The Pharma Innovation Journal 2021; 10(7): 931-937

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(7): 931-937

www.thepharmajournal.com
Received: 03-04-2021
Accepted: 07-06-2021

Vishakha Singh
Research Scholar, Department of Food Science and Nutrition, Assam Agricultural University, Jorhat, Assam, India

Mamoni Das
Professor, Department of Food Science & Nutrition, Assam Agricultural University, Jorhat, Assam, India

Dibyakanta Seth
Assistant Professor, Department of Food Process Engineering National Institute of Technology (NIT), Rourkela, Odisha, India

Corresponding Author:
Vishakha Singh
Research Scholar, Department of Food Science and Nutrition, Assam Agricultural University, Jorhat, Assam, India

Chemical and functional evaluation of Burma black rice based instant beverage Mix (BBIBM)

Vishakha Singh, Mamoni Das and Dibyakanta Seth

Abstract
The present investigation was undertaken to develop Burma black rice Based Instant Beverage Mix (BBIBM)using Burma black rice (*Oryza sativa* L. *indica*), lentil (*Lens culinaris*), sweet potato (*Ipomoea batatas*) and mulberry (*Morus nigra*) flour, and evaluated its chemical and functional properties. Developed Burma black rice based instant beverage mix had a moisture content of 10.25g/100gat par with the permissible limit recommended by Food Safety and Standards Regulations, 2011,the crude protein content of 14.34±0.08g/100gm, crude fat content of 3.10±0.2 g/100gm, crude fibre content of 11.34±0.22 g/100gm, total mineral content of 2.43±0.02 g/100gm, total carbohydrate content of 58.54±1.33 g/100gm and energy value of 319.42 ±0.9kcal at par with commercially available health drink powder (56g/100g of carbohydrate and 335kcal of energy). It has good functional properties with water holding capacity of 63±2.3%water/100g,bulk density of 0.67±0.07g/cm^3,tapped density of 0.81±0.01g/cm^3,flowabilityof 17.28±1.2% at par with Carr's compressibility index (16-20%), cohesiveness of 1.2±0.1 at par with Husnar ratio (1.19 to 1.25), dispersibility of 62.71±1.82%, Hygroscopicity of 66.46±1.42%, viscosity of 5.75±0.46cP and wettability of 55.00± 2.83 sec. The developed Burma black rice based instant beverage mixis rich in nutrient and had excellent functional characteristics indicating a quality product for consumer acceptability.

Keywords: Instant beverage mix, chemical composition, functional property, evaluation

Introduction
Beverages are the most active functional food category because of their convenience and possibility to meet consumer demands for a search of new novel foods. Plant based food products experienced an increased interest (Hever *et al.* 2017) [29] due to their specific health benefits properties as they are packed with a wide array of nutrients, including vitamins, antioxidants, fibres, minerals and amino acids which are capable of combating and preventing a wide spectrum of non-communicable diseases such as diabetes, cardiovascular disorder, cancer, hepatic disorder and its complications (McMacken *et al*. 2017) [43]. Apart from being an extremely rich source of nutrients, plant based foods are comparatively cheaper than animal based foods and need to be incorporated into the daily diet to see their complete potential as functional foods (Tuso *et al.* 2013) [66]. Ready to serve and ready to eat foods that use blends of cereal, pulse, vegetable and fruit in new product development, increases the nutrients, as well as the market value of the product. There are limited reports on the use of black rice for the development of instant beverages. The present study was planned to use indigenous plant based food ingredients including Burma black rice (*Oryza sativa L. indica*), lentil (*Lens culinaris*), sweet potato (*Ipomoea batatas*) and mulberry (*Morusnigra*) to produce Burma black rice Based Instant Beverage Mix (BBIBM) rich in nutrient and functional value.

Methodology
Sample Procurement: Sample of black rice (*Oryza sativa* L.), lentil (*Lens culinaris*), sweet potato (pale yellow flesh) *(Ipomoea batatas)* and black mulberry (*Morusnigra*) were procured from the local market of Jorhat, Assam, India.

Processing of raw ingredients for development of cereal based instant beverage mix (CBIBM)
Black rice (*Oryza sativa* L.) was processed to black rice flour following the method by Sutinium *et al.* (2008) [61], germinated lentil was processed according to Hernandez-Aguilar *et al.* (2019) [28] with little modification. Sweet potato flour was obtained by the method outlined by Julianti *et al.*, (2017) [36] and mulberry flour was obtained by the method outlined by Ali *et al.* (2016) [3].

Processing of Burma black rice flour

Black rice was Sorted, cleaned, washed in tap water, drained using Rice draining Colander, soaked in tap water (Black rice: tap water = 1:3 w/w) for 30 min., Rinsing with distilled water for 2 times and removing excess water, then steamed for 50 min by portioning into a cup and adding water (Raw black rice: water = 1:1.5 w/w) using stainless steel perforated colander, then spread it on blotting paper and allow it to be cool at room temperature for 45 min, then spread it on still based Hot air oven tray with a *thickness* of 1x5 cm. and dried for 8 hours at 60^0C using Hot air oven, allow to cool at room temperature for 12 hours, dry milling (250µm particle size) in a hammer mill and blended with a mechanical ribbon blender to obtain a homogeneous mixer. Then flour was sieved through 150 mess size to get fine flour. The flour was then packaged in high density polyethylene (HDPE) virgin airtight containers for future use (Sutinium *et al.*, 2008) [61].

Processing of germinated lentil flour

Lentil seed was washed using tap water and then soaked inside a glass bottle with distilled water (1:2 w/w)for 24 hours and covered with a cotton cloth. After this hydration and imbibition process, the seeds were washed again and the excess water was left to drain from the seeds for 10 min using a perforated colander. Next, the seed was allowed to germinate in muslin cloth, washing them with purified water every 24 h for 5 days, then steamed for 20 min by Portioning into a cup and adding water (lentil:water = 1:1.5 (w/w) using stainless still perforated colander, then spread it on blotting paper and allow it to be cool at room temperature for 45 min., then spread it on still based Hot air oven tray with a *thickness* of 1x5 cm. and dried for 72 hours at 40ºC using hot air oven, allow to cool at room temperature for 12 hours, sprout removed by hand abrasion, peeled removed and ground (250µm particle size) using paddy de-husking machine and sieve through 150 mess size to get fine flour. Flour was packed in HDPE virgin airtight container and stored at room temperature for further analysis (Hernandez-Aguilar *et al.* (2019) [28].

Processing of Sweet potato flour

Yellow flashed sweet potato were peeled, washed and dab in a muslin cloth to remove water, then uniform slicing (10x10x5) using stainless steel potato slicer using stainless still, spread in a tray and was oven-dried at 60 C for 10 h and after which it was ground into flour using mixture grinder. The flours were screened through a 100 mesh sieve to get fine flour. Flour was packed in HDPE virgin airtight container and stored at room temperature for further analysis (Julianti, 2017) [36].

Processing of mulberry flour

Fresh ripe black mulberry was sorted, pulped and cabinetdried at 55ºC for 30 hours and after which it was ground into powder using a mixture grinder. The powder was screened through a 100 mesh sieve to get fine flour and flour were packed in HDPE virgin airtight container and stored at room temperature for further analysis (Ali *et al.*, 2016) [3].

Formulation of Burma black rice Based Instant Beverage Mix (BBIBM)

The formulation ofinstant beverage mix was done using the method outlined by Sengev *et al.* (2010) [58]. For the present study black rice flour (*Oryza sativa L. indica*), germinated lentil flour (*Lens culinaris*), sweet potato flour*(Ipomoea batatas) and* black mulberry powder(*Morusnigra*) of varying proportion were blended to obtain Five test sample namely TS1,TS2, TS3,TS4 and TS5 for each formulation as shown in Table 1.

Table 1: Formulation of Burma black rice based instant beverage mix (BBIBM).

Blend	Formulation of Burma black rice Based Instant Beverage Mix (BBIBM)			
	Black rice flour (*Oryza sativa L. indica*)	Germinated lentil flour (*Lens culinaris*)	Sweet potato flour (*Ipomoea batatas*)	Black Mulberry powder (*Morusnigra*)
TS 1	35.00	21.66	21.66	21.66
TS 2	40.00	20.00	20.00	20.00
TS 3	50.00	16.66	16.66	16.66
TS 4	55.00	15.00	15.00	15.00
TS 5	60.00	13.33	13.33	13.33

Table 2: Chemical composition of developed Burma black rice Based Instant Beverage Mix (BBIBM)

Nutrient	BBIBM (per 100 g of dry weight basis)	Horlicks (per 100 g of dry weight basis)
Moisture (g)	10.25±0.25	-
Crude Protein (g)	14.34±0.08	33
Crude Fat (g)	3.10±0.2	1
Crude Fibre (g)	11.34±0.22	-
Ash content (g)	2.43±0.02	-
Total Carbohydrate content (g)	58.54±1.33	56
Energy (Kcal)	319.42±0.9	365

3 replicate of each values are expressed in mean ± SD (Standard deviation)

Table 3: Functional properties of developed Burma black rice Based Instant Beverage Mix (BBIBM)

Parameters	Value
Water holding capacity (%)	63±2.3
Bulk density(g/cm^3)	0.67±0.07
Tapped density(g/cm^3)	0.81±0.01
Flow property (%)	17.28±1.2
Cohesiveness (HR value+)	1.2±0.1
Dispersiability (%)	62.71±1.82
Hygroscopicity (%)	66.46±1.42
Viscosity (cP)	5.75±0.46
Wettability (Sec.)	55.00± 2.83

3 replicate of each values are expressed in mean ± SD (Standard deviation)

Organoleptic evaluation of formulated Burma black rice Based Instant Beverage Mix (BBIBM).

For each test sample 30gm of instant beverage mix was mixed in 200ml of soya milk and were subjected to organoleptic evaluation.

The sensory evaluation of the developed Burma black rice Based Instant Beverage Mix (BBIBM)was performed using the method of Iwe, M.O., (2002) [33]. The scoring was based on a 9- point hedonic scale ranging from 9 (extremely like) to 1 (extremely dislike) and 5 (neither like nor dislike). It was done by a panel of the 21semi-trained person of the department of food science and nutrition, Assam agricultural university, Jorhat.

Determination of Chemical composition

The chemical composition (i.e., moisture, protein, fat, fibre, ash) of the formulated instant beverage mixes was estimated according to the standard analytical methods (AOAC, 2000). The carbohydrate content was determined by the calculated difference method and energy value was determined by multiplying the proportion of protein, fat and carbohydrate by their respective physiological energy values and taking the sum of the products (Farzana *et al.*, 2015) [21].

Determination of functional properties

Water absorption capacity

Water absorption capacity of the flours was determined using the method outlined by Sosulski *et al.* (1976) [60]. Ten milliliter of distilled water was added to 1.0g of the sample in a tube and allowed to stand at ambient temperature (30±2°C) for 30 min, then centrifuged for 30 min at 3,000 rpm or 2000×g. Water absorption was examined as percent water bound per gram flour.

Loose and packed bulk densities

Loose and packed bulk densities were determined according to the method of Akpapunam *et al.*, (1981). Ten grams of the prepared samples were weighed into a measuring cylinder (100 ml) and the loose volume was noted for loose bulk density and then tapped for packed bulk density. Bulk density was expressed as mass per volume of the sample.

Wettability

Wettability was evaluated according to the method described by NIRO (1978) [49] with slight modifications. 100 ml of distilled water at 25°C were poured into a 400 ml beaker (diameter 70mm). A glass funnel (height 100 mm, lower diameter 40 mm, upper diameter 90 mm) was placed and maintained on the upper edge of the beaker. A test tube was placed within the funnel to block the lower opening of the funnel. 3g powder is placed around the test tube; while the timer is started, the tube is simultaneously elevated. Finally, the time is recorded when the powder is completely wet (visually assessed that all powder particles have diffused into the water).

Hygroscopicity

Hygroscopicity was determined by placing 10g of a powder sample in the desiccator at ambient temperature (25°C). Saturated sodium chloride solution was kept in the desiccator to maintain a relative humidity of 73.36% (Bhusari *et al.*, 2014) [11]. The weight change of the sample was observed after a week. All the measurements were analyzed in triplicates, and the results were expressed in grams of adsorbed moisture per 100 g of dry solids (Vivek *et al.* 2020) [68].

Viscosity

The viscosityof the sample was determined as per the method given by Hallic and Kelly (1959) [27] by using Visco Basic Plus Viscometer (Fungillab). The test samples developed were reconstituted in water at different solid concentrations (2, 4, 6 and 8 percent), heated for 20 min on a boiling water bath, cooled to ambient temperature and the viscosity was measured in ViscoBasic Plus Viscometer with rpm 20, 30 and 60 varying appropriate spindles. The viscosity was measured in centipoises (cP).

Dispersibility

Dispensability was determined according to the method given by Shittu and Lawal (2007) [59]. Dispensability of the test sample was determined by dissolving approximately 10g of powder in 100ml of distilled water at 21^0 C and manually stirred for 1 min and then left for 30 min to settle down. The suspended particles before the supernatant were carefully decanted.

The mass of the supernatant was then determined by transferring an aliquot of the supernatant into a 50 ml density bottle. The weight of the dispersed solid was calculated as double the difference in the mass of the supernatant and an equal volume (50 ml) of distilled water. All the weight determinations were done in triplicate using digital scales.

Cohesiveness

The **c**ohesiveness of the powders was calculated in term of the Hausner ratio (HR), The Hausner ratio is the ratio of tapped bulk density to the loose bulk density and it relates to gain in cohesive strength after the compaction (Hausner, 1967) [30]. The powders with little gain in bulk density are considered to be non-cohesive (Hausner ratio < 1.25) (Horn, 2008) [31] while a higher value indicates greater cohesion calculated from the bulk density (P_B) and tapped density (P_T). (Jinapong *et al.* 2008; Turchiuli *et al.* 2005) [34, 65]

$$\text{Hausner ratio (\%)} = \frac{\text{Tapped bulk density (Pt)}}{\text{Loose bulk density (Pt)}}$$

The flow property of test samples was evaluated using Carr's index (CI) (Arepally and Goswami, 2019) [4]. The CI was calculated using the following expression.

$$\text{Carr's index(\%)} = \frac{\text{Tapped bulk density (Pt)} - \text{Loose bulk density (Pb)}}{\text{Tapped bulk density (Pt)}} \times 100$$

Result and Discussion

Organoleptic evaluation of developed Burma black rice Based Instant Beverage Mix (BBIBM)

The result of sensory evaluation reveals that out of 5 test sample, Test sample 2 had the highest significant organoleptic score in term of colour (7), texture (8), flavour (7), appearance (7) and test (8) in comparison to other test samples.

Based on its highest organoleptic score the sample was further analyzed for chemical and functional properties.

Chemical composition of developed Burma black rice Based Instant Beverage Mix (BBIBM)

Chemical composition

The moisture content of developed BBIBM was 10.25g/100gwhich were within the permissible limit recommended by Food Safety and Standards Regulations, 2011. The protein content of developed Burma black ricebased instant beverage mix was14.34±0.08g/100g,many research studies showed that the protein content of Burma black rice based instant beverage mix was within the range from 13.17g/100g to 17.85g/100g (Reza *et al.,* (2014) [56]; Oluwole *et al.* (2012) [52]. When compared with the commercially available health drink powders like horlicks (33g/100g) were significantly lower probably due to the use of protein powder as commercially available health drink products. The fat content of BBIBM was 2.9g/100g which was higher than the commercially available health drink powders (1g/100g). High fat content in developed BBIBM could be due to the presence of pulse flour in the mix which contained a high amount of fat (Farzana *et al.,* 2017) [20]. The crude fibre content of BBIBM was recorded 11.34±0.12g/100g. Several researchers observed similar crude fibrecontent in Burma black rice based instant flour ranged from 9.87-12.47g/100g (Thomas *et al.* 2013; Issara and Rawdkuen 2016) [32]. Incorporation of germinated lentil flour in BBIBM might behave enhancing the fibre content (Uppal and Bains 2012) [67]. The high fibre content in germinated flour due to the synthesis of new polysaccharides (Cellulose, Hemicellulose, Resistant starch)during the germination process (Benitez *et al.* 2013) [10]. Ash content of developed BBIBM was 2.08 g/100g. Which was within the range from 2.03g/100g to 2.41g/100g as reported by Obilana *et al.* and Croitoru *et al.* in 2018 [51, 15] for black rice based instant mix. The total carbohydrate content and energy value of the BBIBM was 58.59g/100g and 328.14±2.1kcal/100g respectively. Similarly, Gandhi N. *et al.* (2018) [43] also reported 327 kcal/100gm of energy value for Cereal based Instant Soup Mix incorporated vegetable flour.

Functional properties of developed Burma black rice Based Instant Beverage Mix (BBIBM)

Water-holding capacity (%)

Water-holding capacity (WHC) plays an important role in developing food texture (Haque *et al.* 2016) [26], improving the binding of the structure, enhancing flavor retention, improving mouth feel and reducing moisture loss from the food materials (Prinyawiwatkul *et al*. 1997).

Developed Burma black rice based instant beverage mix had 63% of the water holding capacity. Many studies have reported that the water holding capacity of cereal based flour mix varying between 53% and 90%water/100g (Berggren *et al.* 2017; Park *et al.* 2017, Niu *et al.* 2017) [9, 55, 48]. WHC of about 149.1-471.5% are considered criticalfor viscous food such as sauces, chocolate mass, soups, starches, cereal mix (Oyarequa and Adeyeye, 2009) [54] and high viscous is undesirable for beverage product thus the low water holding capacity of developed burma black rice based instant beverage mix is desirable.

Bulk and tapped density

The bulk density of the developed Burma black rice based instant beverage mix was found to be 0.67±0.07g/ cm^3.Several studies have reported that the bulk density of cereal based flour mix ranged from 0.60-0.88g/cm^3 (Adebowale *et al.*, 2012; Mbaeyi-Nwaoha *et al.*, 2016) [2, 42]. Anaval bulk density chart also reported 0.68g/cm3 of bulk density for cereal based mix (ANVAL Bulk Density Chart - Anval - First in Feeders & Airlocks. This indicates that the space required for storage is less for the developed cereal based instant beverage mix. The higher the bulk density, the less occluded air within the powders and, therefore, less possibility for product oxidation and reduced storage stability (Lewis M.J. 1987) [41].

The high bulk density of flour suggests their suitability for use in food preparations and reducing shipping and packaging costs and influences other powder properties such as flow ability and instant characteristics (Bian *et al*. 2015) [12]. Tapped density was 0.81g/ cm^3. Several study have reported that the tapped density of cereal based flour ranged from 0.76-0.84g/ cm^3 (Barba *et al.* 2020; Etti *et al.* 2019 [19]; Swaminathan's and Guha, 2018) [62]. In product with higher bulk and tapped density, particles come closer together and start to fill the voids between them, resulting in better packing fraction by obtaining lesser volume for packing (Bodhmage, 2006) [13]. Bulk and tapped density influenced by interparticulate interactions which interfere with powder flow.

Flow ability and Cohesiveness

Flow ability of food powder is defined as the ease with which a material will flow under a specified set of conditions. Hence, a material with good flow characteristics flows consistently without assistance (Chinwan *et al.* 2019) [14]. Carr's compressibility index (CI, %) is a measure of powder bridge strength and stability. The higher values of CI and HR indicated the cohesive nature of the flours with poor flow ability (Bala *et al.* 2020) [7].

Developed Burma black rice based instant beverage mix has high CI value (17.8) and fair flow behaviour. Powder with CI from 16-20 was classified as fair flowability (Geldert *et al.* 1984) [24]. The flowability of the product directly related to the moisture content of the product this might accelerates agglomeration because of the strong interlocking force associated with the inter-particle liquid bridges that resulted in stickiness or cakingof the product (Mitra *et al.* 2017) [45]. An increase in moisture content of the powders resulted in decreased powder flowability caused by the cohesion between the powder particles (Jung *et al.*, 2018) [37]. Opalinski *et al.* (2012) [50] explored the fact that the moisture content is responsible for increasing or decreasing the mechanical strength of the powder excellent or poor flowability of the powder.

As Carr's compressibility, the Index Hausner ratio also measures the product ability to settle and provide information about the flow behaviour of the flour samples (Bala *et al.* 2020) [7].

The ratio of tapped density to bulk density is known as the Hausner ratio (HR). Hausner ratio (HR) less than 1.18

indicate good flow, greater than 1.25 indicate poor flow and value from 1.19 to 1.25 was classified as fair cohesive (Geldert D. *et al.* 1984) [24].

Developed Burma black rice based instant beverage mix had HR value of 1.2±0.1 indicates fair flow property of the powder. Fair flowability may be due to the higher moisture content (10.25±0.25 g/100g) of the product (Aulton, 2013) [6]. The same observation was made by Chinwan *et al*. in 2019 [14] indicating that the higher moisture content increases the Hausner's ratio (HR) and Carr's Index (CI) thereby reducing the flowability of an instant mix.

Dispersibility

Dispersibility of the product is directly related to flowability. A product with an HR value of 1.19 to 1.25 indicates better flowability and higher dispersibility (Ganesan *et al.* 2008) [25]. The developed Burma black ricebased instant beverage mix had 63% of Dispersibility which was similar to the dispersibility value of cereal based formulated mix of 60-65% (Kulkarni *et al.* 1991) [39]. This lead to less lump formulation and agglomerations of the powder that fall apart in the water. Good dispersibility enhances the emulsifying and foaming properties of proteins, which was observed as an important functional property of flour for instant beverages applications which significantly affects consumer acceptability (Kinsella *et al.* 1979) [38].

Hygroscopicity

Developed Burma black rice based instant beverage mix had 50% of hygroscopicity. many research studies showed that hygroscopicity of instant beverage mix was within the range from 47% to 65% (Tonon *et al.* 2009; Rodriguez *et al.* 2005; Mishra *et al.* 2014) [64, 57, 44]. Many studies have revealed that a hygroscopicity value of more than 60% decreases the flowability of instant beverage mixes (Juarez-enriquez *et al.*2017; Arigo *et al.* 2019) [35, 5].

Viscosity

Viscosity is responsible for the “mouth feel” parameter such as texture, consistency of a beverage product (Lee *et al.* 2018) [40]. Developed cereal based instant beverage mix had 5.75±0.46cP of viscosity and fulfilled the criteria of viscosity (not more than 50cP) for beverage production given by the National Dysphagia Diet (2002) [46].

Wettability

Reconstitution properties in terms of wettability reflect how long, the particles become wet during the reconstitution process (Nguyen *et al.* 2015) [47].

The wettability of the developed Burma black rice based instant beverage mix was 55.00 sec. fulfilled the criteria of wettability (66sec.) for beverage powder given by the American dairy product institute (1971) [1]. Several studies have reported that the wettability ranged from 50.00 to 60.15 secin cereal based blend reflecting the ease of flour dispersing and fastest dissolution in water (Iwe *et al.* 2007; Dupas *et al.* 2015; Dhingra *et al.* 2004) [17, 18]. Flour neededa long time 100-120sec. to wet reflecting poor wettability, because of low specific surface area and particle’s texture/microstructure, and chemical composition (Nguyen *et al.* 2015) [47].

Conclusion

It is evident from the investigation that the developed Burma black rice Based Instant Beverage Mix (BBIBM) had superior chemical and functional characteristics. The developed Instant Beverage Mix was rich in protein, crude fibre, total carbohydrate and energy value. BBIBM showed excellent hygroscopicity, dispersibility, reconstitution behaviour and flow rate indicating quality product for consumer acceptability.

Acknowledge

In this chapter by the author gratefully acknowledges various other people such as Dr. Mamoni Das from Department of Food Science & Nutrition, Assam Agricultural University (AAU), Dr. Dibyakanta Seth from the Department of Food Process Engineering National Institute of Technology (NIT), Sukhveer Singh Yadav from NIFTIM, and Prabal Pratap Singh from BHU who have helped to ensure the best outcome for work described in this volume.

References

1. American Dry Milk Institute. Standards for Grades of Dry Milks Including Methods of Analysis. American Dry Milk Institute 1971.
2. Adebowale AA, *et al*. Functional properties and biscuit making potentials of sorghum-wheat flour composite. American Journal of food technology 2012;7(6):372-379.
3. Ali Murtaza, Yasser Durrani, Muhammad Ayub. Effect of Drying Techniques and Storage on Mulberry (Morus alba) Quality. Sarhad Journal of Agriculture 2016;32(2).
4. Arepally Divyasree, Tridib Kumar Goswami. Effect of inlet air temperature and gum Arabic concentration on encapsulation of probiotics by spray drying. *Lwt* 2019;99:583-593.
5. Arigo A. Effect of Hygroscopicity on pharmaceutical ingredients, methods to determine and overcome: An Overview. Journal of Pharmaceutical Sciences and Research 2019.
6. Aulton, Michael E, Taylor KMG. Powder flow. *Aulton's Pharmaceutics:* The Design and Manufacture of Medicines 2013;5:189-200.
7. Bala Manju, *et al*. "Physicochemical, functional and rheological properties of grass pea (Lathyrussativus L.) flour as influenced by particle size. *Heliyon* 2020;6(11):e05471.
8. Barba, Anna Angela, *et al*. Microwave Treatments of Cereals: Effects on Thermophysical and Parenchymal-Related Properties" Foods 2020;9(6):711.
9. Berggren, Sofia. Water holding capacity and viscosity of ingredients from oats: the effect of b-glucan and starch content, particle size, pH and temperature 2018.
10. Benítez, Vanesa, *et al*. Impact of germination on starch, dietary fiber and physicochemical properties in non-conventional legumes. Food Research International 2013;50(1):64-69.
11. Bhusari SN, Khalid Muzaffar, Pradyuman Kumar. Effect of carrier agents on physical and microstructural properties of spray dried tamarind pulp powder. Powder technology 2014;266:354-364.
12. Bian Qi, *et al*. Bulk flow properties of hard and soft wheat flours. Journal of Cereal Science 2015;63:88-94.
13. Bodhmage, Abhaykumar Krishnarao. Correlation between physical properties and flowability indicators for fine powders. Diss 2006.
14. Chinwan Dipanshu, Elena Castell- Perez M. Effect of conditioner and moisture content on flowability of yellow

cornmeal. Food science & nutrition 2019;7(10):3261-3272.
15. Croitoru, Constantin, *et al*. Improvement of Quality Properties and Shelf Life Stability of New Formulated Muffins Based on Black Rice. Molecules 2018;23(11):3047.
16. Chareonthaikij, Phantipha, Tanat Uan- On, Witoon Prinyawiwatkul. Effects of pineapple pomacefibre on physicochemical properties of composite flour and dough, and consumer acceptance of fibre- enriched wheat bread. International journal of food science & technology 2016;51(5):1120-1129.
17. Dupas Julien, Laurent Forny, Marco Ramaioli. Powder wettability at a static air–water interface. Journal of colloid and interface science 2015;448:51-56
18. Dhingra Shfali, Sudesh Jood. Effect of flour blending on functional, baking and organoleptic characteristics of bread. International journal of food science & technology 2004;39(2):213-222.
19. Etti Christopher J, Victoria G. Ekanem."Nutritional and sensory analyses of wheat-unripe plantain composite flour on bread making. International Journal of Engineering Applied Sciences and Technology 2021;5:83-87.
20. Farzana Tasnim, *et al*. Formulation and nutritional evaluation of a healthy vegetable soup powder supplemented with soy flour, mushroom, and moringa leaf. Food science & nutrition 2017;5(4):911-920.
21. Farzana Tasnim, Suman Mohajan. Effect of incorporation of soy flour to wheat flour on nutritional and sensory quality of biscuits fortified with mushroom. Food science & nutrition 2015;3(5):363-369.
22. Vignolles Marie-Laure, *et al*. Free fat, surface fat and dairy powders: interactions between process and product. A review." Le Lait 2007;87(3):187-236.
23. Gandhi Neeraj, *et al*. Extrusion process optimization of corn starch to develop instant vegetable soup mix. International Journal of Current Microbiology and Applied Sciences 2018;7(2):2886-2910.
24. Geldart D, Wong ACY. Fluidization of powders showing degrees of cohesiveness—I. Bed expansion. Chemical Engineering Science 1984;39(10):1481-1488.
25. Ganesan Vykundeshwari, Kasiviswanathan Muthukumarappan, Kurt A. Rosentrater. "Effect of moisture content and soluble level on the physical, chemical, and flow properties of distillers dried grains with solubles (DDGS). Cereal Chemistry 2008;85(4):464-470.
26. Haque MdAmdadul, Yakindra Prasad Timilsena, Benu Adhikari. Food proteins, structure, and function. Reference Module in Food Science; Elsevier: Amsterdam, The Netherlands 2016.
27. Halick JV, Vincent J Kelly. Gelatinization and pasting characteristics of rice varieties as related to cooking behavior. Cereal Chemistry 1959;36(1):91-98.
28. Hernández-Aguilar Claudia, *et al*. Photoacoustic spectroscopy in the optical characterization of foodstuff: A review. Journal of Spectroscopy 2019.
29. Hever Julieanna, Raymond J Cronise. Plant-based nutrition for healthcare professionals: implementing diet as a primary modality in the prevention and treatment of chronic disease. Journal of geriatric cardiology: JGC 2017;14(5):355.
30. Hausner Henry H. Friction conditions in a mass of metal powder. Polytechnic Inst. of Brooklyn.Univ. of California, Los Angeles 1967.
31. Horn, Eben. Development of a composite index for pharmaceutical powders. Diss. North-West University 2008.
32. Issara, Utthapon, Saroat Rawdkuen. Instant organic rice bran milk: Production and its primarily quality attributes. Proceeding of Food Innovation Asia Conference 2016.
33. Iwe MO. Handbook of sensory methods and analysis. Rojoint Communication Services Ltd., Enugu, Nigeria 2002, 7-12.
34. Jinapong Nakarin, Manop Suphantharika, Pimon Jamnong. Production of instant soymilk powders by ultrafiltration, spray drying and fluidized bed agglomeration. Journal of food engineering 2008;84(2):194-205.
35. Juarez-Enriquez E, *et al*. Effect of water content on the flowability of hygroscopic powders. Journal of Food Engineering 2017;205:12-17.
36. Julianti Elisa, Herla Rusmarilin, Era Yusraini. Functional and rheological properties of composite flour from sweet potato, maize, soybean and xanthan gum. Journal of the Saudi Society of Agricultural Sciences 2017;16(2):171-177.
37. Jung Mina, *et al*. Porous-Nafion/PBI composite membranes and Nafion/PBI blend membranes for vanadium redox flow batteries. Applied Surface Science 2018;450:301-311.
38. Kinsella, John E. Functional properties of soy proteins. Journal of the American Oil Chemists' Society 1979;56(3):242-258.
39. Kulkarni, Karuna D, Kulkarni DN, Ingle UM. Sorghum malt-based weaning food formulations: preparation, functional properties, and nutritive value. Food and nutrition bulletin 1991;13(4):1-7.
40. Lee, Seung- Chul. Fluorescent molecular rotors for viscosity sensors. Chemistry–A European Journal 24.52 (2018): 13706-13718.
41. Lewis MJ. Physical Properties of Food and Food Processing Systems' Chichester. Fllis Horwood Ltd 1987, 108-155.
42. Mbaeyi-Nwaoha IE, Uchendu NO. Production and evaluation of breakfast cereals from blends of acha and fermented soybean paste (okara). Journal of food science and technology 2016;53(1):50-70
43. McMacken Michelle, Sapana Shah. A plant-based diet for the prevention and treatment of type 2 diabetes. Journal of geriatric cardiology: JGC 2017;14(5):342.
44. Mishra Poonam, Sanjay Mishra, Charu Lata Mahanta. Effect of maltodextrin concentration and inlet temperature during spray drying on physicochemical and antioxidant properties of amla (Emblicaofficinalis) juice powder. Food and Bioproducts Processing 2014;9(3):252-258.
45. Mitra Sourav, *et al*. Performance evaluation and determination of minimum desorption temperature of a two-stage air cooled silica gel/water adsorption system. 2017;206:507-518.
46. National Dysphagia Diet Task Force, and American Dietetic Association. National dysphagia diet: Standardization for optimal care. American Dietetic Associati 2002.
47. Nguyen DucQuang, Sabah Mounir, Karim Allaf.

Research Article Functional Properties of Water Holding Capacity, Oil Holding Capacity, Wettability, and Sedimentation of Swell-Dried Soybean Powder 2015;3(4):402-412.
48. Niu Qianwen, *et al*. Solvent retention capacities of oat flour. International journal of molecular sciences 2017;18(3):590.
49. NIRO. Analytical Methods for Dry Milk Products. Copenhagen, Denmark: A/S Niro Atomizer - GEA NIRO 1978, 109.
50. Opaliński I, Chutkowski M, Stasiak M. Characterizing moist food-powder flowability using a Jenike shear-tester. Journal of food engineering 2012;108:51-58.
51. Obilana Anthony O, Barthi Odhav, Victoria A. Jideani. "Nutritional, biochemical and sensory properties of instant beverage powder made from two different varieties of pearl millet. Food & nutrition research 2018, 62.
52. Oluwole Oluwatoyin Bolanle, Sulaimon BabatundeK osoko, Samuel Oluwasina Owolabi. Development and Production of High Protein and Energy Density Beverages from Blends of Maize (Zea mays), Sorghum (Sorghum bicolor) and Soybeans (Glycine max) for School Aged Children: Effect of Malting Period on Chosen Proximate Parameters and Sensory Qualities of Developed Beverages. International Journal of Applied Science and Technology 2012;2(7):285-292.
53. Warinporn Klunklin. Geoffrey Savage Physicochemical, antioxidant properties and *in vitro* digestibility of wheat–purple rice flour mixtures Warinporn Klunklin & Geoffrey Savage Original article Physicochemical, antioxidant properties and *in vitro* digestibility of wheat–purple rice flour mixtures Warinporn Klunklin* & Geoffrey Savage
54. Oyarekua MA, Adeyeye EI. Comparative evaluation of the nutritional quality, functional properties and amino acid profile of co-fermented maize/cowpea and sorghum/cowpea Ogi as infant complementary food. Asian Journal of Clinical Nutrition 2009;1(1):31-39.
55. Park Sin-Young, *et al*. Effect of black rice powder on the quality properties of pork patties." Korean journal for food science of animal resources 2017;37(1):71.
56. Reza M Toufiq, *et al*. Hydrothermal carbonization (HTC): Near infrared spectroscopy and partial least-squares regression for determination of selective components in HTC solid and liquid products derived from maize silage. Bioresource technology 2014;161:91-101.
57. Rodríguez-Hernández GR, *et al*. Spray-drying of cactus pear juice (Opuntiastreptacantha): effect on the physicochemical properties of powder and reconstituted product. Drying Technology 2005;23(4):955-973.
58. Sengev IA, Ingbian EK, Gernah DI. Sensory and storage properties of instant kununzaki: a non-alcoholic fermented sorghum beverage supplemented with mango mesocarp flour. Nigerian Food Journal 2010;28(2).
59. Shittu TA, Lawal MO. Factors affecting instant properties of powdered cocoa beverages. Food Chemistry 2007;100(1):91-98. maternal mental health and immunity during lactation. Europian Journal of Nutrition 2007;46:391–396.
60. Sosulski F, *et al*. Functional properties of rapeseed flours, concentrates and isolate. Journal of Food Science 1976;41(6):1349-1352.
61. Sutinium Duangjongkon, VichaiHaruthaithasan, Penkwan Chompreeda. Development of instant nutritious beverage from germinated jasmine brown rice for elderly consumers. Agriculture and Natural Resources 2008;42(1):88-98.
62. Swaminathan, Indhurathna, Manisha Guha. Protein‐ rich instant rice beverage mix and its quality attributes." Journal of food processing and preservation 2018;42:6:e13628.
63. Thomas Rachel, Wan-Nadiah WA, Rajeev Bhat. Physiochemical properties, proximate composition, and cooking qualities of locally grown and imported rice varieties marketed in Penang, Malaysia. International Food Research Journal 2013;20(3).
64. Tonon, Renata V, Catherine Brabet, Míriam D. Hubinger. "Influence of process conditions on the physicochemical properties of açai (Euterpeoleraceae Mart.) powder produced by spray drying. Journal of food engineering 2008;88(3):411-418.
65. Turchiuli Christelle, *et al*. Oil encapsulation by spray drying and fluidised bed agglomeration. Innovative Food Science & Emerging Technologies 2005;6(1):29-35.
66. Tuso Philip J, *et al*. Nutritional update for physicians: plant-based diets. The Permanente Journal 2013;17(2):61.
67. Uppal Veny, Kiran Bains. Effect of germination periods and hydrothermal treatments on *in vitro* protein and starch digestibility of germinated legumes. Journal of food science and technology 2012;49(2):184-191.
68. Vivek Kambhampati, Sabyasachi Mishra, Rama Chandra Pradhan. Characterization of spray dried probiotic Sohiong fruit powder with Lactobacillus plantarum. LWT 2020;117:108699.