Fortification of Yellow Alkaline Noodles with Wheat Bran and the Impact on Physical and Sensorial Properties

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Summary Food fortification is a commonly-used method to increase nutritional value of food products in order to reduce the risks of Non-Communicable Diseases (NCDs). Noodles are a versatile and popular staple food, especially in Asia, that can be nutritionally enriched using various types of ingredients and one of them is wheat bran that is rich in dietary fiber. This study aimed to determine effect of fortification of fresh yellow alkaline noodles with wheat bran on its physical and sensorial properties. Addition of wheat bran was varied in concentration (0–20%) and physical properties of fortified yellow alkaline noodles were assessed. Additionally, 9-point hedonic scale and ‘Just About Right’ scale were employed to assess sensory properties of the fortified noodles, using 40 non-trained panelists. Noodles fortified with the highest amount of wheat bran exhibited the highest cooking loss (4.61%) compared to the non-fortified one (2.78%), indicating weak structural integrity, presumably due to the impaired gluten network. On contrary, noodles fortified with various amount of wheat bran did not demonstrate significant alteration of textural properties in terms of springiness, cohesiveness, and resilience. Sensorially, noodles fortified with 10% of wheat bran had the highest preference among the panelist based on general appearance, overall acceptability, color suitability, hardness suitability, and smoothness. Proximate analysis showed noodles supplemented with 10% of wheat bran met regulatory criteria for claim as a high-fiber food, with its dietary fiber content of 5.40 g/100 g of noodles. Conclusively, fortification of yellow alkaline noodles with wheat bran could improve its product properties.

Key Words yellow alkaline noodles, wheat bran, dietary fiber, food product properties

Nowadays, food fortification becomes a common practice under governmental or public policy to combat nutrient deficiencies within a population in certain regions. Nutrient-associated chronic diseases, which is also regarded as Non-Communicable Diseases (NCDs), has account for up to 71% of deaths worldwide (1). These diseases are often pronounced as metabolic changes, such as raised blood pressure, overweight/obesity, hyperglycemia, and hyperlipidemia. resulted from unhealthy lifestyle (alcohol consumption, tobacco use, and physical inactivity) and unhealthy diet (poor eating habit and food selection) (2) that results in the inadequacy of essential nutrient intake, such as vitamins, minerals, and even dietary fiber (3, 4).

By definition, food fortification is a process where certain amount of ingredients is added to the food products in order to enhance the nutritional value and/or to improve product properties (5). One of many food products that are fortified belongs to the staple food category, including tubers and cereal-based product, such as bread and noodle. In Asia region, noodle is a commonly consumed staple food, which is made from unleavened wheat flour dough, flat-rolled, and cut or extruded into long strips or strings shape. Similar to any staple food, noodle contains mostly carbohydrate in a form of starch and protein in a form of gluten. However, noodle also lacks in several essential nutrients, such as vitamins, minerals, and dietary fibers, which are mostly lost during flour refinement (6). Several studies have shown the feasibility of supplementing various ingredients to increase the nutritional value, yet, mostly limited to only protein enhancement using high-protein composite flours, such as legumes-based flour (7, 8) and dairy-based flour (9). Other improvements in noodle have also been made by supplementing the noodle with various dietary fiber sources such as fruit peel (10), and indigestible parts of cereal-based ingredients, such as husks and brans (11, 12). A well-known alternative ingredient, which is wheat bran, has also been widely used as a food forticant in various food products, which is mainly to increase dietary fiber intake (13). Not only that, wheat bran was also reported to contain essential vitamins and minerals as well as phenolic acid and flavonoids, which serves as an excellent ingredient as food forticant in order to combat NCD (14). Albeit the feasibility of high-fiber noodle development, the product may also suffer a retrogression in product properties, both physically and sensorially, which to date remains the challenges in terms of its acceptability. The aim of this study was to fortify fresh yellow alkaline noodle...
with various concentration of wheat bran for nutritional value enhancement, particularly on dietary fiber, and to evaluate its impact on physical (cooking properties, texture, and color) and sensorial properties.

MATERIALS AND METHODS

Noodle formulation and production. Yellow alkaline noodle was produced based on the study of Prairahong (15) with slight modification. The raw materials and product formulation used in this study are listed on the table below (Table 1).

Guar gum (Indo Food Chem), salt (Indo Food Chem), Soda ash (Indo Food Chem), wheat gluten (Indo Food Chem), and STTP (Indo Food Chem) were dissolved in the distilled water for 10 min or until the guar gum was swollen completely to produce a wet mixture. Then, a dry flour blend, consisting of wheat flour (all purpose flour Segitiga Biru, Indo Food Chem), wheat gluten (Indo Food Chem), and wheat bran (purchased from local market in East Jakarta) were thoroughly mixed in the mixer (Kitchenaid Food Mixer) using slow speed for 1 min. Subsequently, the wet mixture was combined with the dry flour blend by slowly pouring it into the mixer with medium speed for 5 min.

The noodle dough was processed using a Noodle Maker (Oxone). The crumbled dough was molded by passing it into the rollers. Then, the dough was sheeted and folded in half for three times through the rollers with the same size as before to firming the dough. The thickness of dough sheet was gradually reduced by consecutively passing through smaller gap rollers. For each gap, the dough sheet was rolled three times. After the dough sheet met the final thickness, the dough sheet was rested for 15 min and then passed into the extruder. Finally, the Noodle was kept in plastic clip at 25˚C for further analysis.

Cooking properties. Cooking loss and cooking yield were determined as the cooking properties of yellow alkaline noodles according to American Association of Cereal Chemist (AACC) methods (16) with slight modifications.

First, 25 g of noodles was cooked in 300 mL of boiling distilled water. The optimum cooking time was assessed by observing the disappearance of the central opaque core in the noodle during cooking. Two transparent glasses were used to squeeze the noodle to observe the disappearance of the central opaque core. The central opaque core of the noodle was checked every 10 s. The cooking loss was measured by drying the cooking water at 105˚C to constant weight and was calculated as a percentage of starting material using the following calculation:

Cooking loss (%) = \( \frac{(W_r - W_b)}{W_s} \times 100 \)

Where \( W_r \) is the total weight of beaker and dried residue (g), \( W_b \) is the weight of pre-dried beaker (g), and \( W_s \) is the weight of noodle before cooking (g).

Cooking yield (%)(Wa/Wb)×100

Where WA is the weight of noodles after cooking (g) and WB is the weight of noodles before cooking (g).

Texture analysis. TA-XT2i Texture Analyzer (Stable Micro System) was utilized for Texture Profile Analysis (TPA) (17). The fresh noodle was cooked according to the optimum time. Five strands of noodle were put on the measuring table centered under the noodle firmness rig. The data collection was done in three repetition. Pre-test speed, test speed, and post-test speed were 1.0 mm/s, 0.2 mm/s, and 0.2 mm/s, respectively. The compression strain was 90% of the noodle strand thickness. Four texture parameters were obtained from TPA, which were hardness (indicating hard or soft bite), springiness (indicating the degree of recovery after the first bite), cohesiveness (indicating the noodle structure), and resilience (indicating the noodles regain its shape).

Color analysis. All noodle samples were subjected to color analysis using a colorimeter (CR-400 Chromameter, Konica Minolta) with three readings on different spot based on L*, a*, and b* values.

Sensory analysis. Sensory acceptability of each sample was evaluated for general appearance, color suitability, overall acceptability, hardness suitability, and smoothness using 40 non-trained panelists. The overall acceptability and general appearance were determined based on 9-point hedonic scales, ranging from “dislike
extremely: 1” to “neither like nor dislike: 5” to “like extremely: 9”. Other parameters were determined by five point Just About Right (JAR) scales. The scales ranged from “too light/soft/harsh=1” to “just about right=3” to “too dark/hard/smooth=5”.

**Proximate analysis.** The yellow alkaline noodle with different concentration of wheat bran were subjected to proximate and dietary fiber analysis (Table 2).

**Statistical analysis.** The experiments were performed in three repetitions. Significance among means was assessed by the one-way Analysis of Variance (one-way ANOVA) at the 5% level of probability. When significant differences in one-way ANOVA were detected, means were compared using the post-hoc Tukey test. For the 5 point just-about-right scale was analyzed using one-way ANOVA supplemented with Kruskal-Wallis test.

**RESULTS**

As displayed by Table 3, significant differences were observed in cooking loss, cooking yield, hardness, and color measurements, particularly on L* and a* values; while springiness, cohesiveness, resilience as well as the b* value of fortified yellow alkaline noodle samples remained statistically similar. Highest cooking properties were observed in noodle sample fortified with 20% of wheat bran, which were 4.61% and 215.60% for cooking loss and cooking yield, respectively. Additionally, all noodle samples that were fortified with different concentration of wheat bran exhibited darker color, shown by a gradual decrease in L* value (75.30 to 62.20) as well as a* value (0.67–5.61) inversely with the increasing value of wheat bran addition (5–20%). Sensorial properties of fortified yellow alkaline noodle samples are shown by Table 4. Briefly, noodle fortified with 10% of wheat bran had the highest overall acceptability (6), general appearance (6), and was the most preferred by the panelists. Additionally, noodle fortified with 10% of wheat bran also was scored as the most “Just About Right” value (3) on color and hardness, perceived by the panelists. Based on the proximate analysis (see Table 5), noodles fortified with various concentrations of wheat bran exhibited similar values, particularly on moisture, carbohydrate, and ash contents. Generally, noodle samples supplemented with the highest concentration of wheat bran (20%) displayed the highest moisture content (32.7%), protein content (10.25%) and dietary fiber (7.94%).

**DISCUSSION**

The effect of wheat bran fortification to the physical properties of yellow alkaline noodles

Cooking yield and cooking loss were crucial parameters to indicate the cooking quality of noodle samples. Generally, noodle which possesses high cooking yield and low cooking loss value, is categorized as a high-quality noodle (18). Cooking loss indicates the number of solids that are dissolved in the water during cooking. Furthermore, it can also be used as an indicator of the noodle structural integrity during cooking (19). In this study, different concentrations of wheat bran fortifica-

tion in yellow alkaline noodles caused significant changes in the cooking properties, both cooking loss and cooking yield. Noodle samples which contained higher concentration of wheat bran fortification had significantly higher cooking loss and cooking yield compared to the other noodle samples which had lower concentration of wheat bran concentrations. This occurrence might be due to the disruption effect of wheat bran to the starch-gluten network in noodle. The same occurrence was also found in the study by Aravind et al. (20), where the addition of insoluble dietary fiber ingredient changed the cooking properties in dried pasta. On the contrary, cooking yield values were significantly increased in noodle samples fortified with wheat bran, indicating high water holding capacity, presumably due to the hydroxyl group content in wheat bran, which mostly had been lost in the wheat flour due to the refinement process (21). Furthermore, it has also been reported that coarse bran particles, such as wheat bran were likely to retain more water compared to the fine bran particles, such as wheat flour: hence might explain the increase in cooking yield (22).

Physical properties of the noodle were assessed in this study in the form of hardness, springiness, cohesiveness, and resilience (see Table 3). In this study, certain amount of gluten flour were added to supplement the physical properties of the noodle samples, which was increased along with the wheat bran addition. Significant higher values of hardness were observed in the noodle sample fortified with 5%, followed by 10%, 15%, and 20%, compared to the control. The noodle samples that were fortified with higher concentration of wheat bran had lower hardness value as it appeared to exhibit a brittle texture and were easily ruptured, which was also reported by Niu et al. (23). Albeit the addition of gluten flour to enhance the physical properties of the noodle samples, there was a limit to where wheat bran fortification would disrupt the texture, which was observed contrastly between 5% and 20%, based on the hardness value (2.837 g and 2.559 g, respectively). On the contrary, the springiness, cohesiveness, and resilience values were not significantly among all samples, presumably due to presence of the additives support the gluten strength in noodle dough.

Color analysis showed that the Lightness, indicated by L* value, of the noodle samples decreased proportionally to the increase concentration in the wheat bran (see Table 3). On contrary, noodles fortified with higher concentrations of wheat bran had a significant increase in red color (indicated by a* values) compared to the control, which were 2.82, 4.61, 4.74, 5.61, and 0.67 for 5%, 10%, 15%, 20% addition of wheat bran and no addition of wheat bran (0%), respectively. This could be due to the action of Polyphenol Oxidase (PPO) enzyme, contained in the wheat bran that was exposed during the grinding, mixing, and cooking process, hence inducing rapid oxidation reaction and darkening color of the noodle samples fortified with various concentration wheat bran (24, 25).
Table 3. Cooking properties, texture analysis, and color measurement of yellow alkaline noodle samples with different wheat bran concentration. Each value presented is expressed as mean ± RSD (n=3). Values with different lowercased letter in the same column indicates significant difference at p<0.05.

| Wheat Bran Concentration | Cooking Properties | Texture Analysis | Color Measurement |
|--------------------------|--------------------|------------------|-------------------|
|                          | Cooking Loss (%)   | Cooking Yield (%)| L*                |
|                          |                    |                  | a*               |
|                          |                    |                  | b*               |
| 0%                       | 2.78 ± 4.84a       | 184.80 ± 0.23a   |                  |
| 5%                       | 3.06 ± 1.06b, c    | 193.10 ± 0.06b   | 256.05 ± 22.60a  |
| 10%                      | 3.45 ± 1.33b, c    | 197.57 ± 0.26b   | 283.94 ± 9.04a   |
| 15%                      | 3.90 ± 2.32c       | 201.56 ± 0.04c   | 280.41 ± 6.89c   |
| 20%                      | 4.61 ± 2.07d       | 215.60 ± 0.34d   |                  |

Table 4. Sensory analysis of yellow alkaline noodle samples with different wheat bran concentration. Each value presented is expressed as mean ± RSD (n=3). Values with different lowercased letter in the same column indicates significant difference at p<0.05.

| Wheat Bran Concentration | 9-points Hedonic Test (1–9) | “Just About Right” Test (1–5) | Preference Test (n) |
|--------------------------|-------------------------------|--------------------------------|---------------------|
|                          | Overall Acceptability | General Appearance | Color | Hardness | Smoothness |                  |
|                          |                      |                    | 2a    | 2ab     | 4c       | 5                 |
|                          |                      |                    | 2ab   | 3a      | 4bc      | 10                |
|                          |                      |                    | 3bc   | 3ab     | 2abc     | 11                |
|                          |                      |                    | 4cd   | 3ab     | 2ab      | 8                 |
|                          |                      |                    | 4d    | 3b      | 2a       | 6                 |

Table 5. Proximate analysis of yellow alkaline noodle samples with different wheat bran concentration. Each value presented is expressed as mean ± RSD (n=3). Values with different lowercased letter in the same column indicates significant difference at p<0.05.

| Wheat Bran Concentration | Total calorie kcal/100 g | Moisture % | Carbohydrate % | Protein % | Fat % | Ash % | Dietary fiber % |
|--------------------------|--------------------------|------------|----------------|-----------|-------|-------|-----------------|
| 0%                       | 273.14 ± 0.18c           | 30.94 ± 0.06a | 57.19 ± 0.07d | 9.61 ± 0.01a | 0.66 ± 0.21a | 1.60 ± 0.01a | 3.25 ± 0.01a    |
| 5%                       | 274.56 ± 0.33d           | 31.66 ± 0.08b | 55.29 ± 0.01c | 9.75 ± 0.06a | 1.60 ± 0.14c | 1.70 ± 0.01b  | 4.46 ± 0.02b    |
| 10%                      | 271.98 ± 0.27c,d         | 32.26 ± 0.05c | 53.90 ± 0.10b | 9.82 ± 0.12a | 1.90 ± 0.21d  | 1.68 ± 0.01b  | 5.40 ± 0.04c    |
| 15%                      | 271.66 ± 0.10b           | 32.44 ± 0.08c | 54.37 ± 0.01b | 10.17 ± 0.09b | 1.50 ± 0.35b  | 1.70 ± 0.01b  | 6.44 ± 0.01d    |
| 20%                      | 271.24 ± 0.22a           | 32.70 ± 0.03d | 54.05 ± 0.08a | 10.25 ± 0.09b | 1.56 ± 0.21bc | 1.70 ± 0.01b  | 7.94 ± 0.01c    |
Sensorial properties of yellow alkaline noodles fortified with wheat bran

As shown in Table 4, the highest and the lowest overall acceptability were observed in the noodle samples added with 10% wheat bran concentration and 20% wheat bran concentration, which were 6.00 and 4.80, respectively. This trend was also similar for the general appearance of the fortified noodle, which were scored 6.22 and 5.05 for the 10% and 20% wheat bran added, respectively. This could imply that the overall acceptability perceived by the panelists was significantly affected by the concentration of wheat bran added in the noodle samples based on the one-way ANOVA-Tukey post hoc analysis ($p<0.05$). Secondly, “Just About Right” test revealed that noodle samples fortified with various wheat bran addition were scored as “Just About Right” (3 point) in terms of the hardness, however were also scored variously in terms of color and smoothness. Finally, sensory analysis of all fortified noodle samples suggests that noodle fortified with 10% of wheat bran was suitable and palatable based on the panelists’ perception on color, hardness, and smoothness, shown by the result of 9-points scale hedonic test on overall acceptability and general appearance and 5-points scale of “Just About Right” test. This analysis was also reflected in the preference test in which out of 40 non-trained panelists, 11 of them were choosing the noodle sample fortified with 10% of wheat bran as a preferred product. Another way to improve the sensorial properties of wheat-bran fortified food is by altering the particle size distribution as reported by Song et al. (19).

Proximate analysis of yellow alkaline noodles fortified with wheat bran

In this study, proximate analysis of noodle samples was conducted to evaluate the nutritional properties, especially on the dietary fiber content. As seen in Table 5, noodle fortified with various wheat bran concentration had significant changes in total calories, moisture content, carbohydrate, protein, fat, ashes, and dietary fiber content. Albeit the significances, noodles fortified with higher concentration of wheat bran resulted in lower values in terms of total calories and carbohydrate content. Inversely, higher concentration of wheat bran addition increase the moisture, protein, fat, ashes, and dietary fiber content in all fortified noodle samples, compared to the control (0%). The increase in dietary fiber content in all fortified noodle samples was expected in this study as wheat bran is an excellent source of fiber that can contain up to 36.5–52.4 g/100 g (26). According to Badan Pengawas Obat dan Makanan Republik Indonesia (BPOM) (27), fresh noodle should contain 20% up to 40% of water and should contain at least 5% of protein. In addition, BPOM also stated that solid food can be claimed as high fiber food products if it contains at least 3 grams/100 grams of dietary fiber. Therefore, all of the noodle samples in this study was in accordance to BPOM regulation and could be regarded as a high fiber food.  

Conclusive remark

This study highlighted the use of wheat bran as a fortificant of yellow alkaline noodle product. Considering all evaluated product properties, noodle fortified with 10% of wheat bran is deemed to be suitable to develop as high-fiber food product.

Disclosure of state of COI

No conflicts of interest to be declared.

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