# New BARI Wheat Cultivars:
# Evaluation of Processing and Nutrition Value

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**Abstract: - Wheat is considered a good source of protein, minerals and B-vitamins. It is highly rich in several essential dietary nutrients and is an excellent health-building food. The present research was carried out to assess the biochemical, minerals and the functional properties of three newly released BARI wheat cultivars using standard analytical methods. The experimental results were compared statistically. The result showed that the BARI 28 wheat cultivar had the highest amount of protein (12.31%) and calcium (24.48 mg/100g) content which was significantly higher ($p < 0.05$) from the conventional wheat flour (10.14% protein and 12.32 mg/100g calcium) and BARI 30 wheat cultivar (10.22% protein, 16.11 mg/100g calcium) whereas the least value was recorded for BARI 26 wheat cultivar (9.51 % protein and 14.21 mg/100g calcium). Lowest carbohydrate was found in BARI 28 wheat cultivar (74.02%) while highest score of carbohydrate was observed in conventional wheat flour (80.09%) and they varied significantly ($p < 0.05$). The highest dispersibility (44%), oil holding capacity (282.67%), foaming capacity (6.94%), least gelation concentration (LGC) (8%), swelling power (38.26%) were associated with the BARI 28 wheat cultivar while more water absorption capacity (269.33%), emulsion activity (53.29%), emulsion stability (48.78%) were recorded in BARI 30 wheat cultivar and the BARI 26 wheat cultivar had low bulk density (0.56 g/cm$^3$) and gelatinization temperature (58.48$^0$C) but higher percentage of solubility (8.63%). All the tested parameters were varied significantly ($p < 0.05$) with each other. The nutritional and the functional properties of these cultivars showed their uniqueness and various innovative products could be developed by supplementing these flours to suit the consumers need and enhance nutritional security.**

***Keywords**: BARI Wheat Cultivars, Proximate Composition, Minerals and Functional Properties.*

## I. INTRODUCTION

Wheat (*Triticum aestivum*) is a cereal grain grown all over the world. In terms of its total production, wheat placed second position to rice as the main food crops (Meheruunahar *et al,* 2018). Globally, the demand of wheat-based food products is increasing with the increases of human population. It is the prime source of vegetal protein and is considered the most popular energy gain food for the production of confectionary products. According to Okaka (2005), only wheat contains substantial amount of gliadin and glutenin. Its desirable texture and flavor are the basic ingredients of bread and other bakery goods such as noodles, macaroni, pasta, pastries, cakes and cookies (Akhtar *et al,* 2008). It is a rich source of essential nutritional components like vitamins, minerals and protein. It reduces the risk of heart diseases and regulates blood glucose level for the diabetic patients. Anemia, mineral deficiencies, gallstones, breast cancer, chronic inflammation, obesity, asthenia, tuberculosis, pregnancy and breastfeeding complications are relieved by consuming unprocessed wheat (Potter and Hotchkiss, 2006). Wheat is the most wholesome food items and it ensures a diet rich in nutrients. Bangladesh Agriculture Research Institute (BARI), Joydebpur, Gazipur has released a number of high yielding varieties of wheat crop. Rashid and Hossain (2016) reported that BARI 26, 28 and 30 wheat cultivars are the newly released wheat varieties from the BARI. BARI 26 has accepted for its cultivation environment due to its excellent heat tolerance, diseases resistance and above all rapid growth and maturity. The BARI 28 and 30 cultivars are also receiving attention with their spatial attributes like disease-resistance to leaf, heat tolerance and high yield (Rashid and Hossain, 2016). But no research data have been available in terms of its biochemical, mineral and functional characteristics for their bakery usage. So this research has been carried out to evaluate the nutritional, mineral and functional characteristics of BARI wheat cultivars and compare them with the conventional wheat flour available in Bangladesh.

## II. MATERIALS AND METHODS

### 2.1 Sample Preparation and Preservation

The wheat varieties were purchased from Bangladesh Wheat Research Institute (BWRI), Dinajpur. The raw wheat grains were placed in a tray from where the chaff and damaged grains were separated manually from the healthy ones and then discarded. The healthy grains were milled to produce flour, which was subsequently dried in an oven at

$70^0$C, sieved through 60 µm mesh and finally packaged in an air-tight plastic containers for analyses.

### 2.2 Biochemical properties

The biochemical properties of the three varieties of BARI wheat cultivars and the conventional one were determined as follows:

### 2.2.1 Moisture content, $xw$ (AOAC, 2005)

A pre-weighed amount of the flour-sample was spread on a dry metallic pan in thin layer was placed in an oven maintained the temperature at 105°C. After a period of 5-6 hours of drying time it found to be sufficient enough for the sample to be bone-dry (completely free of moisture), the pan was taken out and cooled to room temperature in a desiccator. Then the final weight of the dried sample was measured on an electronic balance. The moisture-content, $x_w$ (%), of the flour was calculated by the following relation:

$$x_w = \frac{W_0 - W_f}{W_0} \times 100$$

Where $W_0$ and $W_f$ (g) are, respectively, the initial and the final weight of the flour-sample.

### 2.2.2 Ash content, $x_{ash}$

If the water and organic matter have been removed by heating in the presence of oxidizing agent then the remaining inorganic residue entitled as ash content of food. A moisture-free sample was placed in a ceramic container and then put in a muffle furnace at 700°C for 8 h for complete combustion of the sample as described by the method of AOAC (2005). The ash content, $x_{ash}$ (%), was calculated by the following formula:

$$x_{ash} = \frac{W_{ash}}{W_{0,d}} \times 100$$

Where $W_{ash}$ and $W_{0,d}$ (g) are, respectively, the weight of the combustion product (ash) and the initial weight of the dry-sample.

### 2.2.3 Crude protein content, $x_p$

The nitrogen content was determined by the micro-Kjeldahl method (AOAC 2005), and then the crude protein content, $x_p$ (%), was estimated by the following formula:

$$x_p = \frac{\text{Total nitrogen content} \times 5.83}{\text{Weight of the sample taken}} \times 100$$

Where the number 5.83 is the conversion factor of nitrogen content to protein content.

### 2.2.4. Crude Fat content, $x_F$

Soxhlet extraction technique was employed to leach the fat materials out of the dried samples by an organic solvent (petroleum ether) at 40-60 $^0$C and followed by a reflux for 6 h. Then the total fat content in the organic solvent was determined by a methodology prescribed by AOAC (2005). The crude fat content, $x_F$ (%), was calculated by the following formula:

$$x_F = \frac{\text{Amount of total fat}}{\text{Weight of the sample taken}} \times 100$$

### 2.2.5 Crude Fiber, $x_f$

The experiment of crude fiber was carried out using the standard method as described by AOAC (2005). Two gram of dry fat free sample previously extracted with petroleum ether and it was boiled with 200 ml of $H_2SO_4$ for 30 minutes with the help of bumping chips. Thereafter, the mixture was filtered through a muslin cloth and then washed with boiling water until the residue was free from acid. The residue was then boiled with 200 ml NaOH solution for 20 minutes. Again, the mixture was filtered through a muslin cloth .The residue was then transferred to a pre weighed ashing dish. Thereafter, it was dried for 2 hours at 130 ±2°C, cooled in a desiccator and then weighed. The dry dishes containing the samples were then ignited for 30 minutes at 600 ±15°C.Finally, the sample was cooled in a desiccator and then weighed again.

$$x_f = \frac{\text{Weight of the residue} - \text{ weight of the Ash}}{\text{Weight of the sample taken}} \times 100$$

### 2.2.6 Carbohydrate content, $x_{ch}$

The carbohydrate content was estimated with the assumption that the measurable ingredients in a wheat-sample are moisture, fat, protein and inorganic salts. There might be some other ingredient, but they are not so significant and remain within experimental error. Although the inorganic salts are converted into oxide forms (ash) in a muffle furnace, and definitely there is a gap between the amount of inorganic salts and the corresponding ashes, still the amount of inorganic salts in a wheat-sample is approximated by that of the ashes. Thus, the carbohydrate content, $x_{ch}$ (%) is evaluated as follows:

$$x_{ch} = 100 - x_w - x_F - x_p - x_{ash}$$

## III. MINERALS

Mineral contents were determined according to the method of AACC Official Method, (2000), samples were dried and ashed at 700°C for 6 hours. The ash was dissolved in (3 ml hydrochloric acid +5 ml distilled water) to a final volume of 50 ml with distilled water and filtered. Sodium and potassium were determined by flame photometry (Flame Photometer Model: PFP7, Germany). Calcium, iron and phosphorous were determined by atomic absorption spectroscopy according to AACC Official Method (2000).

## IV. DETERMINATION OF FUNCTIONAL PROPERTIES

### 4.1 Solvent (water/oil) absorption capacity

The water and the oil absorption capacity of the flours were determined by the method described by Sosulski *et al*, (1976). Approximately one gram of flour sample was mixed with 10 ml of distilled water or oil (as the parameter requires) and allowed to stand still for 30 min at ambient temperature. The mixture was centrifuged for 30 min at 3000 rpm and that resulted in a two-layered composition, the top one being a clear solvent and the bottom is the flour-precipitate. The clear supernatant from the top layer was decanted out. Then the precipitate was taken out, and subsequently, the excess solvent adhered to the surface of the precipitate was dried with some filter/blotting paper. Then the precipitate was weighed. The solvent (water or oil) absorption capacity was defined as follows:

$$\text{water/oil absorption capacity} = \frac{W_{cp}\text{-}W_s}{W_s} \times 100$$

Where $W_{cp}$ and $W_s$ are the amount of the centrifuged precipitate and the flour sample respectively

### 4.2 Foam-forming capacity (FFC) and stability

These two parameters were evaluated by a method reported by (Narayana and Narasinga (1982) with slight modification. One gram of the flour sample was added to 50 ml of distilled water in a graduated cylinder. The suspension was mixed and shaken for 5 min to foam. The volume of the foam in 30 s after whipping was expressed as foam capacity using the formula. The volume of foam was recorded one hour after whipping to determine the foam stability (FS) as per cent of initial foam volume.

$$FFC = \frac{\text{Volume of foam AW} - \text{Volume of foam BW}}{\text{Volume of foam AW}} \times 100$$

$$FS = \frac{\text{foam-volume of1h after whipping}}{\text{initial foam-volume}} \times 100$$

Where AW= after whipping and BW = before whipping.

### 4.3 Emulsion activity and stability

Emulsion activity and stability was evaluated using a method described in Yasumatsu *et al*, (1972). A mixture of approximately 1g flour of the sample, 10 ml distilled water and 10 ml oil was taken in a calibrated centrifuge-tube. The emulsion was centrifuged at 2000 rpm for 5 min. The EA (%) is defined as follows:

$$EA = \frac{\text{height of the remaining emulsion layer}}{\text{total mixture-height}} \times 100$$

For the determination of emulsion activity, the mixture does not undergo any thermal treatment. The emulsion stability (ES) as a concept is similar to the EA. But for its measurement, thermal treatment of the emulsion is required. Thus, the mixture of approximately 1g flour of the sample, 10 ml distilled water and 10 ml oil was taken in a calibrated centrifuge-tube was heated at 80°C for 30 min in a water-bath, then cooled for 15 min under running tap water and finally centrifuged at 2,000 rpm for 15 min. The *ES* is calculated by the same formula as that employed for *EA*.

### 4.4 Starch solubility and Swelling power determination

The starch solubility (*SS*) and the swelling power *(SP)* were determined by a method described in Hirsch (2002). Approximately one gram of flour samples were taken into pre-weighed properly labeled graduated centrifuge tube, and 10 ml of distilled water was added to each of the samples. Then the suspension was homogenized with stirring and then the tube was placed in a water bath at a temperature of $70^0$C for 1 hr with occasional shaking. The samples were cooled to room temperature under running water and centrifuged for 15 min at 3000 rpm. After centrifuging, the supernatant liquid was decanted from the sediment into a pre-weighed petri-dish followed by evaporation of the liquid at 100 °C. As the evaporation was complete, the petri-dish is weighed again along with the fine dry mass. Same procedure was followed for the temperature of 80 and $90^0$C. The *SS* (g/mL) was determined by the following equation:

$$SS = \frac{\text{weight of the dry mass on petri dish}}{\text{volume of water taken } (\approx 10 \text{ mL})}$$

The wet mass sediment in the centrifuge tube is weighed, dried and again weighed. The *SP* (%) was calculated by the following formula:

$$SP = \frac{\text{weight of wet mass sediment}}{\text{weight of the dry matter in the sediment}} \times 100$$

### 4.5 Bulk density determination

The bulk density (*BD*) was determined by a method as described in (Suresh *et al*, 2013). As per the method, approximately 10 gram of the flour-sample was poured into a 50 ml graduated measuring cylinder, and then the later was gently tapped on the table 10-15 times to obtain a constant volume. The *BD* (g/cm$^3$) is defined as follows

$$BD = \frac{\text{weight of the sample taken}}{\text{Volume of the sample after tapping}} \times 100$$

### 4.6 Least gelation concentration (LGC)

The LGC was evaluated using a method described by (Shinde, 2001). The flour dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 30% (w/v) prepared in 5 ml distilled water was heated at 90°C for 1 h in water bath. The contents were cooled under tap water and kept for 2 h at 10 ± 2°C. The minimum dispersion concentration for which the sample does not slip from the inverted tube was taken to be the LGC.

### 4.7 Gelatinization temperature

The gelatinization temperature was determined by a method described in Shinde (2001). 1 g flour sample was weighed accurately in triplicate and transferred to 20 ml screw capped tubes. 10 ml of water was added to each sample. The samples were heated slowly in a water bath until they formed a solid gel. At complete gel formation, the respective temperature was taken to be the gelatinization temperature.

### 4.8 Dispersibility

The dispersibility was measured by a method described in (Kulkarni *et al*, 1991). Flour-sample of 10g was dispersed in 20mL distilled water in a 100 ml measuring cylinder and then the distilled water was added up to 50 ml mark. The mixture was shaken vigorously and allowed to stand for 3 hrs. The volume of settled particles was noted. The percentage dispersibility of the flour was calculated as follows:

$$Dispersibility = \frac{50 - \text{volume of settled particle (mL)}}{50} \times 100$$

## V. DATA ANALYSIS

The data were analyzed to statistical one-way ANOVA test and Tukey HSD test was applied for the comparison of each group. The analysis was carried out using SPSS version 22 and the whole data were presented as the mean ± SD. The P values of <0.05% were considered to indicate statistical significance.

## VI. RESULTS AND DISCUSSION

### 6.1 Biochemical properties of the flour from the selected wheat varieties

The biochemical properties of the respective samples are presented in Table 1, and the results are discussed for each property separately in the following sub-sections.

### 6.1.1 Moisture

BARI 28 wheat cultivars had the highest mean moisture content of 7.18% while the conventional wheat flour had the least mean moisture content of 4.82% (Table 1). The mean moisture content of BARI 28 wheat cultivar (7.18%) was significantly higher ($p < 0.05$) than the mean moisture content (4.82%) of conventional wheat flour. The result is in agreement with the research investigation of Singh *et al*, (2005). He reported that < 10% moisture content of wheat flour is suitable for long term storage and it will have a longer shelf life and would be more susceptible from the deterioration and spoilage of mold and other microorganisms. So the moisture content of BARI wheat cultivars are in line and it is as suitable as the conventional wheat flour for long term storage due to its low moisture content.

### 6.1.2 Ash

The ash content of the three BARI wheat cultivars are in the range of (1.62-2.15) %. BARI 28 and 30 wheat flours contained significantly higher ( $p < 0.05$) amount of ash content (2.15 and 2.01%) than the conventional wheat flour (1.80%) and BARI 26 wheat flour contained significantly lower ($p < 0.05$) amount of ash (1.62%) content from all the samples. Arawande *et al*, (2010) showed that the ash content of refined wheat flour was 1.40%. Ash content is an imperative indication of mineral contents of food and definitely the BARI 28 and 30 varieties show higher mineral contents of ash compared to BARI 26 and from conventional one.

### 6.1.3 Protein

Protein is considered the most important nutrient for humans and animals. The mean protein content of BARI 28 wheat flour was 12.31 % which was significantly higher ($p < 0.05$) than the conventional wheat (10.14%), BARI 26 (9.51%) and BARI 30 (10.22%) wheat flours and no significant difference ($p < 0.05$) was observed between the sample of conventional wheat flour (10.14%) and BARI 30 wheat flour (10.22%). The tested parameter were in agreement of 10.39% as reported by Meherunnahar *et al*, (2018). She also defined that protein content of a cereal depends on the geographical location and if the nitrogen levels of soil goes to higher level then it also affects the protein level of the agro-products.

### 6.1.4 Fat content

The mean fat content of wheat flour ranged from 2.15% to 3.44% where BARI 28 wheat flour had (3.44%) of fat which was significantly high ($p < 0.05$) comparing to BARI 26 (3.03%), BARI 30 (3.19%) and from the conventional wheat flour (2.15%). But no significant difference ($p < 0.05$) was observed between the sample of BARI 26 and BARI 30 wheat flour. The fat content of soft wheat flour was 1.33 % as reported by David *et al*, 2015. Though fat plays an important role in the shelf-life of food products but BARI wheat cultivars is not a good source of fat content because it is not an oil bearing seed.

### 6.1.5 Fiber content

The mean fiber content of the different BARI wheat cultivars were analyzed and compared with conventional wheat flour. It indicates that BARI 26 and 28 wheat cultivars had the lower quality of fiber content (1.80 and 2.11%) than the conventional wheat flour whereas BARI 30 wheat flour having the highest mean fiber content of 3.14%. This is in contrast to David *et al*, (2015) who found that the fiber content of soft wheat flour was 0.51%. Higher fiber content of a sample helps in the prevention of heart diseases, colon cancer and diabetes etc and BARI wheat cultivars are a medium source of fiber content.

### 6.1.6 Carbohydrate

The mean carbohydrate content of the different BARI wheat cultivars ranged from 74.02% to 79.26% and they were significantly different ($p < 0.05$) from each other. BARI 28 wheat cultivar had significantly lower amount of carbohydrate (74.02%) than the conventional one (80.09%). BARI 26 wheat cultivar had 79.26% carbohydrate which was very similar with conventional wheat flour (80.09%) and BARI 30 wheat cultivar (77.45%). Ahmed *et al, (*2012) found that the carbohydrate content of wheat flour was 74.22%. Result showed that BARI wheat cultivars are the good sources of carbohydrates which will be more preferable for energy giving food.

### 6.2 Minerals

### 6.2.1 Sodium and Potassium

BARI 26 wheat cultivars had the highest sodium (Na) content of 53.40 mg/100g while BARI 30 wheat flour had the least sodium content of 15.22 mg/100g (Table 2). The mean sodium content of BARI 26 wheat cultivar (53.40 mg/100g) was significantly higher ($p < 0.05$) than the mean sodium content of BARI 30 wheat flour (15.22 mg/100g), conventional wheat flour (49.12 mg/100g) and BARI 28 (38.3 mg/100g) wheat cultivar. The level of potassium of

BARI 28 wheat cultivar was (259.37 mg/100g), significantly higher ($p < 0.05$) than BARI 26 (207.01 mg/100g) BARI 30 (235.01 mg/100g) and also from conventional wheat flour (158.23 mg/100g). Potassium has been found as a vital element in kidney function and ultrafiltration (Abagale *et al*, 2013).

### 6.2.2 Calcium

Table 2 shows that all the BARI varieties had improved quality of calcium than the conventional wheat flour. Among them BARI 28 wheat cultivar was highly enriched with calcium (24.48 mg/100g) which varied significantly ($p < 0.05$) than BARI 26 (14.21 mg/100g), BARI 30 (16.11 mg/100g) and from conventional wheat cultivar (12.32 mg/100g). Meherunnahar *et al,* 2018 found that calcium content of wheat flour was 13.35 mg/100g. She also described that calcium played an important role in the body to constituent of bones and teeth, muscle contraction, nerve function, and blood clotting. It is also required for membrane permeability, normal transmission of nerve impulses and in neuromuscular excitability.

### 6.2.3 Iron

Highest amount of iron was found in BARI 28 wheat cultivar 1.33 mg/100g which was significantly higher ($p < 0.05$) as compared to BARI 26 (0.65 mg/100g), BARI 30 (0.50 mg/100g) and also from conventional wheat flour (0.71mg/100g). Iron is required for making HB level. Iron and calcium occur together in the body to maintain body blood. Kamara *et al,* (2009) reported that iron is highly important because of its requirement for blood formation and BARI wheat cultivars would not be a good source of iron content since the iron contents of all BARI wheat cultivars were in low quantity.

### 6.2.4 Phosphorous

The conventional wheat flour had higher amount of phosphorous (262.13 mg/100g) which varied significantly ($p< 0.05$) from all the BARI wheat cultivars and the values were (255.08, 171.35 and 152.03) mg/100g for BARI 26, 28 and 30 wheat cultivars. Soetan *et al, (*2010) reported that phosphorous works as a constituent of bones, teeth, adenosine and triphosphate (ATP) and nucleic acid.

## VII. FUNCTIONAL PROPERTIES OF SELECTED WHEAT CULTIVARS

The functional properties of BARI wheat cultivars play an important role in the manufacturing of food products. Table 3 shows various functional properties of BARI 26, 28 and 30 wheat cultivars.

### 7.1 Water absorption capacity

The water absorption capacity of different BARI wheat cultivars had a ranging from (257.00-269.30)% and the highest water absorption capacity was observed in BARI 30 (269.33%) wheat cultivar which was very similar with BARI 28 wheat cultivar (268.67%) while BARI 26 had the least water absorption capacity of 257.00%. All the BARI samples were significantly higher percentage of WAC ($p < 0.05$) than the conventional one (239.75%). The water absorption capacity was found to be 140% as reported by Suresh and Samser (2013). He also reported that less WAC can be attributed to the less availability of polar amino acids. Water absorption capacity represents the ability of the products to associate with water under conditions when water is kneaded with dough's (David *et al*, 2015). The result of this work suggested that the high water absorption capacity represents the presence of higher amount of starch and fiber and BARI wheat cultivars are the good source of water absorption capacity (WAC).

### 7.2 Oil absorption capacity

Oil absorption capacity is ascribed mainly to the physical frame of oils. It is an indication of the rate at which protein builds to fat in food formulation. From Table 3, it could be seen that the oil absorption of the different wheat flour ranged from (262.33-282.67) % and they were significantly higher ($P < 0.05$) than the conventional wheat flour (228.38%). BARI 28 had the highest mean value of oil absorption capacity (282.67%) and the least value of oil absorption capacity was observed in conventional wheat flour (228.38%) and no significant difference ($p < 0.05$) was found between the sample of BARI 26 (264.33 %) and BARI 30 (265.29%) wheat cultivar. Meherunnahar *et* al, (2018) reported that oil absorption is an indication of the rate at which the protein binds to fat in food formulations and higher OAC represents the better quality of mouth feels and flavor enhancer of a flour. Higher percentage of oil absorption capacity also indicates the presence of polar amino acids in the wheat flour and it could be useful in food formulation like sausage and bakery products and Table 2 indications that all the BARI varieties had higher percentage of OAC then the conventional one, which is very good for bakery products.

### 7.3 Foam capacity and foam stability

BARI 28 wheat cultivar contained significantly ($p < 0.05$) higher amount of foaming capacity (6.94%) and lower amount of foaming stability (1.21%) as compared to BARI 26 (3.58 and 0.96%) and BARI 30 (5.60 and 0.79%) wheat cultivars whereas conventional wheat flour had (3.71 and 0.61%) of foam forming capacity and foaming stability. The foaming capacity and foaming stability depends on protein concentration, its solubility, swelling power and dispersion. Meherunnahar *et al,* (2018) found that foaming capacity and stability is required to improve the texture, consistency and appearance of a food.

### 7.4 Emulsion activity (EA) and stability

BARI 26 and 30 wheat cultivars showed relatively higher percentage of emulsion activity (48.49 and 53.30%) and lower percentage of emulsion stability (32.44 and 48.73%) while conventional wheat and BARI 28 wheat cultivar showed the reverse condition, low emulsion activity (38.12 and 36.82%) and high emulsion stability (41.48 and 42.21%). Increasing EA and ES capacity of a flour depends on primary functional properties of protein and this protein is important to enhance the formation and stabilization of emulsions for many applications of the food products like cake, coffee whiteners, frozen desserts, salad dressings and mayonnaise (Suresh and Samser, 2013).

### 7.5 Bulk density

The bulk density depends on the particle size shapes and pertaining moisture content of flours. BARI 26, 28 and 30 wheat cultivars were in the range of (0.57-0.59)g/cm$^3$ bulk density whether BARI wheat varieties showed higher bulk density than the conventional one (0.56 g/cm$^3$) and they varied significantly ($p<0.05$). Mean highest bulk density was observed in BARI 30 and BARI 26 wheat cultivars (0.59 g/cm$^3$) and they were significantly different from BARI 28 wheat cultivar (0.57g/cm$^3$) but no significant difference was observed between the conventional wheat flour (0.56 g/cm$^3$) and BARI 28 wheat cultivar (0.57 g/cm$^3$). David et al, 2015 stated that bulk density is an important factor to choose the appropriate packaging units and lower bulk is always preferable to reduce paste thickness and infant feeding.

### 7.6 Swelling power and solubility

The swelling power and the solubility of the flour samples at different temperatures are presented in Fig. 1 and Fig. 2. The swelling power of different flours ranged between 13.02-38.26%. Both the parameters increases with the increasing temperature and the highest value of swelling power and solubility was found for all wheat cultivars at a temperature of 90$^0$. The swelling power of BARI 28 wheat cultivar was 38.26% (Fig. 1) which was significantly higher ($p < 0.05$) than BARI 26 (29.78%), BARI 30 (26.14%) and also from conventional wheat flour (34.58%). According to David *et al,* (2015), the extent of swelling depends on the temperature, water availability, starch species, carbohydrates and proteins. Highest percentage of solubility was found in BARI 26 wheat flour (8.63%) and lowest percentage of solubility was found in BARI 30 wheat cultivar (6.57%) at a temperature of 90$^0$C (Fig. 2) and they varied significantly ($p < 0.05$) with each other. But no significant difference ($p < 0.05$) was found between BARI 28 (7.54%) and conventional wheat flour (7.34%) at the same temperature. The same trend was observed in Adeleke and Odedeje (2010). They found that the solubility of wheat flour was 8.68%. The high swelling capacity and solubility in this study suggests that BARI wheat cultivars was digestible and suitable for the ingredients in infant food formulations and bakery food products for its improved solubility.

### 7.7 Least gelation concentration (LGC, %)

BARI 26 and 30 wheat cultivars formed gel quickly in a lower concentration (6 g/ 100 ml) which is very similar to conventional wheat flour (6.67 g/ml) and BARI 28 wheat flour formed gel comparatively in high concentration (8.38 g/100 ml) which satisfy the previous result (10.75%) as described by Adeleke and Odedeji (2010). He also suggest that high gelation value is a good gel forming agent and this variation in the gelling properties may be the ratios of different constituents such as protein, carbohydrates and lipids in different BARI wheat cultivars.

### 7.8 Gelatinization temperature (GT, °C)

Gelatinization temperature of BARI 26, 28 and 30 wheat cultivars were in the range of (56.43- 61.48)$^0$C. Highest GT was found in conventional wheat flour (61.48°C) and lowest for BARI 28 wheat cultivar (56.43 °C) which is very similar with BARI 30 wheat cultivar (58.48$^0$C). The study revealed that conventional wheat flour and BARI 26 wheat cultivar had high temperature of gelatinization due to higher starch content whereas BARI 28 wheat cultivar had low temperature due to lower starch content.

### 7.9 Dispersibility

It is a measure for reconstitution of flour or starch in water. The dispersibility of the BARI wheat cultivars were in the range of (42-46)% while BARI 26 and 30 wheat cultivar had the lowest dispersibility (42%) which were more or less similar with conventional wheat flour (41.33%) and BARI 28 had the highest dispersibility (46%) and they varied significantly ($p < 0.05$). If the dispersibility of a sample is high then the reconstitutes of water in a sample is also high and BARI 28 wheat cultivars had higher source of dispersibility.

## VIII. CONCLUSION

Functional properties show that the processing of flour from new BARI wheat cultivars would be quite similar to those of the conventional one and no additional tool or expertise is required. Nutritional value is quite satisfactory for the food product based on these cultivars to be consumed by human population. Under this condition and considering the cultivation parameters, it is concluded that the new BARI wheat varieties could be produced in massive scale and the corresponding food product could be included in the human food chain.

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## APPENDIX'S: LIST OF TABLES AND FIGURES

### Table 1: Nutritional parameters of wheat cultivars

| *Parameters tested* | *Conventional Wheat* | *BARI 26* | *BARI 28* | *BARI 30* |
|---|---|---|---|---|
| ***Moisture*** | $4.82 \pm 0.05^{d}$ | $5.88 \pm 0.18^{c}$ | $7.18 \pm 0.11^{a}$ | $6.13 \pm 0.12^{b}$ |
| ***Ash*** | $1.80 \pm 0.03^{b}$ | $1.62 \pm 0.04^{c}$ | $2.15 \pm 0.41^{a}$ | $2.01 \pm 0.03^{a}$ |
| ***Protein*** | $10.14 \pm 0.41^{b}$ | $9.51 \pm 0.06^{c}$ | $12.31 \pm 0.17^{a}$ | $10.22 \pm 0.08^{b}$ |
| ***Fat*** | $2.15 \pm 0.04^{c}$ | $3.03 \pm 0.07^{b}$ | $3.44 \pm 0.08^{a}$ | $3.19 \pm 0.07^{b}$ |
| ***Fiber*** | $2.19 \pm 0.08^{b}$ | $1.80 \pm 0.19^{c}$ | $2.11 \pm 0.10^{c}$ | $3.14 \pm 0.04^{a}$ |
| ***CHO*** | $80.09 \pm 0.47^{a}$ | $79.26 \pm 0.33^{a}$ | $74.02 \pm 0.20^{c}$ | $77.45 \pm 0.16^{b}$ |

Data presented as mean value ± standard deviation of three replications (N=3). Means in the columns with different superscript letters are significantly different at ($p < 0.05$).

### Table 2: Mineral contents of wheat cultivars

| *Parameters tested* | *Conventional wheat* | *BARI 26* | *BARI 28* | *BARI 30* |
|---|---|---|---|---|
| *Na (mg/100g)* | $49.12 \pm .42^{b}$ | $53.40 \pm 0.16^{a}$ | $38.3 \pm 0.28^{b}$ | $15.22 \pm 0.21^{c}$ |
| *K (mg/100g)* | $158.23 \pm 0.86^{d}$ | $207.01 \pm 1.69^{c}$ | $259.37 \pm 0.26^{a}$ | $235.21 \pm 0.20^{b}$ |
| *Ca (mg/100g)* | 12.32±0.13d | $14.21 \pm 0.17^{c}$ | $24.48 \pm 0.42^{a}$ | $16.11 \pm 0.08^{b}$ |
| *Fe (mg/100g)* | $0.71 \pm 0.06^{b}$ | $0.65 \pm 0.05^{c}$ | $1.33 \pm 0.10^{a}$ | $0.50 \pm 0.11^{c}$ |
| *P (mg/100g)* | $262.13 \pm 4.31^{a}$ | $255.08 \pm 7.6^{a}$ | $171.35 \pm 3.71^{c}$ | $152.03 \pm 5.31^{b}$ |

Data presented as mean value ± standard deviation of three replications (N=3). Means in the columns with different superscript letters are significantly different at ($p < 0.05$).

### Table 3: Functional properties of wheat cultivars

| *Parameters tested* | *Conventional wheat* | *BARI 26* | *BARI 28* | *BARI 30* |
|---|---|---|---|---|
| *WAC (%)* | $249.75 \pm 0.93^{c}$ | $257.00 \pm 1.00^{b}$ | $268.67 \pm 2.08^{a}$ | $269.33 \pm 1.53^{a}$ |
| *OAC (%)* | $228.38 \pm 1.13^{c}$ | $264.33 \pm 2.08^{b}$ | $282.67 \pm 2.31^{a}$ | $265.29 \pm 1.53^{b}$ |
| *FC (%)* | $3.71 \pm 0.52^{c}$ | $3.58 \pm 0.47^{c}$ | $6.94 \pm 0.72^{a}$ | $5.60 \pm 0.31^{b}$ |
| *FS (%)* | $0.61 \pm 0.02^{b}$ | $0.96 \pm 0.04^{a}$ | $0.51 \pm 0.20^{c}$ | $0.79 \pm 0.03^{b}$ |
| *EA (%)* | $38.12 \pm 0.08^{c}$ | $48.49 \pm 0.55^{b}$ | $36.82 \pm 1.12^{d}$ | $53.30 \pm 0.15^{a}$ |
| *ES (%)* | $41.48 \pm 0.16^{c}$ | $32.44 \pm 0.28^{d}$ | $42.21 \pm 0.45^{b}$ | $48.73 \pm 0.14^{a}$ |
| *BD (g/cm$^{3}$)* | $0.56 \pm 0.01^{b}$ | $0.59 \pm 0.03^{a}$ | $0.57 \pm 0.03^{b}$ | $0.59 \pm 0.02^{a}$ |
| *LGC (%)* | 6b | 6b | 8a | 6b |
| *LGT ($^{0}$C)* | $61.48 \pm 0.07^{c}$ | $60.56 \pm 0.02^{b}$ | $56.43 \pm 0.02^{c}$ | $58.48 \pm 0.03^{a}$ |
| *Dispersibility (%)* | $41.33 \pm 0.57^{c}$ | $42.00 \pm 0.57^{b}$ | $44.00 \pm 1.08^{a}$ | $42.00 \pm 0.66^{b}$ |

Here WAC-Water absorption capacity, OAC- Oil absorption capacity, FC-Foaming capacity, FS- Foaming stability, EC- Emulsion capacity, ES- Emulsion stability, BD- Bulk density, LGC-Least gelation concentration, LGT- Least gelatinization temperature. Data presented as mean value ± standard deviation of three replications (N=3). Means in the columns with different superscript letters are significantly different at ($p < 0.05$).

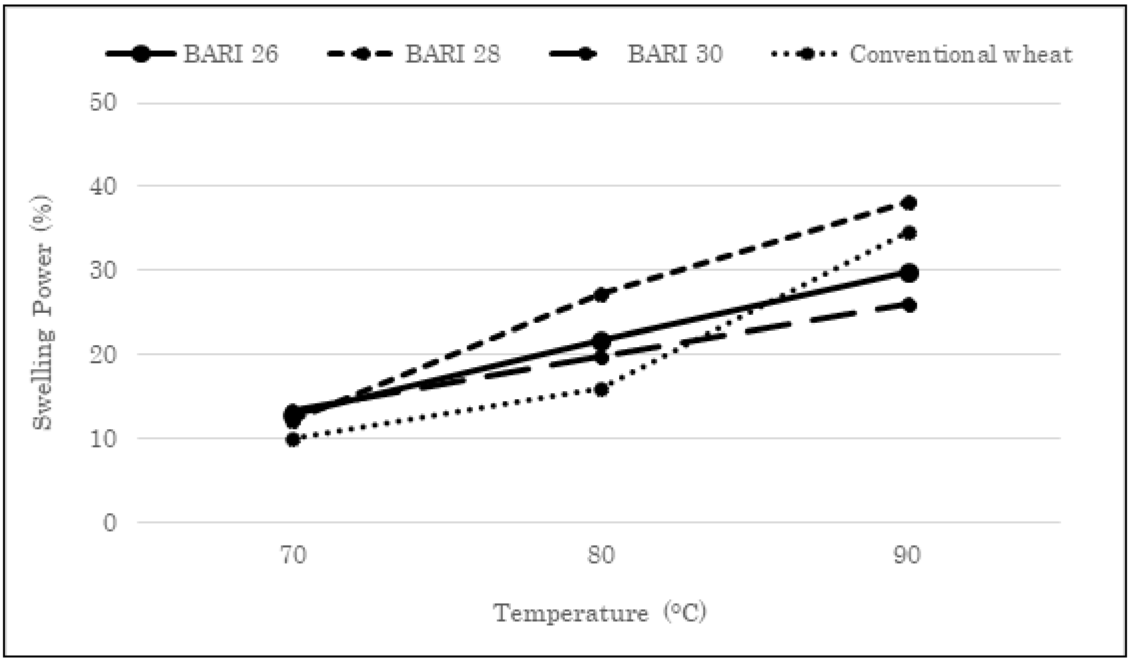

Fig.1: Percentage of swelling power in wheat cultivars

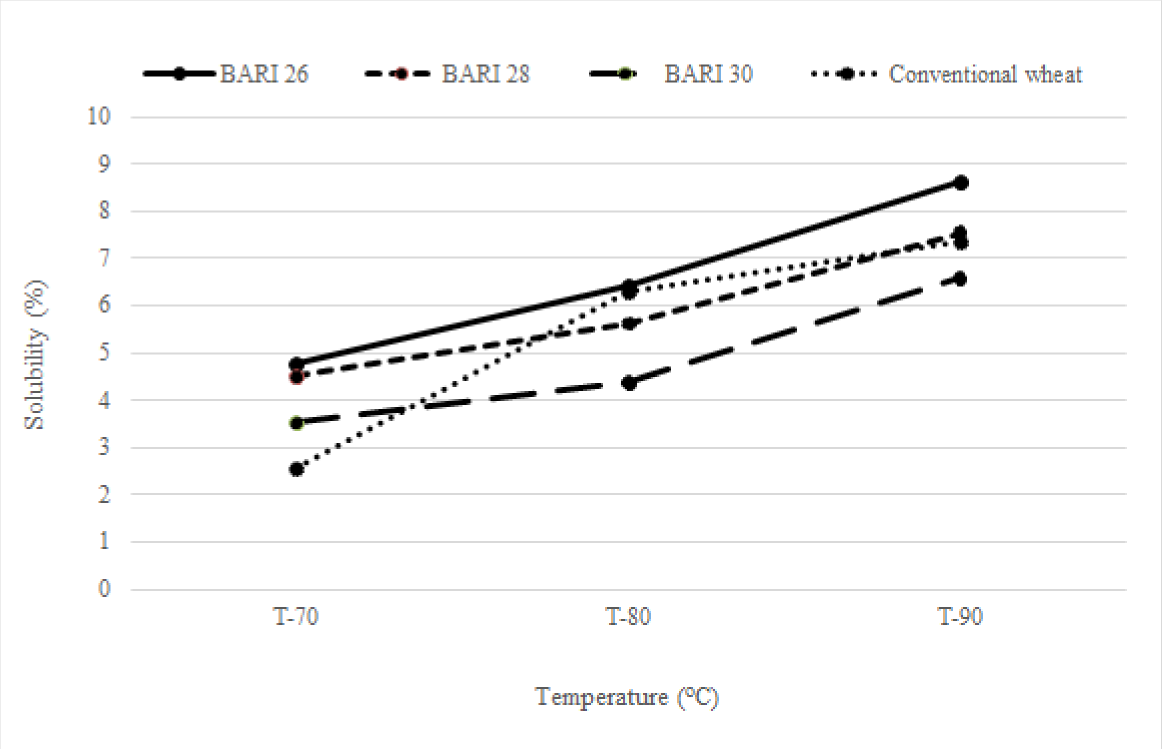

Fig.2: Percentage of solubility in wheat cultivars

Data presented as mean value ± standard deviation of three replications (N=3).