
[4]*Department of Food Engineering, Dhaka University of Engineering and Technology, Bangladesh*

Correspondence should be addressed to Md. Ahmadul Islam; sourav.ftri@bau.edu.bd

Received 30 March 2023; Revised 24 August 2023; Accepted 2 September 2023; Published 9 September 2023

Academic Editor: Néstor Gutiérrez-Méndez

The pace of modern life of dwellers in big cities worldwide increases the demand for fast food or ready-to-cook meals. Dal curry is a common and popular meal item in Bangladesh, but its long cooking time needs to be reduced to satisfy consumer's needs. So, this study is aimed at developing and analyzing ready-to-cook mixed dal powder. Samples were prepared with 100% lentil (control), 25% green gram with 75% lentil (S_1), 25% black gram with 75% lentil (S_2), and 50% of both dal in 1 : 1 ratio with 50% lentil (S_3). Compared to mixed dal powder (8 minutes), the lentil dal powder took less cooking time (7.29 minutes). Mixed dal had no significant effect ($p > 0.05$) on moisture, fat, and ash but affected on protein content. All mixed dal powder samples showed a higher protein content as well as amino acids such as alanine, aspartic acid, cysteine, glutamic acid, histidine, isoleucine, leucine, methionine, and tyrosine compared to the control. In contrast, the control showed the highest amount of arginine, glycine, lysine, proline, serine, and threonine. Control sample showed the highest loose bulk density (0.828 g/ml), tapped bulk density (0.905 g/ml), water absorption index (5.160 g/g), and water solubility index (24.410 g/100 g) than mixed samples. The color was influenced significantly by adding different pulses variety. The flowability of each sample was excellent, as Carr's index (CI) and Hausner ratio (HR) for all samples were within 0-10% and 1.00-1.11, respectively. Although no significant differences were found, the sample with 50% lentil, 25% green gram, and 25% black gram secured the highest score in overall acceptability. Samples' total viable count was assessed for up to 6 months, where the values were within the acceptable limit.

1. Introduction

Pulses, locally known as dal in the Indian subcontinent, accounted for about 2% of Bangladesh's overall grain production over the period between 2021 and 2022 [1, 2]. According to the Bangladesh Bureau of Statistics (BBS) [1], total pulse production in Bangladesh was 432, 000 metric tons, occupying a production area of 926, 000 acres. Common pulses like lentils (*Lens culinaris* M.) or masur dal, green gram (*Vignaradiata* L.) or mungbean, black gram (*Vignamungo* L.) or mashkalai cover 38.55%, 12.30%, and 11.04%, respectively, of total pulse production area in the year of 2021-2022. Pulses have a 60–65% of carbohydrate, about 20 to 25% of protein, less than 3% of lipid, and an ash content ranging from 2% to 5% [3–6]. They are high in folate, thiamine, riboflavin, and niacin and also contain anti-inflammatory, anticancer, antibacterial, and antiulcerative properties containing phytochemicals [7]. Pulse starches with higher retrogradation tendency cause more digestive enzyme resistance, resulting in a lower glycemic index, and are suitable for diabetic and obese people. Besides people with celiac disease, gluten-free pulses can be used in their recipes [8, 9]. Half a serving cup of cooked pulses is equivalent to 30 g of meat, and half of the daily fiber recommendation for adults is found in one cup of cooked lentils [4, 8]. Pulses are also called the "meat of the poor" as they are still the cheapest source of protein [10]. Protein intake is crucial for adequately functioning the brain, immune system, and renal system; thus, getting enough of it is essential for good health [11]. It is important to evaluate the intake of individual amino acids even though overall protein consumption may be sufficient. Despite having a high methionine level, rice protein is low in lysine, whereas pulses protein tends to be low in methionine but high in lysine, isoleucine, leucine, and valine. So, an adequate intake of each can be obtained by combining these amino acid sources [12]. Products from pulses like dal curry, kalairuti, idli, dosa, samber, papadum, dal pakora, dal puri, mung dal nuggets, and others are the popular food items in the Indian subcontinent [13, 14]. In Bangladesh and other Indian subcontinents, the pulse is predominately used as dal curry with rice and ruti and takes a long time to cook (about 30 minutes or more) because pulse starches are difficult to swell and rupture during heating or cooking due to having a strong retrograde tendency [9, 15].

Foods consumed after applying little cooking effort, like boiling or heating, are known as ready-to-cook food (RTC) [16]. Urbanization, cultural, and social modifications significantly impact food habits and cooking methods. Preferences for easy and low-time spending cooking methods and quick-cooked products are increasing to maintain the stress of busy life and save time [17]. From a previous study, ready-to-cook sambar powder prepared with red, Bengal, and black gram grits required less than 10 minutes to be cooked; it was classified as 'liked extremely' concerning its taste and appearance [18]. Ready-to-cook mixed dal powder can be considered a modified form of sambar powder due to its raw materials (lentil, green, and black gram) and processing method [19]. The main focus of this study was to obtain an instant mixed dal powder following the shortest and easiest cooking method improving its physicochemical properties and consumer preferences. Based on the above discussion, the experiment was conducted to analyze the nutritional, physical, sensory properties, and microbial stability of the ready-to-cook mixed dal powder.

2. Materials and Methods

The experiment was conducted in the Department of Food Technology and Rural Industries' laboratory, Department of Microbiology and Hygiene, Bangladesh Agricultural University, and Department of Pharmacy, Jashore University of Science and Technology.

2.1. Materials

2.1.1. Raw Materials Collection. Lentil (BARI Masur-8) and black gram (BARI Mas-2) grown in the Jashore District and green gram (BARI Mung-5) grown in the Patuakhali District were collected by two local packers. All three types of pulses were collected as a whole (pulse with outer layer). Other ingredients salt (ACI pure), red chilli powder (Radhuni chilli powder), and turmeric powder (Radhuni turmeric powder) were also purchased from Shawpno supermarket in Mymensingh District.

2.2. Formulation of Ready-to-Cook Mixed Dal Powder. The four different samples were made by following the completely randomized design (CRD). As stated in Table 1, all other ingredients were the same for all formulations.

2.3. Preparation of Ready-to-Cook Mixed Dal Powder. The unhusked pulses were cleaned to remove dust, dirt, chaff, stone pieces, immature grains, and other seeds. Then they were soaked in water for 5 hours; after steeping, the wet pulses were sun-dried for three days to loosen the husk. The dehusking and splitting were then carried out with a pestle and mortar. The husk was then separated by winnowing and obtained the desired dal. After weighing all the ingredients, each dal was soaked in water at room temperature for 10 minutes in a cooking pan. After that, each dal was washed three times with water, and then water was discarded through straining. About 3,000 ml of water had been added to it and placed on a gas stove by fixing the temperature at 100°C. All other ingredients were added and mixed properly. The pan lid was closed, boiled for 30 minutes, and stirred frequently. Once the paste formed, the mix was cooled for 15 minutes at room temperature. Next, trays were covered with low-density polyethylene, and dal paste was spread on the trays. Afterward, the trays were placed in a cabinet dryer (Model: RXH-III, Taizhou Quanta Machinery Equipment Co., Ltd., Jiangsu, China) (60°C for 6 hours). The powder was made from the dried dal using a blending machine (Model: TYB-311, Jiangmen Long Term Trading Co., Ltd., China). After weighing the powder and sealing it with high-density polyethylene using a vacuum sealer (Model: DFD-40/40I/40A, Zhejiang Dingye Machinery Co., Ltd.), mixed dal powder was stored at room temperature.

2.4. Proximate Composition. Moisture, ash, fat, and protein content were determined using AOAC [20–23] method. The sample's carbohydrate content was calculated in terms of total carbohydrate. The quantity was determined by deducting the moisture, protein, fat, and ash content percentages from 100 [24].

$$\text{Total carbohydrate} = 100 - (\%\text{moisture} + \%\text{protein} + \%\text{fat} + \%\text{ash}). \tag{1}$$

2.5. Total Calorie. The sum of the protein, fat, and carbohydrate mean multiplied by the factors 4, 9, and 4 correspondingly, yielded the total calorific value [25].

$$\text{Calories} = [9 \times (\text{g fat}) + 4 \times (\text{g protein}) + 4 \times (\text{g carbohydrate})]. \tag{2}$$

2.6. Amino Acid Profile. The content of amino acids in each sample was determined using the Hitachi High-Speed Amino Acid Analyzer (Model: LA8080 Amino SAAYA) by following the protein hydrolysate analysis method (standard analysis method).

Table 1: Formulation of ready-to-cook mixed dal powder.

Ingredients	Control	S_1	S_2	S_3
Lentil (g)	1000	750	750	500
Green gram (g)	0	250	0	250
Black gram (g)	0	0	250	250
Salt (g)	60	60	60	60
Turmeric powder (g)	10	10	10	10
Red chili powder (g)	6	6	6	6
Water (ml)	3000	3000	3000	3000

2.6.1. Biological Activity of Protein. The biological activity of proteins was assessed by using Fischer's ratio as an indicator. It was obtained by calculating the proportion of aromatic amino acids (phenylalanine and tyrosine) to branched chain amino acids (BCAA; valine, leucine, and isoleucine), and the value above 1.8 is a good score for protein biological activity [26]. The BCAA-to-tyrosine ratio (BTR), another indicator connected to Fischer's ratio, is regarded as normal when it is between 4.41 and 10.05 [26].

2.7. Powder Properties

2.7.1. Loose and Tapped Bulk Density. Loose bulk density and tapped bulk density were measured according to the procedure described by Reddy et al. [27]. The following formula was used to calculate the loose and tapped bulk density of the ready-to-cook mixed dal powder:

$$\text{Loose bulk density (g/ml)} = \frac{\text{Weight of powder (g)}}{\text{Bulk powdered volume (ml)}},$$
$$\text{Tapped bulk density (g/ml)} = \frac{\text{Weight of powder(g)}}{\text{Tapped powdered volume (ml)}}. \quad (3)$$

2.7.2. Flowability. In terms of Carr's index (CI) and Hausner ratio (HR), the ready-to-cook mixed dal powder's flowability was assessed. Both CI and HR were calculated from the loose and tapped bulk densities of the ready-to-cook mixed dal powder according to the formula given by Reddy et al. [27].

(1) Carr's Index (CI). It is a simple test to evaluate Carr's index from the loose and tapped bulk density of ready-to-cook mixed dal powder. The Carr's index formula is as follows:

$$\text{Carr's index (\%)} = \frac{\text{Tapped bulk density (g/ml)-Loose bulk density (g/ml)}}{\text{Tapped bulk density (g/ml)}} \times 100. \quad (4)$$

(2) Hausner Ratio (HR). The flowability of the ready-to-cook mixed dal powder is connected with a value known as the Hausner ratio. It was calculated by using the following expression:

$$\text{Hausner ratio} = \frac{\text{Tapped bulk density (g/ml)}}{\text{Loose bulk density (g/ml)}}. \quad (5)$$

2.7.3. Color Measurement. A colorimeter was used to measure the color of the ready-to-cook mixed dal powder samples. (Chroma Meter CR400, Konica Minolta, Japan) under conditions (Illuminant: *C, D65; space: LAB). The equipment was calibrated with a white reference before measurements for color analysis. The color was measured in CIE – $L^* a^* b^*$ system, where L^* indicates lightness ($L^* = 0$, black; $L^* = 100$, white), a^* indicates redness to greenness, and the b^* value indicates yellowness to blueness. The positive a^* indicates redness, and the negative a^* indicates greenness. The positive b^* values indicate yellowness, and the negative b^* values indicate blueness.

2.7.4. Water Absorption Index (WAI) and Water Solubility Index (WSI). The water absorption index and water solubility index of the ready-to-cook mixed dal powder samples were determined by referring to the method reported by Du et al. [28]. The following formulae were used to determine the WAI and WSI:

$$\text{WAI (g/g)} = \frac{\text{Weight of sediment}}{\text{Weight of powder sample}},$$
$$\text{WSI (g/100 g)} = \frac{\text{Weight of dissolved solide in supernatant}}{\text{Weight of powder sample}} \times 100 \quad (6)$$

2.8. Preparation of Dal from Ready-to-Cook Mixed Dal Powder. Ingredients and other spices required to prepare ready-to-eat dal from a 50 g ready-to-cook sample are shown in Table 2. A cooking pan with 15 ml of soybean oil was placed in an induction oven, and then chopped ingredients (onion, garlic, ginger, and chili) and whole cumin were added to the hot oil. All the ingredients were turned brown by frequent stirring within 3 minutes. About 750 ml of water was added and then boiled at 100°C. Then, 50 g of ready-to-cook mixed dal and coriander powder were added and stirred thoroughly. Finally, the desired dal paste was ready to serve. The same procedure and amounts were made from each of the four samples separately. Approximately 9 minutes were required to make ready-to-eat dal from the beginning.

2.9. Sensory Evaluation. The sensory evaluation of four types of dal made from four types of developed dal powder was evaluated for parameters by 10 testers. The M.Sc. Food Engineering students at Bangladesh Agricultural University were used to choose the panelists. The sample's color, flavor, texture, and overall acceptability were all rated by the taste panelists on a 9-point hedonic scale with the ratings of 9 = like extremely, 8 = like very much, 7= like moderately, 6 = like slightly, 5 = neither like nor a dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely.

2.10. Microbial Assessment. Total viable count (TVC) was performed for microbiological assessment based on the methods described by [29].

Table 2: Ingredients used to make dal from 50 g sample.

Ingredients	Amount
Soybean oil	15 ml
Onion (chopped)	25 g
Green chili (chopped)	10 g
Garlic (chopped)	5 g
Ginger (chopped)	5 g
Whole cumin	2 g
Coriander powder	2 g

2.11. Statistical Analysis. Each experiment was carried out three times. Statistical analyses were conducted using SPSS 22.0 (IBM SPSS Inc., Chicago, IL, USA) software. A Duncan's multiple range test was used, and the levels were considered significantly different at $p < 0.05$.

3. Results and Discussion

3.1. Proximate Composition of Developed Ready-to-Cook Mixed Dal Powder. The proximate composition of all the formulated samples is presented in Table 3. The addition of green gram and black gram to the lentil dal powder samples did not affect significantly ($p > 0.05$) the moisture content. Moisture content was recorded as slightly higher in S_2, whereas the lowest moisture content was found in S_3. The recorded moisture content of the control, S_1, S_2, and S_3 samples was $5.777 \pm 0.067\%$, $5.820 \pm 0.171\%$, $5.755 \pm 0.157\%$, and $5.740 \pm 0.082\%$, respectively. But all the recorded values were found to be far below the safe moisture content of 12% for pulses or cereal powder products specified in the study by Befikadu, [30]. The control ready-to-cook dal powder showed the lowest protein content of $23.830 \pm 0.184\%$ and was significantly ($p > 0.05$) similar with the sample S_2 ($24.127 \pm 0.155\%$), though 250 g of black gram was added to this formulation. Highest protein content was found in S_3 ($24.847 \pm 0.183\%$) which was formulated with both of green and black gram. On the other hand, S_1 having the protein content of $24.660 \pm 0.326\%$ and not significantly differ ($p > 0.05$) from S_3. This could be due to protein content was found higher in some varieties of green gram (25.02%) and black gram (24%) than in lentils (20%) in the studies of Ramdath et al. [31], Wani et al. [32], Kamboj and Nanda [33]. Pulses like lentils, black gram, and green gram are low in fat (0.87, 1.1, and 1.43%, respectively) and ash content (2.37, 3, and 3.25%, respectively) [26, 32, 34]. So, changing the formulation of the dal recipe by mixing these pulses did not significantly ($p > 0.05$) affect the fat and ash content (Table 3). In the case of the total carbohydrate content, Control and S_2 significantly differ ($p \leq 0.05$) from S_1 and S_3. The control one obtained the highest amount of carbohydrate content ($59.273 \pm 0.225\%$), whereas S_3 obtained the lowest ($58.263 \pm 0.035\%$). Also, significant ($p \leq 0.05$) changes found in the calories of the experimental formulated mixed dal powder samples. The assessed energy content of control, S_1, S_2, and S_3 samples was found to be 349.183 ± 0.291, 347.913 ± 1.068, 348.990 ± 0.584, and 347.830 ± 0.364 kcal, respectively.

3.2. Amino Acid Content of the Developed Ready-to-Cook Mixed Dal Powder. Table 4 shows the amino acid composition (g/100 g powder) of all the developed ready-to-cook mixed dal powder recipes. In this experiment, we tried to find out if there was any change occurred in amino acid content after mixing different types of pulses while aiming to make the product for easy cooking. Recipe S_3 was higher in total amino acid content (22.120 g/100 g powder) than the other three samples, whereas S_1 had the least number of amino acids (20.901 g/100 g powder). There was a significant increment of alanine content in all the samples except S_2. Arginine and cysteine content were not significantly ($p > 0.05$) affected after mixing the green gram and/or black gram with lentils. Aspartic acid was increased in S_3 and statistically similar ($p > 0.05$) with S_2 but not ($p \leq 0.05$) with other two. The lowest aspartic acid content was detected in the control sample (2.707 ± 0.038 g/100 g), while the highest value was in S_3 (2.880 ± 0.017 g/100 g). Glutamic acid was found to be highest in amount than any other AAC in any sample. The highest amount of glutamic acid content 4.667 ± 0.045 g/100 g detected in S_3, and the control had the lowest amount 3.803 ± 0.045 g/100 g. The glycine content of all the samples was not significantly ($p > 0.05$) affected as the study found it 0.937 ± 0.021, 0.933 ± 0.021, 0.927 ± 0.021, and 0.923 ± 0.021 g/100 g in control, S_1, S_2, andS_3, respectively. Proline was decreased from 0.633 ± 0.035 to 0.567 ± 0.015 g/100 g. This significant ($p \leq 0.05$) reduction was only occurred in S_3 compared to the control, S_1 and S_2. Serine did not significantly ($p > 0.05$) differ in control and S_1. Serine was found in control, S_1, S_2, and S_3 of 1.310 ± 0.02, 1.313 ± 0.031, 1.20 ± 0.02, and 1.207 ± 0.012 g/100 g, respectively. Methionine was not affected significantly ($p > 0.05$) in the developed ready-to-cook mixed dal powder samples. A significant ($p \leq 0.05$) change was observed in the case of histidine, where the increment occurred from $0.617 \pm 0.0\,21$ g/100 g in the control to 0.683 ± 0.045 g/100 g in S_3. Leucine and valine were affected significantly ($p \leq 0.05$) after mixing green and black grams to develop the ready-to-cook mixed dal powder, but there was no significant ($p > 0.05$) difference in isoleucine content among the samples. The isoleucine value was increased from 0.777 ± 0.031 g/100 g in the control to 0.81 ± 0.046 g/100 g in S_2. Leucine was detected highest in S_3 of 1.843 ± 0.045 g/100 g. Valine was significantly ($p \leq 0.05$) increased in S_1 and S_3 but not in S_2. S_2 showed the highest amount of lysine ($1.663 \pm 0.015\,01$ g/100 g) that significantly ($p \leq 0.05$) differed from the other three samples. The control sample had phenylalanine content of 1.133 ± 0.032 g/100 g which did not significantly ($p > 0.05$) differ from the phenylalanine content of S_1 and S_3. Tyrosine was not significantly ($p > 0.05$) affected after replacing lentils with green gram and/or black gram but a little increment in each sample was found. The addition of green gram and black gram also did not significantly ($p > 0.05$) affected threonine though there is a slight decrement in it. It ranged from 0.843 ± 0.021 g/100 g (in S_3) 0.907 ± 0.031 g/100 g (in control). The increment was found in most of the AAs content after mixing the green/or

Table 3: Physical, chemical, sensorial, and microbiological profile of ready-to-cook mixed dal powder samples.

	Control	S_1	S_2	S_3
Physical properties of ready-to-cook mixed dal powder				
Loose bulk density (g/ml)	0.828 ± 0.001^a	0.825 ± 0.002^a	$0.805 \pm 0.004c$	0.811 ± 0.002^b
Tapped bulk density (g/ml)	0.905 ± 0.002^a	0.899 ± 0.001^b	0.884 ± 0.002^d	0.893 ± 0.003^c
Water absorption index (WAI) (g/g)	5.160 ± 0.046^a	5.073 ± 0.025^c	5.143 ± 0.058^a	5.036 ± 0.010^c
Water solubility index (WSI) (g/100 g)	24.410 ± 0.060^a	23.157 ± 0.093^b	23.243 ± 0.045^b	22.370 ± 0.030^c
Carr's index (CI) (%)	$8.507 \pm 0.310b^c$	8.263 ± 0.113^c	8.943 ± 0.350^{ab}	9.167 ± 0.231^a
Hausner ratio (HR)	1.092 ± 0.004^b	1.089 ± 0.001^b	1.10 ± 0.010^{ab}	1.107 ± 0.010^a
L^*	72.463 ± 0.240^c	73.870 ± 0.139^b	73.747 ± 0.042^b	74.753 ± 0.050^a
a^*	-4.853 ± 0.101^b	-5.410 ± 0.027^d	-4.653 ± 0.015^a	-5.043 ± 0.015^c
b^*	48.940 ± 0.252^a	49.293 ± 0.506^a	47.430 ± 0.157^b	47.537 ± 0.120^b
Cooking time (min)	7.29 ± 0.055^b	8.33 ± 0.021^a	8.31 ± 0.057^a	8.30 ± 0.030^a
Percentage proximate composition of ready-to-cook mixed dal powder				
Moisture (%)	5.777 ± 0.067^a	5.820 ± 0.171^a	5.755 ± 0.157^a	5.733 ± 0.080^a
Protein (%)	23.830 ± 0.184^b	24.660 ± 0.326^a	24.127 ± 0.155^b	24.847 ± 0.183^a
Fat (%)	1.863 ± 0.090^a	1.740 ± 0.110^a	1.803 ± 0.085^a	1.710 ± 0.053^a
Ash (%)	9.257 ± 0.110^a	9.377 ± 0.100^a	9.250 ± 0.095^a	9.447 ± 0.096^a
Carbohydrate (%)	59.273 ± 0.225^a	58.403 ± 0.312^b	59.063 ± 0.489^a	58.263 ± 0.035^b
Energy (kcal/100 g)	349.183 ± 0.291^a	347.913 ± 1.068^{ab}	348.990 ± 0.584^{ab}	347.830 ± 0.364^b
Sensory properties of dal made from ready-to-cook mixed dal powder				
Color	8.00 ± 0.817^a	8.30 ± 0.483^a	7.90 ± 0.738^a	8.10 ± 0.568^a
Flavor	7.20 ± 0.789^a	7.30 ± 0.823^a	7.20 ± 0.919^a	7.50 ± 0.527^a
Taste	7.30 ± 0.675^a	7.60 ± 0.843^a	7.50 ± 0.527^a	7.80 ± 0.632^a
Mouthfeel	6.90 ± 0.738^a	6.80 ± 0.632^a	6.40 ± 0.70^a	6.60 ± 0.699^a
Overall acceptability	7.10 ± 0.568^a	7.40 ± 0.699^a	7.20 ± 0.632^a	7.50 ± 0.527^a
TVC (×10^3 CFU/g) of the developed ready-to-cook mixed dal powder				
0 month	1.496 ± 0.014^{Bg}	1.498 ± 0.016^{Ag}	1.495 ± 0.015^{BCg}	1.494 ± 0.015^{Cg}
1 month	1.653 ± 0.020^{Bf}	1.667 ± 0.015^{Af}	1.640 ± 0.040^{BCf}	1.624 ± 0.010^{Cf}
2 months	1.870 ± 0.020^{Be}	1.860 ± 0.030^{Ae}	1.830 ± 0.017^{BCe}	1.833 ± 0.025^{Ce}
3 months	1.983 ± 0.015^{Bd}	2.013 ± 0.023^{Ad}	1.973 ± 0.015^{BCd}	1.980 ± 0.010^{Cd}
4 months	2.080 ± 0.030^{Bc}	2.10 ± 0.0250^{Ac}	2.063 ± 0.040^{BCc}	2.060 ± 0.010^{Cc}
5 months	2.127 ± 0.010^{Bb}	2.167 ± 0.040^{Ab}	2.123 ± 0.025^{BCb}	2.103 ± 0.030^{Cb}
6 months	2.160 ± 0.010^{Ba}	2.220 ± 0.070^{Aa}	2.186 ± 0.020^{BCa}	2.123 ± 0.020^{Ca}

Control = 100%lentil; S_1 = 75%lentil + 25%green gram; S_2 = 75%lentil + 25%black gram; and S_3 = 75%lentil + 25%green gram + 25%black gram. Data are the means ± standard deviations ($n = 3$). Different uppercase letters in the same row indicate differences ($p < 0.05$) in means among formulations and different lower case letters in the same column indicate differences ($p < 0.05$) in means among storage periods. TVC= total viable count; CFU= colony forming unit.

black gram into the samples. Arginine, aspartic and glutamic acids, and leucine accounted for more than half of the total AAs in each sample as said by [35]. Alanine, aspartic acid, glutamic acid, leucine, methionine, phenylalanine, proline, tyrosine, and valine content were found to be higher in green gram from the study by Ullah et al. [36] than the lentils found in the study of Khazaei et al. [37] and Grela et al. [38]. These AAs of green gram were also higher than black gram (except Met) found in the experiment of Zia-Ul-Haq et al. [39] and USDA [40]. So, these AAs were found to be higher in the amount in the samples containing green grams (S_1 and S_3). In this study, Fischer's ratio was found to be 1.868, 1.914, 1.981, and 1.997 for the control, S_1, S_2, and S_3, respectively, which were > 1.8. The BTT ratio for the control, S_1, S_2, and S_3 was also found to be 5.10, 5.254, 5.014, and 5.127, respectively. Fischer's ratio is the ratio of aromatic amino acid to branched chain amino acid, and BTT means the ratio of branched chain amino acid to tyrosine. Both are used to assess the biological activity of protein and which were within the expected range between >1.8 and 4.41 and 10.05, respectively [26].

Table 5 shows the comparison between the essential amino acid (EAA) composition (mg/g protein) of all developed ready-to-cook mixed dal powder and their requirements in the human body in mg/kg of body mass. Considering age, EAA composition was measured against two scoring patterns of adult and young children. As seen in Table 5, 100 g of dal powder is sufficient to meet the entire EAA requirement for adult but not for young children per

Table 4: Amino acid content of developed ready-to-cook mixed dal powder samples (g/100 g powder).

Amino acids (AAs)	Control	S_1	S_2	S_3
Alanine (Ala)	0.963 ± 0.025^{bc}	1.037 ± 0.035^{a}	0.933 ± 0.040^{c}	1.01 ± 0.02^{ab}
Arginine (Arg)	1.767 ± 0.025^{a}	1.767 ± 0.035^{a}	1.737 ± 0.02^{a}	1.737 ± 0.012^{a}
Aspartic acid (Asp)	2.707 ± 0.038^{b}	2.873 ± 0.025^{a}	2.733 ± 0.032^{b}	2.880 ± 0.017^{a}
Cysteine (Cys)	0.143 ± 0.015^{a}	0.15 ± 0.02^{a}	0.153 ± 0.015^{a}	0.163 ± 0.006^{a}
Glutamic acid (Glu)	3.803 ± 0.045^{d}	4.350 ± 0.043^{b}	4.20 ± 0.026^{c}	4.667 ± 0.045^{a}
Glycine (Gly)	0.937 ± 0.021^{a}	0.933 ± 0.021^{a}	0.927 ± 0.021^{a}	0.923 ± 0.021^{a}
Histidine (His)	$0.617 \pm 0.0\ 21^{b}$	0.623 ± 0.015^{b}	0.680 ± 0.026^{a}	0.683 ± 0.045^{a}
Isoleucine (Ileu)	0.777 ± 0.031^{a}	0.773 ± 0.031^{a}	0.81 ± 0.046^{a}	0.807 ± 0.015^{a}
Leucine (Leu)	1.660 ± 0.03^{c}	1.803 ± 0.035^{ab}	1.747 ± 0.038^{b}	1.843 ± 0.045^{a}
Lysine (Lys)	1.570 ± 0.02^{b}	1.443 ± 0.038^{c}	1.663 ± 0.015^{a}	1.537 ± 0.025^{b}
Methionine (Met)	0.41 ± 0.021^{a}	$0.423 \pm 0.025a$	0.427 ± 0.031^{a}	0.440 ± 0.010^{a}
Phenylalanine (Phe)	1.133 ± 0.032^{ab}	1.187 ± 0.032^{a}	1.057 ± 0.035^{c}	1.113 ± 0.025^{bc}
Proline (Pro)	0.633 ± 0.035^{a}	0.603 ± 0.031^{ab}	0.597 ± 0.025^{ab}	0.567 ± 0.015^{b}
Serine (Ser)	1.310 ± 0.02^{a}	1.313 ± 0.031^{a}	1.20 ± 0.02^{b}	1.207 ± 0.012^{b}
Threonine (Thr)	0.907 ± 0.031^{a}	0.897 ± 0.04^{a}	0.853 ± 0.04^{a}	0.843 ± 0.021^{a}
Tyrosine (Tyr)	0.657 ± 0.021^{a}	0.680 ± 0.05^{a}	0.690 ± 0.044^{a}	0.710 ± 0.036^{a}
Valine (Val)	0.907 ± 0.025^{b}	0.997 ± 0.032^{a}	0.903 ± 0.035^{b}	0.990 ± 0.01^{a}
BCAA (IIeu+Leu+Val)	3.344^{d}	3.573^{b}	3.460^{c}	3.640^{a}
AAA (Phe+Tyr)	1.790^{c}	1.867^{a}	1.747^{d}	1.823^{b}
Fischer's ratio (BCAA/AAA)	1.868^{c}	1.914^{b}	1.981^{a}	1.997^{a}
BCAA to tyrosine ratio (BCAA/Tyr)	5.10^{b}	5.254^{a}	5.014^{c}	5.127^{b}

Control = 100%lentil; S_1 = 75%lentil + 25%green gram; S_2 = 75%lentil + 25%black gram; and S_3 = 75%lentil + 25%green gram + 25%black gram. Data are the means ± standard deviations ($n = 3$). Different superscripts letters in columns indicate statistical differences ($p < 0.05$). BCAA= branched chain amino acids; AAA: aromatic amino acids.

Table 5: Essential amino acid (EAAs) composition (mg/g protein) against the recommended [50] and 2013 amino acid scoring patterns for human requirements in mg/kg of body mass.

Amino acids	FAO scoring pattern (age groups)		Samples			
	Young child [50]	Adult [51]	Control	S_1	S_2	S_3
Histidine	66	16	25.89	25.26	28.18	27.49
Isoleucine	95	30	32.61	31.35	35.57	32.48
Leucine	198	61	69.66	73.11	72.41	74.17
Lysine	83	48	65.88	67.44	68.93	61.86
Methionine+Cysteine	183	23	23.21	23.24	24.04	24.27
Phenylalanine+Tyrosine	88	41	75.12	75.71	72.41	73.37
Threonine	103	25	38.06	36.37	35.35	33.93
Tryptophan	29	6.6	—	—	—	—
Valine	130	40	38.06	40.43	37.43	39.84

Control = 100%lentil; S_1 = 75%lentil + 25%green gram; S_2 = 75%lentil + 25%black gram; and S_3 = 75%lentil + 25%green gram + 25%black gram.

1 kg of body weight. Some EAAs like leucine, valine, methionine-cysteine, and threonine are much more required for young children than adult, so they need to more dal intake. Only threonine of EAAs was decreased after supplementing lentil with green gram or black gram or both. Thus mixed dal powder could be a great meal of balanced EAAs.

3.3. Powder Properties

3.3.1. Physicochemical Properties. A powder's loose bulk density and tapped bulk density are important characteristics as the choice of the container size and strength of powder food depend on them [41]. The water absorption index (WAI) reveals the integrity of starch in aqueous dispersions and calculates the volume that the starch occupies after swelling in excess water. The water solubility index (WSI) represents the solubility of a molecules [28]. Loose bulk density, tapped bulk density, WAI, and WSI of the control and mixed pulse samples were determined. The results are shown in Table 3. For measured loose bulk density, control (0.828 ± 0.001 g/ml) and S_1 (0.825 ± 0.002 g/ml) were significantly ($p > 0.05$) similar, but they both differed from S_2 (0.805 ± 0.004 g/ml) and S_3

(0.811 ± 0.002 g/ml). All the developed samples were found significantly ($p < 0.05$) different from each other in the case of measured tapped bulk density, and those were found to be 0.905 ± 0.002, 0.899 ± 0.001, 0.884 ± 0.002, and 0.893 ± 0.003 g/ml for the control, S_1, S_2, and S_3, respectively. There may be comparatively fine granules in S_2 and S_3 which caused lower values of loose and tapped bulk density by creating less void space. Kaur and Singh [42] showed that the WAI of powder increases with the carbohydrate especially starch which have higher hydrophilicity and gelation capacity. This study showed similar results (Table 3) that the control with higher carbohydrate content (59.273 ± 0.225%) recorded with higher WAI (5.160 ± 0.046 g/g) whereas S_3 with lower carbohydrate content (58.236 ± 0.035%) significantly ($p \leq 0.05$) showed the lower WAI (5.036 ± 0.010 g/g). The WAI of S_1, S_3, S_2, and control were statistically ($p > 0.05$) similar. The control sample containing 100% lentils showed significantly ($p \leq 0.05$) higher WSI (24.410 ± 0.060 g/100 g) than S_1, S_2, and S_3. WSI of S_1 and S_2 were statistically ($p > 0.05$) similar but differed from S_3. Du et al. [28] found WSI of different legumes flour ranges from 19.44 to 29.14 g/100 g. Formation of complexes among starch, lipid, and protein due to cooking heat could affect the water solubility capacity [43].

3.3.2. Flowability and Cooking Time. The real purpose for measuring flowability is to correlate results for powder flowability to actual behavior in the production process [44]. Carr's index (CI) and Hausner ratio (HR) were calculated from the measured loose bulk density, and tapped bulk density and the values are shown in Table 3. The cohesiveness and % compressibility of dry powder products were obtained by Hausner's ratio and Carr's index. Low CI and HR means the product is less compressible and cohesive and then more free to flow [45]. The CI and HR values of all samples ranged from 8.263 ± 0.113% to 9.167 ± 0.231% and 1.089 ± 0.001 to 1.107 ± 0.010, respectively (Table 3) and were considered as excellent because the values were within the standard range (CI: 0 to 10% and HR: 1.00 to 1.11) [27]. Observing the cooking time of all developed instant dal powder, there was no considerable change ($p > 0.05$) except lentil dal, and each sample took less than 9 minutes. From the study of Vanishree et al. [18] and Alim et al. [19], the instant mixed samber powder took less than 10 minutes.

3.3.3. Color Measurement. From Table 3, it is seen that the lightness (L^*) increased significantly ($p \leq 0.05$) with the addition of green and black grams, and among all samples, S_3 showed the highest lightness (74.753 ± 0.050). This may happen because green gram shows higher lightness than lentil flour, and dehusked black gram shows higher lightness than green gram and lentils [46, 47]. Green gram mixed sample (S_1) showed higher greenness (−5.410 ± 0.027) and yellowness (49.293 ± 0.506) because green gram powder shows more greenness and yellowness than the black gram [32]. The use of turmeric powder could also be responsible for the increase of yellowness (b^*) in the products.

3.4. Sensory Evaluation. Based on color, flavor, taste, mouth feel, and overall acceptability, the sensory qualities of the dal produced from the formulated samples were assessed. The results are shown in Table 3.

Table 3 showed that the dal made from each developed ready-to-cook mixed dal powder did not differ significantly ($p > 0.05$) in sensory properties. S_1 was higher in color score (8.30 ± 0.483) and was ranked as like very much. Only S_2 was ranked moderately in this parameter. In preferences of flavor, taste, and overall acceptability, S_3 got the highest scores. The control one scored the highest in case of mouth feel. All the samples were ranked as like moderately in terms of flavor, taste, and overall acceptability, and like slightly in terms of mouth feel.

3.5. Microbial Stability. The total viable count, TVC ($\times 10^3$ CFU/g), of the samples was observed for up to 6 months. The results are shown in Table 3. Duncan's multiple range tests found a significant ($p \leq 0.05$) difference in TVC considering the months (storage periods) and sample formulations as fixed factors. The initial microbial load ranged from 1.494 ± 0.015 to 1.498 ± 0.016 ($\times 10^3$ CFU/g), whereas after six months it ranged from 2.123 ± 0.02 to 2.220 ± 0.07 ($\times 10^3$ CFU/g) as seen in Table 3. With lower moisture content (Table 3) and vacuum packaging using HDP, the increment was not so considerable (Table 3). In addition, salt (sodium chloride) used in sample development had a preventive action against microbial growth [48]. Initial TVC was slightly higher in S_1 as it contained slightly higher moisture, and it remained higher during the whole storage period than the others. The highest TVC of S_1 ($2.220 \pm 0.07 \times 10^3$) at 6 months was far below the microbial load after a storage period of 30 days and 60 days for sambar powder developed by Vanishree et al. [18] in retort pouch (1×10^4 CFU/g and 4×10^4 CFU/g, respectively), polyethylene terephthalate (PET) (3×10^4 CFU/g and 8×10^4 CFU/g, respectively), low density polyethylene (LDPE) (17×10^4 CFU/g and 19×10^4 CFU/g, respectively), and polypropylene (PP) (20×10^4 CFU/g and 24×10^4 CFU/g, respectively). In this research, the TVC values of each sample were also far below the TVC values (37 to 55×10^4 CFU/g) of ready-to-cook lentil powder developed by Alim et al. [19] which was stored in LDPE for up to 6 months. The dry powder should have less than 5.0×10^4 CFU/g, under the Codex Alimentarius Commission guidelines [49], and the TVC values were found within the acceptable range.

4. Conclusion

Since dal has excellent capacity to meet daily protein requirement for both poor-rich and vegetarian-nonvegetarian people, it is consumed most of the days of a week. On the other hand, dwellers in big cities do not have enough time to cook. That is why they are getting more dependent on ready-to-eat and ready-to-cook foods to maintain their busy schedule by spending less time on cooking. Our research product ready-to-cook mixed dal samples took only around 8 minutes to cook. All samples were protein-enriched, while amino acids varied with different formulations followed by mixing lentil, green, and black gram in various proportions. Although all the samples were acceptable on the basis of their taste preference, physical properties, and excellent keeping capacity within 6 months by

HDPE packaging system, the sample with 50% lentil, 25% green gram, and 25% black gram secured the highest score. There is not many research that specifically address ready-to-cook mixed dal from lentil, green, and black gram. Some of the studies were focused on red or black gram. So, the food businesses might leverage the findings of this study to develop this time-demanding instant mixed dal powder. Further research might be carried out to optimize amino acid content by optimum combination of different pulses.

Data Availability

Data will be made available on request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that can affect the study.

Authors' Contributions

K. M. Mahdiuzzaman Sayed did the data curation, formal analysis, and methodology. Farzana Akter was responsible for writing the original draft. Md. Ahmadul Islam did the writing the original draft, and writing, which includes review and editing. B.M. Khaled was assigned in data curation and writing, which includes review and editing. Lopa Aunsary was tasked with writing the original draft and includes review and editing. Abdullah Iqbal did the writing, which includes review and editing. Md. Abdul Alim conducted the resources, supervision, and writing, which included review and editing.

Acknowledgments

The authors would like to acknowledge the funding support from the Ministry of Science and Technology, Government of Bangladesh.

References

[1] Bangladesh Bureau of Statistics, *Bangladesh Bureau of Statistics, Yearbook of Agricultural Statistics-2022, Statistics and Informatics Division*, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh, 2022.

[2] M. Rasheduzzaman, *Effect of nitrogen and phosphorus on the growth and yield of BARI Mashkalai-1 (Vignamungo L.), [M.S. thesis]*, Department of Soil Science, Sher-e-Bangla Agricultural University, Bangladesh, 2015.

[3] W. J. Dahl, L. M. Foster, and R. T. Tyler, "Review of the health benefits of peas (Pisum sativumL.)," *British Journal of Nutrition*, vol. 108, no. S1, pp. S3–S10, 2012.

[4] M. Dekhane, *International Year of Pulses Is Here!*, Science Reporter, 2016.

[5] C. Hall, C. Hillen, and J. G. Robinson, "Composition, nutritional value, and health benefits of pulses," *Cereal Chemistry*, vol. 94, no. 1, pp. 11–31, 2017.

[6] B. K. Tiwari and N. Singh, *Pulse Chemistry and Technology*, Royal Society of Chemistry, 2012.

[7] B. Venkidasamy, D. Selvaraj, A. S. Nile, S. Ramalingam, G. Kai, and S. H. Nile, "Indian pulses: a review on nutritional, functional and biochemical properties with future perspectives," *Trends in Food Science & Technology*, vol. 88, pp. 228–242, 2019.

[8] J. G. Robinson, *Pulses: The Perfect Food, Healthy to Eat, Healthy to Grow; Peas-Lentils-Chickpeas. (FN1508, Reviewed Nov. 2017)*, Developed for the Northern Pulse Growers Association. North Dakota State University, USA, 2017, https://www.ag.ndsu.edu/publications/food-nutrition/pulses-the-perfect-food-healthy-to-eat-healthy-to-grow-peas.

[9] N. Singh, *Physico-Chemical and Functional Properties of Pulse Starch. Pulse Foods: Quality, Technology, and Nutraceutical Application*, Elsevier, Amsterdam, 2010.

[10] P. Leterme and L. C. Muñoz, "Factors influencing pulse consumption in Latin America," *British Journal of Nutrition*, vol. 88, no. S3, pp. 251–254, 2002.

[11] Institute of Medicine, *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*, The National Academies Press, Washington DC, United States of America, 2005.

[12] J. E. Heck, J. W. Nieves, Y. Chen et al., "Protein and amino acid intakes in a rural area of Bangladesh," *Food and Nutrition Bulletin*, vol. 31, no. 2, pp. 206–213, 2010.

[13] M. Mohiuddin, N. Akter, and R. Khanum, "Economics of black gram cultivation and its impact on farmers livelihood in two selected districts of Bangladesh," *SAARC Journal of Agriculture*, vol. 16, no. 2, pp. 83–96, 2019.

[14] I. L. Pardeshi, S. A. Bhuskade, and V. B. Kalmegh, "Development of cold extruded ready-to-cook mung (*Vigna radiata* L.) nuggets," *Journal of Food Research and Technology*, vol. 1, no. 1, pp. 21–28, 2013.

[15] N. Singh, Y. Nakaura, N. Inouchi, and K. Nishinari, "Structure and viscoelastic properties of starches separated from different legumes," *Starch Stärke*, vol. 60, no. 7, pp. 349–357, 2008.

[16] S. Temgire, A. Borah, S. Kumthekar, and A. Idate, "Recent trends in ready to eat/cook food products: a review," *The Pharma Innovation Journal*, vol. 10, no. 5, pp. 211–217, 2021.

[17] T. Malik, M. Saxena, and K. S. Sonu, "Development of a ready-to-cook curry," *International Journal of Innovative Science and Research Technology*, vol. 3, no. 3, pp. 354–357, 2018.

[18] S. Vanishree, U. Nidoni, S. Huchchannanavar, and A. Ganachari, "Development and evaluation of ready to cook sambar powder using pigeon pea (Cajanuscajan L.)," *The Pharma Innovation Journal*, vol. 10, no. 12, pp. 769–771, 2021.

[19] M. A. Alim, K. M. M. Sayed, S. Hossain, and S. M. R. Pervez, "Development of ready-to-cook lentil powder," *Journal of Agricultural Engineering*, vol. 42, no. 3, pp. 33–42, 2019.

[20] AOAC International, *Official method 950.46. Moisture in meat and meat products*, AOAC International, Gaithersburg, MD, twenty-first edition, 2019.

[21] AOAC International, *Official method 920.153 ash in meat and meat products*, AOAC International, Gaithersburg, MD, twenty-first edition, 2019.

[22] AOAC International, *Official method 981.10. Crude protein in meat and meat products*, AOAC International, Gaithersburg, MD, twenty-first edition, 2019.

[23] AOAC International, *Official method 922.06. Fat in grain and flour*, AOAC International, Gaithersburg, MD, twenty-first edition, 2019.

[24] R. P. Srivastava and K. Sanjeev, *Fruit and vegetable preservation principles and practices*, International book distributing co, 3rd edition, 2002.

[25] S. W. Souci, W. Fachmann, and H. Kraut, *Food composition and nutrition tables (No. Ed. 6)*, Medpharm GmbH Scientific Publishers, 2000.

[26] A. N. Aryee and J. I. Boye, "Comparative Study of the Effects of Processing on the Nutritional, Physicochemical and Functional Properties of Lentil," *Journal of Food Processing and Preservation*, vol. 41, no. 1, Article ID e12824, 2017.

[27] R. S. Reddy, C. T. Ramachandra, S. Hiregoudar, U. Nidoni, J. Ram, and M. Kammar, "Influence of processing conditions on functional and reconstitution properties of milk powder made from Osmanabadi goat milk by spray drying," *Small Ruminant Research*, vol. 119, no. 1-3, pp. 130–137, 2014.

[28] S. K. Du, H. Jiang, X. Yu, and J. L. Jane, "Physicochemical and functional properties of whole legume flour," *LWT-Food Science and Technology*, vol. 55, no. 1, pp. 308–313, 2014.

[29] W. Horwitz, *Official Methods of Analysis of AOAC International*, AOAC International, Arlington, USA, 2000.

[30] D. Befikadu, "Postharvest losses in Ethiopia and opportunities for reduction: a review," *International Journal of Sciences: Basic and Applied Research (IJSBAR)*, vol. 38, pp. 249–262, 2018.

[31] D. D. Ramdath, Z. H. Lu, P. L. Maharaj, J. Winberg, Y. Brummer, and A. Hawke, "Proximate analysis and nutritional evaluation of twenty Canadian lentils by principal component and cluster analyses," *Food*, vol. 9, no. 2, p. 175, 2020.

[32] I. A. Wani, S. N. Andrabi, D. S. Sogi, and I. Hassan, "Comparative study of physicochemical and functional properties of flours from kidney bean (*Phaseolus vulgaris* L.) and green gram (Vignaradiata L.) cultivars grown in Indian temperate climate," *Legume Science*, vol. 2, no. 1, 2020.

[33] R. Kamboj and V. Nanda, "Proximate composition, nutritional profile and health benefits of legumes-a review," *Legume Research-An International Journal*, vol. 41, no. 3, pp. 325–332, 2018.

[34] I. A. Wani, D. S. Sogi, and B. S. Gill, "Physicochemical and functional properties of flours from three black gram (*Phaseolus mungo* L.) cultivars," *International Journal of Food Science & Technology*, vol. 48, no. 4, pp. 771–777, 2013.

[35] World Health Organization, Food and Agriculture Organization of the United Nations, and United Nations University, *Protein and Amino Acid Requirements in Human Nutrition; Report of a Joint WHO/FAO/UNU Expert Consultation*, WHO Technical Report Series 935, Geneva, Switzerland, 2007.

[36] R. Ullah, Z. Ullah, S. S. Al-Deyab, M. Adnan, and A. Tariq, "Nutritional assessment and antioxidant activities of different varieties of *Vigna radiata*," *The Scientific World Journal*, vol. 2014, Article ID 871753, 5 pages, 2014.

[37] H. Khazaei, M. Subedi, M. Nickerson, C. Martínez-Villaluenga, J. Frias, and A. Vandenberg, "Seed protein of lentils: current status, progress, and food applications," *Food*, vol. 8, no. 9, p. 391, 2019.

[38] E. R. Grela, B. Kiczorowska, W. Samolińska et al., "Chemical composition of leguminous seeds: part I—content of basic nutrients, amino acids, phytochemical compounds, and antioxidant activity," *European Food Research and Technology*, vol. 243, no. 8, pp. 1385–1395, 2017.

[39] M. Zia-Ul-Haq, S. Ahmad, S. A. Bukhari, R. Amarowicz, S. Ercisli, and H. Z. Jaafar, "Compositional studies and biological activities of some mash bean (*Vignamungo* L.) Hepper cultivars commonly consumed in Pakistan," *Biological Research*, vol. 47, no. 1, pp. 1–14, 2014.

[40] United State Department of Agriculture and Agricultural Research Service, *National Nutrient Database for standard reference, legacy release*, Food data central, 2018.

[41] G. V. Barbosa-Cánovas and P. Juliano, "Physical and chemical properties of food powders," in *Encapsulated and powdered foods*, pp. 51–86, CRC press, 2005.

[42] M. Kaur and N. Singh, "Relationships between various functional, thermal and pasting properties of flours from different Indian black gram (*Phaseolus mungo* L.) cultivars," *Journal of the Science of Food and Agriculture*, vol. 87, no. 6, pp. 974–984, 2007.

[43] S. Wang, C. Chao, J. Cai, B. Niu, L. Copeland, and S. Wang, "Starch–lipid and starch–lipid–protein complexes: a comprehensive review," *Comprehensive Reviews in Food Science and Food Safety*, vol. 19, no. 3, pp. 1056–1079, 2020.

[44] J. K. Prescott and R. A. Barnum, "On powder flowability," *Pharmaceutical Technology*, vol. 24, no. 10, pp. 60–60, 2000.

[45] A. Goyal, V. Sharma, M. K. Sihag et al., "Development and physico-chemical characterization of microencapsulated flaxseed oil powder: a functional ingredient for omega-3 fortification," *Powder Technology*, vol. 286, pp. 527–537, 2015.

[46] C. Barbana and J. I. Boye, "In vitro protein digestibility and physico-chemical properties of flours and protein concentrates from two varieties of lentil (Lens culinaris)," *Food & Function*, vol. 4, no. 2, pp. 310–321, 2013.

[47] B. Kavitha, G. Hemalatha, S. Kanchana, S. P. Sundaram, and K. Sivasubramaniam, "Physicochemical, functional, pasting properties and nutritional composition of selected black gram (*Phaseolusmungo* L.) varieties," *Indian Journal of Science and Technology*, vol. 6, no. 10, pp. 5386–5394, 2013.

[48] P. J. Taormina, "Implications of salt and sodium reduction on microbial food safety," *Critical Reviews in Food Science and Nutrition*, vol. 50, no. 3, pp. 209–227, 2010.

[49] Codex, "Codex General Standard for the Use of Dairy Terms, Codex Standard 206-1999," in *Codex Alimentarius Commission*, Food & Agriculture Organization (FAO), Rome, 1999.

[50] Food and Agriculture Organization, *Report of the FAO Expert Working Group: Protein quality assessment in follow-up formula for young children and ready to use therapeutic foods*, Food and Agriculture Organization of the United Nations, Rome, 2017.

[51] FAO (Food and Agriculture Organization), "Dietary protein quality evaluation in human nutrition: report of an FAO Expert Consultation," in *Food and Nutrition Paper*, vol. 92, FAO, Rome, 2013.