Journal of Applied Horticulture, 26(1): 27-32, 2024
https://doi.org/10.37855/jah.2024.v26i01.05
Journal of Applied Horticulture
ISSN: 0972-1045

Characterization of wheatgrass and ripened banana flour blends to evaluate textural properties of biscuits

M.S. Srinivas, K. Rajesh*, P. Supraja, E. Tejaswini, M. Meghana and A. Srihari

College of Food Science and Technology, Acharya N.G. Ranga Agricultural University, Pulivendula, Andhra Pradesh.
**E-mail: k.rajesh@angrau.ac.in*

Abstract

The study was undertaken to develop fortified powder blends of wheatgrass and ripened banana to evaluate the technical properties of flours. The combinations were produced by adding banana powder to the wheatgrass in the combinations of C1 (50W:50B), C2 (25W:75B), C3 (75W:25B), C4 (0W:100B), C5 (100W:0B). The proximate analysis such as moisture content, protein, ash content was reported to be higher in C1 and C2, respectively. Ash content of blend flours ranged between 4.2 to 6.8%, whereas protein was reported between 3.22 to 13.22%. The bulk density and tapped density were reported in the following order: C4>C1>C2>C3>C5 with bulk density values of 0.487, 0.384, 0.317, 0.263 and 0.232 g/cc, respectively. Hausner's ratio ranged from 1.108 to 1.307 across different flours, which fall under fair and passable flow characteristics. A solubility index of 0.16±0.02 g/g was reported for both C2 and C5, represented by 75 and 100% of banana flour, respectively. Biscuits produced from the developed flour blends reported hardness in the order of C3> C1>C2 indicating hard biscuits from blending with a higher proportion of wheatgrass flour. Adhesive force of biscuit samples were 10, 29 and 20 (g) for samples C1, C2 and C3, respectively.

Key words: Ripened banana, freeze drying, biscuits, textural property and solubility index

Introduction

Fruit and vegetable juices have become a part of our diet due to their abundant minerals, vitamins, low energy value and unique taste (Cassano *et al.*, 2003). Banana fruits are the major source of energy-producing carbohydrates, potassium, vitamin B6, vitamin C, dietary fibre, antioxidants and minerals such as calcium, potassium, magnesium, sodium and phosphorus. Many value-added products were made from banana but are limited to production by blending and dehydration. Most of the studies conducted for value-added products from bananas are of unripe and partially ripened stage. After the complete ripening of the banana, limited scope is there for improving shelf life through processing techniques.

On the other hand, freeze drying crystallizes at low temperatures to sublimate from solid to vapour state, favouring better product quality (Liu *et al.*, 2008). It is one of the alternative techniques for temperature-sensitive food products (George and Datta, 2002). Application of freeze-drying technique in food includes tea, coffee, crispy fruits, vegetables, ready-to-eat foods and aromatic herbs. This drying technique can retain the original ingredients intact owing to low temperature.

Cereal grasses are used as healthy food supplements and are becoming popular due to the presence of antioxidants, bioactive compounds, chlorophylls, amino acids, vitamins and enzymes (Rajesh, 2011). It is also called living food because it has the highest chlorophyll content, which contributes 70% of the total chemical constituents. It also exhibits herbal value with therapeutic and healing properties. The challenge of promoting wheatgrass is its bitter taste and unpleasant odour. Incorporating these grasses into palatable processed food would help in addition of beneficial constituents to make the final recipe healthier.

Postharvest loss of banana in the form of over ripening due to market glut leads wastage leading to necessity of techniques for preserving. Starch in banana turns to sugars after ripening, it leads to sticky nature and hinder conventional drying process. Conventional drying techniques use hot air to dry banana and leads to browning of pulp and deposition of air particulate material. In this background, freeze drying of banana could be explored as an alternative to overcome limitations of conventional drying. As the process of removal of moisture from banana is by sublimation, it maintains structure of banana powder after drying.

No attempts are made to bring ripened banana and cereal grass into one product to promote health benefits and mitigate postharvest losses. Hence, the present study is undertaken with an aim of (a) Developing banana powder by using freeze drying technique (b) Evaluation of characteristics of flour blends of wheatgrass and ripened banana and (c) Textural evaluation of developed product from blends.

Materials and methods

Cultivation of wheatgrass and conversion into powder: Wheat seeds were procured from local market of Pulivendula town of Kadapa Dist., Andhra Pradesh, thoroughly washed and soaked in water, followed by tying in plane cloth to provide a congenial condition for sprouting. Sprouted grains were evenly spread on a perforated plastic tray of (400 x 300 mm) as soilless cultivation and placed over a shade net with frequent watering for 7 days. Sprouts grown to 15-20 cm height after 7 days were cut at 10 mm above the root zone. The grass was spread on perforated metal trays and dried using a solar dryer with a temperature between 50 and 60°C. After grass lost sufficient moisture and turned into crispy structures, they were powdered using a heavy-duty mixer. The powder was passed through a 1 mm sieve, packaged in polyethylene pouches, and stored under ambient conditions.

Banana powder preparation: It was reported that (Ahmed *et al.*, 2020) drying of unripe bananas using the hot air oven method was feasible if the banana was taken after 110 days of bunch onset. Hence, ripened bananas (G-9Variety) of 120 days with a deep yellow color were chosen to wash with running water to remove surface adherents. Bananas were peeled and sliced into thin pieces of thickness 5 mm to spread on perforated stainless steel trays. A temperature of 50-60^{o}C was maintained in hot air oven by following the experimental protocol reported by (Ahmed *et al.*, 2020) for 10 h. Slices were found to be brown and sticky with deformed structure after completion of hot air drying. Hence, the drying method by hot air oven was set aside and freeze-drying was adopted. Slices of banana (5 mm) were placed on freezer plates and kept in a deep freezer for 6 h (to facilitate pre-freezing). After pre-freezing, plates were carefully accommodated in freeze dryer platform and confined with air seal enclosure, by maintaining the freezing temperature of -40^{o}C slices were freeze-dried (Lyodel, M/s Delvac Pumps Pvt LTD, Thirumudivakkam, Chennai) for ten h. No significant colour change was noticed after freeze drying. Hence, the slices were removed from the plate and ground to powder to pass through a 0.5 mm sieve before packing in an airtight glass container (stored at refrigerated conditions -2 to -4^{o}C).

Incorporation of wheatgrass and banana flour in food product: Numerous products were developed or tried using banana flour to replace conventional ingredients. Juices, instant powders and baby-weaning foods were identified as foods to incorporate wheatgrass and banana powder. However, preliminary studies showed that juices and weaning baby foods were found to be bitter and non-palatable to consume despite adding sweeteners. Hence, it was decided to blend two flours in different proportions to prepare fortified biscuits with regular ingredients.

Ranjana *et al.* (2000) incorporated 20% defatted soy flour with regular ingredients to report better product digestibility. Since, banana flour is a non-hindering agent for taste, digestibility and other organoleptic properties hence, wheatgrass powder and banana flour proportions were varied to compare biscuit properties. Table 1 is enlisted with ingredients, proportions, and ratio of two fortified flours in the study. The wheatgrass and banana powder were mixed in proportions (wheatgrass powder %: banana powder %) as C_1-50:50, C_2-15:35, C_3-35:15. Based on proportion weights, jaggery and shortening were whipped. Wheat flour, combinations of fortified powders, baking powder and baking soda were sieved and kneaded together with milk to form dough. Prepared dough was flattened with the help of a traditional wooden roller known as "*Belan*" to a thickness of 5 mm. Circular shapes of size 6 cm dia were cut from flattened dough with the help of steel mould. Circular dough sheets were kept in a tray and placed in a microwave oven, maintaining a temperature of 180°C for 25 min. Baked biscuits were cooled, packed and sealed in polyethylene bags before evaluation of various textural properties.

Compositional analysis: Moisture content of fortified powder and biscuits were determined by (Horwitz and Latimer, 2005). To determine ash content, the sample of 2.5g was used to expose the sample in a muffle furnace by following Horwitz and Latimer (2005). Protein content of sample was quantified by the kjeldahl technique with a conversion factor of 6.25. pH of the samples were measured by following the method reported by Gbadegesi *et al.* (2017), where 10% (w/v) suspension was prepared to measure by pH meter (M/s Henna checker H17007L) after calibration.

Table 1. Blends of flour and other ingredients used in making of biscuits

Ingredients	Quantity (g)
Wheat flour	50
Wheatgrass powder	C_1-25, C_2-15, C_3-35
Banana powder	C_1-25, C_2-35, C_3-15
Jaggery	40
Milk	5
Shortening agent	10
Baking powder	1
Baking soda	0.5

Textural profile analysis: Biscuit analysis was instrumentally conducted using a Brookfield texture analyzer (Model CT3, Middleboro, USA). The instrument was designed with 10 kg load cell with different probes for measurement of textural properties of food products. A cylindrical probe of (diameter 4 mm cylindrical/TA44) was used with 5 mm target distance test conditions, one mm/s test and post-test speed with trigger load 7 g. Texture Pro CT V1.6 software (M/s Brookfield Engineering Labs) was deployed to assess textural attributes.

Colour of samples: The colour of fortified powders and biscuits was measured by a Hunter Lab Colour meter (M/s Colorflex, 45/0, HunterLab Reston, VA, USA). Before measuring sample colour, the instrument was calibrated using a standard white plate followed by a black plate as described in user manual. Instrumental values L*, a* and b* indicate lightness, redness/greenness, and yellowness/blueness, respectively.

Bulk density and water solubility index: Different blends of wheatgrass and banana flour were analysed for bulk density by pouring flour into a measuring glass cylinder. Mass to volume ratio was measured to express bulk density on g/cc. The measuring cylinder was tapped 120 times before reporting tapped density to obtain tapped density. Bulk and tapped density of flours were used to calculate Hausner's ratio (HR) as a ratio of tapped density to bulk density (Gulsah and Nur, 2016).

The water solubility index (WSI) was calculated by following the method of Sabhadinde (2014). Blended powder mix (2.5g) was added with 30 mL of distilled water, followed by centrifugation at 2500 rpm for 30 min. Supernatant from centrifuge tubes was carefully decanted into a tarred beaker to dry and calculated WSI as

$$WSI = \frac{\text{Weight of sample in supernatent (g)}}{\text{Weight of sample (g)}}$$

Sensory evaluation: The sensory attributes of developed biscuits were evaluated with expert panel members. After every sample scoring, biscuit samples were served to panel members with coded identities and tasted for organoleptic properties by rinsing tongue with purified water.

Statistical analysis: All experiments were conducted in triplicates (n=3) and mean values were reported with standard deviation.

Minitab 18 (Minitab Inc., State College, Pennsylvania, 193 USA) was used to calculate significant differences among samples by Tukey's test.

Results and discussion

Ash, protein and pH values of flour blends: The ash content of ripened banana flour is slightly higher than wheatgrass flour. However, the two samples showed no significant difference (P<0.05). Blends of wheatgrass and ripened banana flour were reported to have slightly higher values (Table 2). This trend could be attributed to the proportional representation of different kinds of flours in analysed sample. The protein content of blends was reported to be very low in raw banana flour than ripened banana. Campuzano *et al.* (2018) reported 3.69 to 5.52% of the protein in banana ripening stages due to down-regulation of enzymes in the climacteric peak and post-climacteric period (Toledo *et al.*, 2012).

Table 2. Proximate composition and moisture content of blends prepared by wheatgrass and banana powder

Sample	Moisture (%)	Ash (%)	Protein (%)	pH
C1	10.70±0.20^{a}	5.6±0.62^{b}	13.25±0.85^{a}	6.9±0.9^{bc}
C2	9.60±0.20^{a}	6.8±0.46^{a}	12.2±0.8^{a}	6.7±0.2^{bc}
C3	10.01±0.51^{a}	4.2±0.2^{c}	8.24±0.26^{b}	7.7±0.6^{ab}
C4	7.00±1.00^{b}	5.2±0.2^{bc}	3.22±0.2^{c}	5.7±0.3^{c}
C5	5.51±0.49^{b}	4.6±0.45^{bc}	12.5±0.5^{a}	8.5±0.5^{a}

C1=50W:50B; C2=25W:75B; C3=75W:25B; C4=0W:100B and C5=100W:0B. *The same alphabets in the column indicate no significant difference (P<0.05) by Tukey's test

While evaluating wheatgrass powder Ghumman *et al.* (2017) reported 7.55% to 18.51% of protein content among two varieties evaluated in study. Results reported for banana and wheatgrass powders are in agreement with values reported in previous works. Different flour blends reported slightly better values at C1 and C2; however, the C3 sample reported the lowest value. pH values were slightly acidic for banana flour and basic for wheatgrass samples. Blends of flours with different proportions reported nearly neutral values for pH and no significant difference was observed between C1 and C2 (P<0.05).

Moisture content and solubility index of flour blends: Freeze-dried flour of banana and solar-dried wheatgrass powder reported lesser moisture content compared to blends. No significant difference was reported between the moisture content of banana and wheatgrass flour at P<0.05 (6-7% for banana flour; 5.02-6% for wheatgrass powder). Pardeshi *et al.* (2013) reported 4.36, 7.65, 2.81, 6.39 and 3.94% moisture content in wheatgrass powder by sun drying, shade drying, forced air solar drying, solar drying with natural drift, forced air shade drying, respectively. Juarez *et al.* (2006) reported 7.1% moisture content in unripe banana flour by gravimetric method. Values of moisture reported for both flour blends are corroborating to data reported in previous research work. However, blends prepared in different proportions showed slightly higher moisture content values (Table 2). This could be due to moisture absorption by both kinds of flours while blending.

Bulk density, tapped density and Hausner's number of flour blends: The bulk density of ripened banana flour is significantly higher than that of wheatgrass flour (P<0.05). Interestingly, 50:50 blends of banana and wheatgrass flour reported higher bulk density values than the other two blends with a mean value of 0.384 (g/cc) (Table 3). However, blends of ripened banana and wheatgrass flour in the remaining two blends showed no significant difference (P<0.05).

Table 3. Bulk density, tapped density and Hauser's ratio of blends of banana and wheatgrass flour

Sample	Bulk density	Tapped density	Hausners ratio
C1	0.384±0.036^{b}	0.476±0.066^{ab}	1.239±0.246^{a}
C2	0.317±0.017^{bc}	0.377±0.037^{bc}	1.189±0.053^{a}
C3	0.263±0.013^{cd}	0.344±0.006^{c}	1.307±0.087^{a}
C4	0.487±0.034^{a}	0.54±0.040^{a}	1.108±0.160^{a}
C5	0.232±0.032^{d}	0.285±0.029^{c}	1.228±0.045^{a}

C1=50W:50B; C2=25W:75B; C3=75W:25B; C4=0W:100B and C5=100W:0B. *Different alphabets in each column indicates significant difference by Tukey's test (P<0.05)

Suntharalingam and Ravindran (1993) reported 0.5 g/mL as bulk density while working with two varieties of green banana flour. Similarly, Falade and Oyeyinka (2015) reported 0.535, 0.308 and 0.447 g/mL as loose density for yellow and ripened banana flour by oven, foam mat and sun drying, respectively. The author also reported that the loose and packed density of dried commodities decreases with increase in maturity. Values reported for banana flour by freeze-drying are nearly equal to those reported in previous reports by other drying techniques. A similar trend was observed for tapped density of banana flour (Table 3). Tapped density was highest in ripened banana flour with 0.54 g/cc, which agrees with values reported by Falade and Oyeyinka (2015) for packed density between 0.36 and 0.537 g/mL across different drying methods. Blends of flours did not follow any trend; this might be due to the interaction of two flours leading to different orientations of particulate material while measuring bulk and tapped density. Samples of C2 and C3 did not show any significant difference among each other for both bulk and tapped density. However, samples with equal proportion of flour blends (C1-50:50) showed significantly higher values compared to the other two blends.

For wheatgrass powder, no work has been reported to identify bulk or tapped flour density. Bulk and tapped density of wheatgrass powder was 0.232±0.032 and 0.285± 0.029 g/cc, respectively. Both the values are significantly different from that of ripened banana flour. Lower density values of flour can also be related to the moisture content of flour. As wheatgrass flour reported lower values among different blends, this could have contributed to less cohesion between particles.

Hausner's ratio is useful in the classification of flour for flow characteristics under different categories. A higher proportion of ripened banana flour in blends was reported with a higher value for Hausner's ratio. Values of Hausner's ratio ranged from 1.108 to 1.307 across different flours studied (Table 3). Evaluated blends fall under the category of fair and passable flow characteristics which is useful in flour movement. Alam *et al.* (2023) reported 1.13±0.05 to 1.16±0.00 for two banana cultivars by different drying methods. The values reported in the present study agree with studies Alam *et al.* (2023) reported for ripened banana flour. Also, it is noted that decreased powder size will increase the value of Hausner's ratio due to inter-particle size and van der Walls force.

Water solubility index of banana and wheatgrass flour: The water solubility index determines the amount of polysaccharides released from the granule by adding excess water. It depends on the fragmented particles' semi-crystalline structure and starch granules' disruption. Solubility index values were better in flours with higher ripened banana flour proportions than wheatgrass powder. A solubility index of 0.16±0.02 g/g was reported for both C2 and C5, represented by 75 and 100% of banana flour, respectively.

Table 4. Solubility index and color values of ripened banana and wheatgrass flour blends

Sample	Solubility index (g/g)	L*	a*	b*
C1	0.12±0.02^{a}	68.92±0.92^{b}	-5.83±0.17^{cd}	25.26±1.26^{b}
C2	0.16±0.02^{b}	65.23±0.73^{bc}	-4.69±.37^{b}	21.05±0.95^{c}
C3	0.08±0.01^{ab}	65.23±0.86^{bc}	-5.28±0.22^{bc}	27.15±1.65^{b}
C4	0.16±0.02^{a}	89.99±2.97^{a}	0.11±0.01^{a}	11.61±0.49^{d}
C5	0.05±0.04^{b}	64.52±0.30^{c}	-6.24±0.19^{d}	36.21±0.58^{a}

C1=50W:50B; C2=25W:75B; C3=75W:25B; C4=0W:100B and C5=100W:0B. *Different alphabets in each column indicates significant difference by Tukey's test ($P<0.05$)

Savlak *et al.* (2016) worked on unripe banana flour of different particle sizes and reported water solubility index as g soluble flour/ g dry flour. The study reported 0.074±0.00 to 0.091±0.019 g soluble flour/ g dry flour for samples with particle sizes of >212 to 501-700 µm (Table 4). Authors opined that a higher solubility index is due to the availability of free molecules to leach from starch granules in addition to excess water. Higher values of ripened banana flour solubility index can be attributed to better soluble compounds than wheatgrass flour. While reporting the water solubility index of unripe *Luvhele* cultivar banana flour with different pre-treatment, Anyasi *et al.* (2017) reported a value of 0.02 to 0.17 (g/g). Ripened banana flour reported slightly higher values for solubility index due to its controlled drying under freeze drying. Bala *et al.* (2020) reported 9.7 to 19.5% water solubility values of grass peas of different particle sizes. However, no work has been reported to establish wheatgrass powder's water solubility index.

Colour values of banana and wheatgrass flour: Colour values of ripened banana and wheatgrass flour produced by freeze-drying and hot air oven drying, respectively, are depicted in Table 4. All samples reported L* values above 60, indicating a slightly whiter colour of samples. Among the tested samples, banana flour reported the highest value for L*, indicating brighter than blends and wheatgrass flour. Wheatgrass flour reported the lowest values among the samples with L* value of 64.82 whereas, banana and wheatgrass flour blends did not show any significant difference (p>0.05).

Kumar *et al.* (2019) worked with different banana cultivars and studied green banana flour's color properties. Across different varieties studied, L*>80 was reported in the study, indicating colour value towards lighter colour. However, ripened banana flour is darker as biochemical changes turn the pulp color slightly creamy. Excluding ripened banana flour, all other flours showed negative values for a*, indicating a greenish colour feature. These values agree with results reported by Campuzano *et al.* (2018), who reported colour values of banana flour during different ripening stages dried by hot air. Blends with a relatively higher proportion of banana flour were inclined towards zero, whereas other flours retained values as wheatgrass flour. The slightly reddish colour of banana flour could be attributed to biochemical changes during ripening. In the case of b* value, all samples reported >20 values excluding banana flour, indicating yellowness in flour. Wheatgrass flour influenced the blends by its yellow nature in samples. Wheatgrass flour b* colour values agree with muffins prepared by fortifying in different proportions (Rehman *et al.*, 2015).

Moisture content and colour values of biscuits prepared by blends of ripened banana and wheatgrass flour: Moisture content of biscuits prepared by equal proportion of wheatgrass and ripened banana flour was significantly higher than other blends (Table 5). This could be due to interaction effect of flours with wheat flour, which resulted in the binding of moisture content in the biscuit structure. In a study by Wang *et al.* (2012), there was no significant change in the moisture content of crackers with different proportions of green banana flour. A similar trend can be seen in this study for samples C2 and C3 where biscuits showed no significant difference.

Table 5. Moisture content and colour values of biscuits with different blends

Sample	Moisture content	L*	a*	b*
C1	6.4±0.52^{a}	40.23±2.50^{b}	5.76±0.24^{a}	25.59±0.91^{b}
C2	4.33±0.33^{b}	48.18±3.08^{a}	4.01±0.04^{b}	33.98±0.52^{a}
C3	4.31±0.31^{b}	38.8±1.97^{b}	2.41±0.29^{c}	26.03±1.03^{b}

C1=50W:50B; C2=25W:75B; C3=75W:25B. *Different alphabets in each column indicates significant difference by Tukey's test ($P<0.05$)

Lighter colour was observed in biscuit samples with a higher proportion of banana flour over other samples (Table 5). No significant difference was noticed between samples C1 and C3 with L* values between 38 and 40 ($P<0.05$). With the increase in the proportion of green banana flour, a decrease in whiteness was observed by Mabogo *et al.* (2021). The study inferred that drying of banana slices led to brown colour in flour which subsequently carried to the composition of biscuits. Similar observations can be attributed to change in biscuits' color values prepared with different proportions of ripened banana flour. However, effect of freeze drying had led to milder colour change than compared to oven dried samples. Values of b* reported in present study *i.e.*, 25.59 to 33.98 is slightly higher that values reported by Mabogo *et al.* (2021). Higher b* value indicates yellowness in biscuit samples which would be due to change in colour of banana pulp to creamy during ripening. Colour values of a* is in agreement with the previous study with values ranging from 2.41 to 5.76.

Texture profile analysis of biscuits prepared by banana and wheatgrass flour: Textural profile of food product indicates various attributes which are beneficial in design of any food formulation. Hardness of biscuit is one of the important attribute of biscuits which governs biting difficulty by consumer. The order of hardness in increasing order is $C_3 > C_1 > C_2$ indicating hard biscuits from blend with higher proportion of wheatgrass flour. Hardness (g) values of C1, C2 and C3 were reported as 675, 545 and 4075, respectively.

Végh *et al.* (2023) replaced wheat flour with pollens of rapeseed, phacelia and sunflower for the production of biscuits. The

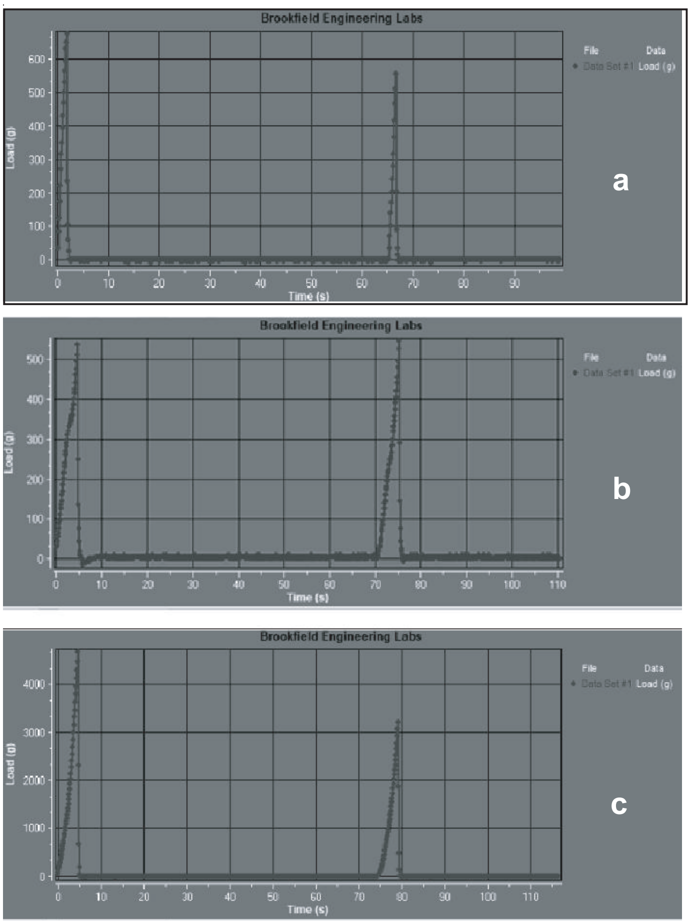

Fig.1 Textural profile of biscuits developed by blends of banana flour and wheatgrass flour (a) C1 (50:50- wheatgrass flour: banana flour) (b) C2 (25:75- wheatgrass flour: banana flour) (c) C3 (75:25- wheatgrass

hardness of resultant biscuits was reported as 196 to 457 (g) across different proportions of replacers. Biscuits prepared with a larger proportion of wheatgrass flour were hard compared to blends of banana flour. The cellulose structure of wheatgrass in flour could have made the biscuit texture harder. The adhesive force of biscuit samples was 10, 29 and 20 for samples C1, C2 and C3, respectively. A higher proportion of banana flour in the C2 sample also led to the adhesiveness of biscuit samples due to the gummy nature of banana flour after water addition in dough formation. The values of adhesive forces are far lower than biscuit samples reported by Végh *et al.* (2022) for replacing wheat flour.

Freeze-dried banana flour and blends from wheatgrass powder were analysed for physical and functional properties. Blends fortified with wheatgrass flour will give an idea of the behaviour of flours in the food industry. Besides, biscuits prepared by combinations of flour were analysed for textural and physical properties to assess the suitability of flour for bakery products. Available information on flour and blends will help food designers include in their processing equipment design for better output.

Acknowledgments

The authors thank College of Food Science and Technology, Pulivendula, Acharya N.G. Ranga Agricultural University, for providing infrastructure and logistical support to execute the experimental plan. Special thanks to The Associate Dean of the college for intervening to supply men and material for conducting experiments.

References

Ahmed, J., L. Thomas and R. Khashawi, 2020. Influence of hot-air drying and freeze-drying on functional, rheological, structural and dielectric properties of green banana flour and dispersions. *Food Hydrocoll.,* 99: 1-10.

Alam, M., M. Biswas, M.M. Hasan, M.F. Hossain, M.A. Zahid, M.S. Al Reza and T. Islam, 2023. Quality attributes of the developed banana flour: Effects of drying methods. *Heliyon*, 9: 1-10.

Anyasi, T.A., A.I. Jideani and G.R. Mchau, 2017. Effects of organic acid pretreatment on microstructure, functional and thermal properties of unripe banana flour. *J. Food Meas. Charact.*, 11: 99-110.

Bala, M., S. Handa, D. Mridula and R.K. Singh, 2020. Physicochemical, functional and rheological properties of grass pea (*Lathyrus sativus* L.) flour as influenced by particle size. *Heliyon*, 6: 1-10.

Campuzano, A., C.M. Rosell and F. Cornejo, 2018. Physicochemical and nutritional characteristics of banana flour during ripening. *Food Chem.,* 256: 11-17.

Cassano, A., G. Galaverna, R. Marchelli and E. Drioli, 2003. Clarification and concentration of citrus juices by integrated membrane processes. *J. Food Eng.,* 57(2), 153-163.

Falade, K.O. and S.A. Oyeyinka, 2015. Color, chemical and functional properties of plantain cultivars and cooking banana flour as affected by drying method and maturity. *J. Food Process. Preserv.,* 39: 816-828.

George, J.P. and A.K. Datta, 2002. Development and validation of heat and mass transfer models for freeze-drying of vegetable slices. *J. Food Eng.*, 52: 89-93.

Ghumman, A., N. Singh and A. Kaur, 2017. Chemical, nutritional and phenolic composition of wheatgrass and pulse shoots. *Int. J. Food Sci. Technol.,* 52: 2191-2200.

Gulsah, C. and S.D. Nur, 2016. The effect of different drying processes and the amounts of maltodextrin addition on the powder properties of sumac extract. *Powder Technol.,* 287: 308-314.

Horwitz, W. and G.W. Latimer, Jr. 2005. Official Methods of Analysis of the Association of Official Analytical Chemists International. Eighteenth Edition. North Frederick Avenue, Gaithersburg, Mary Land, USA.

Juarez, E., E. Agama, S.G. Sáyago, S.L. Rodriguez and L.A. Bello, 2006. Composition, digestibility and application in bread making of banana flour. *Plant Foods Hum. Nutr.,* 61: 131-137.

Kumar, P.S., A. Saravanan, N. Sheeba and S. Uma, 2019. Structural, functional characterization and physicochemical properties of green banana flour from dessert and plantain bananas (*Musa spp.*). *LWT - Food Sci. Technol.,* 116: 1-12.

Liu, Y., Y. Zhao and X. Feng, 2008. Exergy analysis for a freeze-drying process. *Appl. Thermal Eng*., 28: 675–690.

Mabogo, F.A., M.E. Mashau and S.E. Ramashia, 2021. Effect of partial replacement of wheat flour with unripe banana flour on the functional, thermal and physicochemical characteristics of flour and biscuits. *Int Food Res J.*, 28:138-147.

Pardeshi, I.L., R.G. Burbade and R.N. Khod, 2013. Cost effective drying for high quality tender wheatgrass powder. *J. Food Technol. Res.,* 1: 1-10.

Rahman, R., S. Hiregoudar, M. Veeranagouda, C.T. Ramachandra, M. Kammar, U. Nidoni and R.S. Roopa, 2015. Physico-chemical, textural and sensory properties of muffins fortified with wheatgrass powder. *Karnataka J. Agric. Sci.*, 28:79-82.

Rajesh, M. 2011. A study on wheatgrass and its nutritional value. *Food Sci. Qual.,* 2: 1-8.

Ranjana, S., S. Gurmukh and G.S. Chauhan, 2000. Nutritional evaluation of soy fortified biscuits. *J. Food Sci. Technol.,* 37: 162-164.

Sabhadinde, V.N. 2014. The physicochemical and storage properties of spray-dried orange juice powder. *Ind. J. Fundam. Appl.,* 4:153-159.

Savlak, N., B. Türker and N. Yeşilkanat, 2016. Effects of particle size distribution on some physical, chemical and functional properties of unripe banana flour. *Food Chem.,* 213: 180-186.

Suntharalingam, S. and G. Ravindran, 1993. Physical and biochemical properties of green banana flour. *Plant Foods Hum. Nutr.,* 43: 19-27.

Toledo, T.T., S.B. Nogueira, B.R. F.C. Cordenunsi, Gozzo, E.J. Pilau, F.M. Lajolo and J.R.O. do Nascimento, 2012. Proteomic analysis of banana fruit reveals proteins that are differentially accumulated during ripening. *Postharvest Biol. Technol*., 70, 51-58.

Vegh, R., M. Csoka, E. Stefanovits-Banyai, R. Juhasz and L. Sipos, 2023. Biscuits enriched with monofloral bee pollens: nutritional properties, techno-functional parameters, sensory profile, and consumer preference. *Foods,* 12: 1-21.

Wang, Y., M. Zhang and A.S. Mujumdar, 2012. Influence of green banana flour substitution for cassava starch on the nutrition, color, texture and sensory quality in two types of snacks. *LWT - Food Sci. Technol.,* 47: 175-182.

Received: December, 2023; Revised: January, 2024; Accepted: February, 2024