Research Article

Nutritional, Textural, and Sensory Quality of Aloe Vera Leaf Gel Powder Fortified Plain Cake

Dhrubajyoti Singha[1], Md. F. Jubayer[2*], Kumkum Devanath[1], Delara Akhter[3], Thottiam V. Ranganathan[4], Md. T. Rahman[5], Md. A. R. Mazumder[1*]

[1]Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[2]Department of Food Engineering and Technology, Sylhet Agricultural University, Sylhet-3100, Bangladesh
[3]Department of Genetics and Plant Breeding, Sylhet Agricultural University, Sylhet-3100, Bangladesh
[4]Department of Food Processing Technology, School of Agriculture and Bioscience, Karunya Institute of Technology and Sciences, Coimbatore-641114, Tamil Nadu, India
[5]Bangladesh Civil Service (Administration), Lalmonirhat, Bangladesh.

* Correspondence: Md. F. Jubayer, fahadbau21@hotmail.com; jubayer.fet@sau.ac.bd; Tel.: +8801876529642; Md. A. R. Mazumder, anis_engg@bau.edu.bd; Tel.: +8801754146914

Abstract: Aloe Vera leaves have a great potential as an economic supplement with an adequate nutritional profile. In this study, Aloe Vera leaf gel (AVG) powder was used to fortify plain cakes. Freeze drying of AVG was performed for the production of Aloe Vera powder (ALP) and four plain cakes were prepared with different proportions of ALP for further investigation. Analysis suggested that ALP contained significantly ($p<0.05$) higher amount of protein (22.23 vs 12.24), ash (19.83 vs 0.64) and iron (175 vs 3.05) content than refined wheat flour (RWF). ALP also contained significant amount of total polyphenols and antioxidant. Moisture, protein, ash, weight, and minerals (Fe, Ca) content were higher ($p<0.05$) in ALP-cakes; whereas fat, volume, specific volume, height, baking loss, and total carbohydrate content were higher ($p<0.05$) in RWF-cakes. Incorporation of 6 and 8% ALP in the formulation increased the total polyphenols and anti-oxidant activity in plain cakes. Texture analysis revealed that hardness and chewiness increased in ALP-cakes but decreased in RWF-cakes, however, cohesiveness, springiness, and chewiness decreased in ALP-cakes. Sensory attributes suggested that 4% ALP incorporated cake was attributed as the best formulation. In conclusion, ALP can be supplemented in cakes up to 8% to improve the nutrient value.

Keywords: Aloe Vera; cake; minerals; polyphenol; antioxidant; texture.

1. Introduction

Aloe Vera has long been recognized as a natural product and has been well known for its herbal, medicinal, beauty and skin care properties for centuries [1]. The plant has fleshy leaves with three-sides, yellow flowers and fruits containing plenty seeds. Aloe Vera leaf contains 75 potentially active elements, including vitamins, minerals, enzymes, lignin, saponins and amino acids, etc. [2]. These characteristics make it one of the most nutrient-rich plants ever discovered. For these varieties of benefits it is widely used in food, pharmaceutical, and cosmetic industries. It can also be used as natural additives and preservatives in foods [3,4].

Bakery items such as bread, cakes, cookies etc. are consumed on a daily basis in vast amounts across the world and play an important role in human

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 15 June 2021 doi:10.20944/preprints202106.0395.v1

nutrition [5]. Among the different bakery products, cake is a popular and palatable item that is consumed and favored by people of all ages. Cakes have different shapes, colors, flavors, and sizes. Products have been made using a few basic ingredients, including flour, sugar, baking powder, eggs, butter, etc. [5]. Research revealed that Aloe Vera has potential application as a bio-preservative in various food products such as bakery, beverage, confectionary and dairy, etc. It acts as an enhancer of food quality parameters. It also acts as a hydrocolloid that further helps to confirm the rheological properties and texture of food products [6]. Chopra, 2017 have mentioned the use of Aloe Vera gel as a fat substitute in the preparation of low fat cream cakes as a healthy option for overweight and obese people [7].

Wheat flour is one of the main ingredients used for the production of cake. The use and fortification of wheat flour is of great importance to modern food science and technology. The partial or complete substitution of wheat flour is always desirable to improve the nutritional value of the product. Substitution of wheat flour with other flours is stated to boost the functional and nutritional properties of bakery products [8,9,10,11]. Aloe Vera leaves powder (ALP) can be obtained after the grinding of the aloe gel [12]. Considering all nutritional components, ALP can be considered a fine substitute for a small proportion of wheat flour in the production and manufacturing of plain cakes. In addition, a thin coating of Aloe Vera gel can function as a regular food preservative. Therefore, this study aims to investigate the nutritional, textural, and sensory quality of ALP incorporated plain cakes.

2. Materials and Methods

2.1 Raw materials

Aloe Vera was collected from M/S Kawser's Horticulture farm, Natore, Bangladesh. Refine wheat flour was purchased from super market, Mymensngh, Bangladesh and Aloe Vera leaf powder (ALP) was prepared in the laboratory.

2.2 Preparation of ALP

Fresh, undamaged leaves of the Aloe Vera were sorted and washed thoroughly with clean water to remove all dirt. The water was drained for the removal of all latex as excessive intake of latex may cause the adverse effect. All the latex (middle layer) was removed by making a cross sectional cut in the bottom side of the leave and kept for 30 min. Outer layer of the leave was removed by knife. The Aloe Vera gel was soaked in 100 ml of 2% citric acid solution for 10 min and washed using running water. Again, the gel was soaked in 100 ml of 2% ascorbic acid solution for 15 min to avoid enzymatic browning. Aloe Vera powder was prepared by freeze drying process. The gel was pre-frozen at -20ºC for 2 hr followed by lyophilized at -88ºC and 0.01 mm Hg pressure and 0.01 mm Hg pressure for 60 hr to get dried gel fillet. Later is then ground (Panasonic Mixer Grinder MX-AC555, India) to get aloe Vera powder (ALP) with moisture content 4% [12].

2.3 Functional properties of ALP and refined wheat flour (RWF)

2.3.1 Bulk density (g/cm3)

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 15 June 2021 doi:10.20944/preprints202106.0395.v1

Five (5) g of each sample was placed in a 100 ml measuring cylinder and calculated by dividing the mass of the flour by volume occupied in the cylinder [13].

2.3.2 Foaming capacity

Fifty (50) ml of distilled water was added with 2 g of sample and shaken well to form a foam. Foaming capacity is known as the formation and elevation of foam (ml) after mixing of ALP and RWF and distilled water [13].

2.3.3 Water absorption capacity (WAC)

Ten (10) g of sample and water was mixed to obtain stiff consistent dough. The amount of water required was noted as water absorption capacity [14].

$$\textbf{Water absorption capacity (g/g)} = \frac{\textbf{Weight of water (g)}}{\textbf{Weight of sample (g)}} \times 100$$

2.3.4 Oil absorption capacity (OAC)

Oil absorption capacity was determined following the procedure of Tasnim et al. [10]. Oil absorption capacity was calculated as follows.

$$\textbf{Oil absorption capacity (g/g)} = \frac{\textbf{Weight of sample after centrifuge (g)} - \textbf{Weight of sample before centrifuge (g)}}{\textbf{Weight of sample (g)}} \times 100$$

2.3.5 Swelling of flour and solubility

One (1) g sample was taken in a 50 ml centrifuge tube. Ten (10) ml of distilled water was added to the tube and mixed properly. The mixer was heated at 80˚C for 30 min in a shaking water bath (Schufzart, MembartGmBH+ Co., Bϋchenbach, Germany). The tubes were dry and cooled at room temperature (30±2˚C) after removing from the water bath. The mixer was centrifuged at 542 g force for 15 min. Finally, the supernatant was evaporated and dried residue was weighted to determine the solubility.

$$\textbf{Solubility (\%)} = \frac{\textbf{Weight of dried sample in supernatant}}{\textbf{Weight of sample}} \times 100$$

Swelling power of ALP was determine by decanting the supernatant and weighted.

$$\textbf{Swelling} = \frac{\textbf{Weight of wet mass in sediment}}{\textbf{Weight of dried matter in gel}} \times 100$$

2.3.6 Particle size analysis of mix flour (ALP and RWF) and RWF

The analysis of particle size was determined by adopting modified method of Agrahar-Murugkar et al. [15]. AVerage particle size (d3,2 – Surface weighted Mean Diameter – Sauter Mean Diameter and d4,3 – Volume Weighted Mean Diameter – De Brouckere Mean Diameter) of 2, 4 and 6% Aloe Vera flour plus refined wheat flour were determined by particle size analyzer (Malvern Zetasizer Nano Zs, UK).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 15 June 2021 doi:10.20944/preprints202106.0395.v1

2.4 Preparation of ALP fortified plain cakes

The basic formulation for plain cakes (multi-stage mixing) and ALP fortified cakes is the same except for wheat and ALP percentage, as shown in Table 1. Four cake samples were prepared by partial substitution of RWF with different percentage of ALP (0, 4, 6 and 8%) in the basic formulation of cake. The RWF, ALP, and other ingredients for each cake sample were weighed accurately. The RWF and different percentage of ALP were mixed together. Then sugar (90 g), oil (60 g) and butter (20 g) were mixed in a mixer machine for 20 min to produce a cream. 60g of egg, baking powder, skim milk powder and salt were added mixed flour and mixed well for 10 min at low speed (150 rpm) to ensure that the components were evenly distributed. Then another 60 g of egg and vanilla essence (2 drops) was added to the mixer and stirred at medium speed (250 rpm) for 5 min to make proper cake batter. A portion of butter (3 g) was then scaled to a pre-oiled cake bowl. All cakes were baked in the oven at 170°C for 45 min.

Table 1. Basic formulation for the preparation of plain cakes (on 100g flour basis)

Ingredients	Sample			
	Control formulation	ALP incorporated formulation		
	S_4	S_3	S_2	S_1
RWF (g)	100	96	94	92
ALP (g)	0	4	6	8
Sugar (g)	90	90	90	90
Oil (g)	60	60	60	60
Butter (g)	20	20	20	20
Baking powder (g)	4	4	4	4
Skim milk powder (g)	25	25	25	25
Salt (g)	2	2	2	2
Egg (g)	120	120	120	120
Vanilla essence (drops)	2	2	2	2

RWF, refined wheat flour; ALP, Aloe Vera leaf powder

2.5 Proximate composition analysis

Moisture and proximate composition of ALP and plain cakes were determined using 2019 published guidelines and methods of AOAC: moisture content 950.46 [16], crude protein 981.10 [17], crude fat 922.06 [18] and ash 920.153 [19]. Total carbohydrate content of ALP and cake was determined according to methods of FAO [20]. Mineral content of ALP and cakes were determined according to the modified method describe by Poitevin [21]. Mineral content of ALF and cakes were determined according to the modified method describe by Poitevin [21]. Solution (30 ml) of HNO3 and HCLO4 was prepared in a mass ratio of 2:1 to 1.5 g Acheta domesticus powder in a Kjedhal flask. The solution was stand for 24 h. Water (H2O) and HNO3 were removed by slowly boiling of the solutions. Perchloric acid (HCLO4) was added to solution and after cessation of everescent reaction. The test portion was cooled at room temperature (28±2ºC). The solution was transferred to volumetric flask (50 ml)

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 15 June 2021 doi:10.20944/preprints202106.0395.v1

and volume made by distilled water. Iron (Fe). Potassium (k) and calcium (Ca) were analyzed with an inductively with an ICP (inductively coupled plasma) emission spectrophotometer.

2.6 Total polyphenol assay

The total polyphenol content of the ALP and plain cakes was determined using the Folin-Ciocalteu method [22]. Ten (10) mg of ALP and finely ground plain cakes was dissolved in in 200 µl of H2O. 1 ml of Folin-Ciocalteu's reagent was added to the mixer and allows standing for 10 min at room temperature. 0.8 ml of Na2CO3 (7.5% w/v) was added to the mixer and mixed properly. The mixer was allowed to stand for 30 min. Absorption (PerkinElmer, Lambda 25, UV/ VIS spectrophotometer) was measured at 765 nm. The total phenolic content was measured as mg of gallic acid equivalents per 100 g of wet and dry mass [23].

2.7 Total flavonoid assay

Total flavonoid content of ALP was measured using modified method described by Marinova et al. [24]. 10 mg of ALP was dissolved in 1 ml of distilled water and mixed. 60 µl NaNO2 (5% w/v) was added to the mixer and rested for 5 min. 60 µl AlCl3 (10% w/v) was added and settled for 6 min. 400 µl NaOH (1M) was added and volume made up to 2 ml with distilled water. The solution was mixed well and absorption (PerkinElmer, Lambda 25, UV/ VIS spectrophotometer) was measured at 510 nm against reagent blank. Concentrations were measured using catechin stand curve and total flavonoid was expressed as mg of catechin equivalent (CE) per 100 g of wet and dry mass [23].

2.8 Oxygen radical absorbance capacity (ORAC)

In 200 µl methylated β-cyclodextrin solution, 56 nM fluorescein was added followed by addition of 240 nM 2,2′-azobis (2-amidinopropane) dihydrochloride. A Microplate reader (TECAN Austria GmbH, Austria) was used to measure fluorescence of fluorescein (485 nm excitation and 520 nm emission) at every 10 min for 2 hr at temperature 37oC. Anti-oxidant capacity (ORAC) was expressed as micromoles of Torolox equivalents (TE) per germ of wet and dry mass [23].

2.9 Physical properties of ALP fortified plain cakes

Physical properties of ALP fortified plain cakes such as height (cm), weight (g), volume (cm3), and baking loss (%) were determined following the method of Bilgen et al., [25]. Color attributes of product were analyzed with the help of a colorimeter (Chroma Meter CR400, Konica Minolta, Japan) under specific condition (Illuminant: *C, D65, space: LAB). The color was determined in L*, a*, b* system, where L* = lightness (100: white, 0: black), a* = redness (+), or greenness (-), and b*=yellowness (+), or blueness (-).

2.10 Textural properties of ALP powder incorporated plain cakes

Textural properties of ALP supplemented cake (2.0×2.0×2.0 cm) from middle of the cakes were determined using a texture analyzer (TA-XT plus, Stable Micro System, UK). It has 36 mm diameter cylindrical probe, 50% compression with test speed 1.0 mm/s. Operational conditions were: 2.0 mm/s pre-test speed, 2.0 mm/s post-test speed and 5 g trigger force. Hardness, cohesiveness, adhesiveness, springiness, resilience, gumminess and chewiness were determined and Texture Expert 1.05 software (Stable Microsystems) was used to find out the textural properties of the developed cakes by programming a double cycle.

2.11 Determination of sensory attributes

Plain cakes were assessed for color, flavor, texture, and overall acceptability. A 1-9 point hedonic rating test was also performed to determine the degree of acceptability of cakes containing different ALP levels. One slice from each lot of cakes was presented to 10 panelists as randomly coded samples. The taste panelists were requested to rank the sample for color, flavor, texture, and overall acceptability on a 1-9 point scale [26].

2.12 Changes in weight during storage condition

Plain cakes were analyzed for moisture gain or loss at different storage conditions in terms of changes in weight up to 10 days of storage. Samples were vacuum-packed in single layer polythene and kept at room temperature (30±2°C) and refrigeration temperature (5±1°C). The weight gain or loss by control samples and ALP fortified samples were observed every day.

2.13 Statistical analysis

The plain cake samples were analyzed by Fischer's LSD multiple comparison test to view the differences. A single factor analysis of variance (ANOVA) was done to find the significant differences [27]. STATA v15 was used to carry out all the analysis.

3. Results and Discussions

3.1 Comparison of nutritional and functional properties of ALP and RWF

Table 2 shows the comparative study between ALP and RWF for their nutritional composition and functional properties. It is noticeable that ALP is a good source of protein, and ash. Moisture, fat and total carbohydrate content was significantly ($p<0.05$) higher in RWF. Moisture, ash, protein, fat and total carbohydrate of ALP was almost similar to that reported by Hamman [28]. In the case of RWF, the results were in agreement with [29], [30], and [31].

Different functional properties of ALP was compared with RWF and shown in **Table 2**. Functional properties of powder/flour reflect the endogenous physical and chemical properties which influence the food properties across handling, storage, processing, and analysis, etc. [32]. The bulk density of RWF (0.65±0.05 g/ml) was significantly ($p<0.05$) higher than ALP (0.48±0.04 g/ml). **Table 2** suggested that WAC (g water/g sample) were significantly ($p<0.05$) in ALP than RWF. WAC plays a very important role in the textural quality of food staffs such as soups, ground meat, dressing, sauces and bakery products. High WAC leads to swelling properties which provide consistency, thickening, viscosity, adherence properties, increasing weight and decreasing of [33,34]. Therefore, higher WAC of ALP/RWF might cause an increasing in weight, height, and volume of the cakes. The study also suggested that OAC (g/g) and swelling power (%) was significantly ($p<0.05$) higher in ALP than RWF. Comparative analysis for mineral content shows that ALP contain significantly higher amount of iron (Fe) than RWF; whereas RWF contain higher amount of Calcium (Ca) and Potassium (K). Total polyphenols and total flavonoids content of ALP were found to be 75.01±3.22 mg of GAE/100g and 6.87±0.18 mg of CE/100g, respectively. However, anti-oxidant capacity of ALP (measured as ORAC hydrophilic and total) was found to be 49.55±1.2 µmol of TE/g. Plain cakes fortified with ALP can be a good source of anti-oxidant and a viable option for producing healthy baked products.

Table 2. Nutritional and functional properties of Aloe Vera leaf powder (ALP) and refined wheat flour (RWF)

Parameters	ALP	RWF
Moisture (%)	7.65^{b}±0.12	11.50^{a}±0.18
Ash (%)	19.83^{a}±0.78	0.64^{b}±0.05
Crude protein (%)	22.23^{a}±0.21	12.24^{b}±0.10
Crude fat (%)	0.59^{b}±0.001	0.76^{a}± 0.004
Total carbohydrate (by difference) (%)	49.70^{b}±1.02	75.10^{a}± 0.78
Total polyphenols, mg of GAE/100g	75.01±3.22	ND
Total flavonoids, mg of CE/100g	6.87±0.18	
ORAC hydrophilic (µmol of TE/g)	49.55±1.20	
ORAC total (µmol of TE/g)	49.55±1.20	
Fe (mg/100g)	175^{a}±0.08	3.05^{b}±0.20
Ca (mg/100g)	7.05^{b}±0.02	18.40^{a}±0.50
K (mg/100g)	19.85^{b}±0.05	140.65^{a}±1.05
pH	4.91^{b}±0.03^{b}	6.35^{a}±0.03
L*	65.54^{b}± 0.48	71.00^{a}± 0.25
a*	-0.97^{a}±0.03	-0.19^{b}±0.05
b*	7.05^{b}±0.05	8.26^{a}±0.15
Bulk density (g/ml)	0.48^{b}±0.04	0.65^{A}±0.05
Water absorption capacity (g/g)	4.76^{a}±0.06	4.15^{b}±0.05
Oil absorption capacity (g/g)	3.25^{a}±0.08	1.40^{b}±0.04
Foaming capacity (ml)	4.89^{a}±0.33	4.09 ±0.33
Solubility (%)	13.44^{a}±1.22	11.74^{b}±2.02
Swelling power (%)	6.53^{a}±0.08	3.75^{b}±0.05

Values are presented as Mean±SD; means in rows with different superscripts were significantly different ($p<0.05$). ND, Not determined; GAE, Gallic acid equivalents; CE, Catechin equivalents; TE, Trolox equivalents.

3.2 Particle size analysis of mix flour (ALP and RWF) and RWF

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 15 June 2021 doi:10.20944/preprints202106.0395.v1

Figure 1 illustrates the particle size distribution of mixed flour (4, 6, and 8% ALP mixed with RWF) and control flour (RWF). Bimodal particle size distribution was observed for all flours as two distinct peaks were observed for mixed flour, whereas there was no distinct peak for RWF. The results are in agreement with [9], [15], and [35]. **Figure 1** also indicated that most of the flour tested had particle sizes ~ 100 µm, indicating a higher volume of flour. Particle size distribution of mixed flour and RWF was ranged from 0.1 – 100 µm. however, volume of particles for all mixed flour was at ~ 140 µm and for control (RWF) at 88 µm. This result suggested that RWF has lower protein and fiber content as smaller particle size (SPZ) flour suggests low protein and fiber content [36]. SPZ flour gave hard dough with higher density results in less development of biscuits, cake and bread [9,37]. Hence, coarser particle size flour from composite or mixed flour is the most desirable for cake preparation. Mean volume diameter (MVD) (d4,3: 68.85 µm) and surface mean diameter (SMD) of RWF (d3,2: 25.75 µm) were less than ($p<0.5$) all mixed flour (d4,3: 78.15 µm; d3,2: 30.55 µm, respectively). There was no significant difference ($p>0.5$) among 4, 6, and 8% mixed flour. The particle size of flour frequently impacts water absorption capacity, swelling power and density of cakes. If the fine particle sized flour is usually gave a higher density and less effective baking properties [9]. Therefore, coarser particle size composite flour is desired for the preparation of cake.

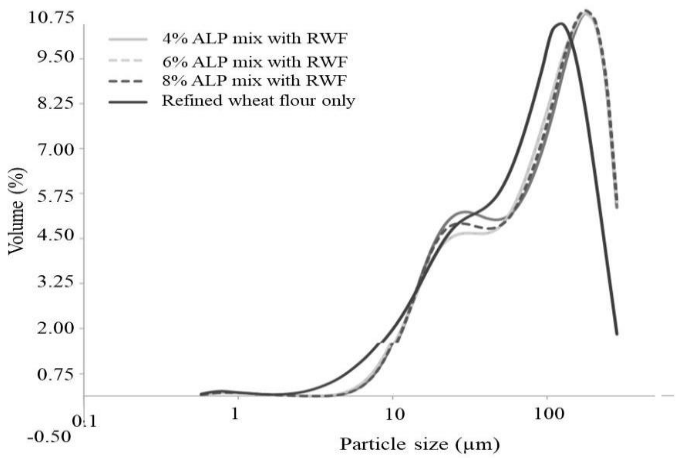

Figure 1. Particle size of mix flour (Aloe Vera powder and refined wheat flour) and refined wheat flour

3.3 Physical properties, proximate composition and mineral content of control cake and cake fortified with ALP

Table 3 shows different physical properties of the developed cakes. Weight of the ALP fortified cakes (225.5–250.8 g) was higher than control cake (216.6 g) due to the higher water absorption capacity of ALP (4.76±0.06) than RWF (4.15±0.05) [29]. As a result, supplementation of ALP increased the weight of cakes. It was also noticeable that weight of cakes (from S3 to S1) gradually increased with the increasing percentage of ALP due to the lower baking loss and higher WAC of ALP [10]. The cakes containing different percentage of ALP had lower volumes (300-310 cm^3) than the control cake (327 cm^3). This might be due to a reduction in gluten content due to supplementation. Research also revealed that partial replacement of wheat flour with non-glutinous flour resulted in lower product volumes [38]. It was also observed that the volume of the cakes decreased with an increasing percentage of ALP (from S3 to S1) due to the absorption of air, oil and fiber components [39].

 doi:10.20944/preprints202106.0395.v1

Specific volume of the cakes (from S3 to S1) gradually decreased with an increasing level of ALP in the formulation. This could be due to a reduction in gluten content due to supplementation. Previous research also showed that specific volume gradually decreased with increasing levels of non-glutinous flour substitution in the developed cake [40]. The height of the control cake (6.70 cm) was found to be higher than that of the cakes containing ALP (6.50-5.65 cm). The decrease in height from 6.70 to 5.65 cm of the cake could be the result of reduction in gluten content of the blends due to supplementation with ALP [31]. There was an inverse relationship was noticed between cake weight and weight loss during baking. Increasing the cake weight and decreasing the weight loss was noticed when the ALP was increased in the dough. Baking loss (%) of the ALP supplemented cakes (S3=47.03%, S2=45.92% and S1=42.66%) were lower than control cakes (50.52%). Supplementation of RWF by ALP reduces the weight loss due to high protein and fiber content of the ALP than RWF [10]. **Table 3** shows that L* of crumb decreased with increasing ALP percentage (from 67.90 to 53.28). S2 (6%) and S1 (8%) did not show any significant difference ($p>0.05$) for L*-values. a*-value of cake crumb increased with ALP supplementation in dough. However, b* -values of cake crumb decreased with increasing ALP addition. ALP used for cake processing was less light, less yellow and more radish in color (**Table 2**) than RWF, which subsequently decreased L*, b* and increased a*-values.

Table 3. Effect of addition of Aloe Vera leaf powder (ALP) on physical and nutritional properties of plain cakes

Parameters	S_4	S_3	S_2	S_1
Weight (g)	216.6^{c}±7.0	225.5^{c}±6.5	235.3^{b}±5.5	250.8^{a}±5.0
Volume (cm^3)	327.0^{a}±6.5	310.0^{b}±6.0	304.0^{c}±7.0	300.0^{c}±7.5
Specific volume (cm^3/g)	1.51^{a}±0.03	1.36^{b}±0.05	1.31^{b}±0.04	1.24^{c}±0.07
Height (cm)	6.70^{a}±1.5	6.50^{b}±1.2	6.40^{b}±1.3	5.65^{c}±1.0
Baking loss (%)	50.52^{a}±3.5	47.03^{b}±2.4	45.92^{c}±3.5	41.66^{d}±2.5
Moisture (%)	18.64^{c}±0.07	20.21^{b}±1.5	21.81^{a}±0.06	22.47^{a}±1.0
Ash (%)	1.80^{d}±0.50	2.53^{c}±0.70	2.76^{b}±0.50	2.95^{a}±.20
Protein (%)	9.60^{d}±0.60	10.30^{c}±0.90	12.31^{b}±0.40	14.10^{a}±1.0
Crude fat (%)	22.24^{a}±1.5	22.15^{a}±1.9	21.52^{b}±1.0	20.95^{b}±1.0
Total carbohydrate	47.42^{a}±1.0	46.14^{a}±1.7	45.79^{b}±1.9	43.65^{c}±2.0
TPC, mg of GAE/100g	ND	2.93^{c}±0.08	4.60^{b}±0.07	5.75^{a}±0.05
ORAC total (μmol of TE/g)	ND	2.01^{c}±0.03	2.99^{b}±0.07	3.71^{a}±0.05
Fe (mg/100g)	5.60^{d}±0.03	7.68^{c}±0.07	8.65^{b}±0.06	9.75^{a}±0.09
Ca (mg/100g)	1.10^{d}±0.05	1.75^{c}±0.03	2.05^{b}±0.08	2.50^{a}±0.09
L*	67.90^{a}±2.30	61.12^{b}±3.5	55.49^{c}±1.50	53.28^{c}±1.10
a*	1.06^{c}±0.08	1.04^{c}±0.20	2.76^{b}±0.50	4.21^{a}±0.80
b*	27.83^{a}±1.50	20.89^{b}±1.20	18.54^{c}±1.00	17.37^{c}±1.4

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 15 June 2021 doi:10.20944/preprints202106.0395.v1

Values are presented as Mean±SD; means in rows with different superscripts were significantly different ($p<0.05$); ND, Not determined; S_4, Control (Refined wheat flour); S_3, 4% ALP (Aloe Vera leaf powder); S_2, 6% ALP (Aloe Vera leaf powder); S_1, 8% ALP (Aloe Vera leaf powder).

The ALP supplemented cakes were analyzed for its nutritional composition (**Table 3**). Moisture content analysis suggested that substitution of RWF by ALP results gradual increase of moisture content in cakes. This might be due to low water binding capacity of ALP protein, high fiber content of ALP and lower baking loss of supplemented cakes. However, research revealed that non-wheat proteins increased the water absorption of dough due to high water binding capacity [41]. Protein content of all samples was higher than the control sample, as ALP is a rich source of protein. Consumption of cakes enriched with 8% ALP can easily supplied recommended dietary allowance (RDA) of protein for healthy people. Fat content of S4 was the maximum (22.24%) among all samples though significantly not differ with S3. Sample S2 and S1 were not significantly different with each other. It was observed that ash content cake increased gradually with the addition of ALP. 8% ALP (S1) cake had the highest ash content (2.95%) and revealed a significant amount of minerals present in the ALP.

100 g plain cake enriched with 8% ALP will contribute more than 15% RDA for iron, compared to 8% iron contribution from control cake for an adult aged 19–50 years. The result suggested that 100 g plain cake enriched with 8% ALP will contribute more than 6% RDA for calcium, compared to 8% iron contribution from control cake for an adult aged 19–50 years based on Institution of Medicine, Food and Nutrition Board. The findings suggested that ALP might be an alternative protein source for bakery products. Total carbohydrate content decreased in ALP enriched cake (from S3 to S1) with increasing amount of ALP in dough. This may be due to the lower percentage of carbohydrate present in ALP determined in the present study (49.37%) than that of wheat flour (72.46%) [29]. Total polyphenols and anti-oxidant activity (measured as ORAC) increased in ALP enriched cake (from S3 to S1) with increasing amount of ALP in dough, as ALP is a rich source of polyphenols and flavonoids.

Symmetry parameters are known as evenness and edges. Evenness includes even, medium even and uneven. Subjective analysis shows that crust color of control cake was brown whereas 8% ALP enriched cake was brownish dark and consistency turned tender to medium tender. Crum color of the cakes was brownish yellow, less brownish yellow, less darkish brown and darkish for control, 4, 6 and 8% ALP supplemented cakes, respectively (**Table 4**). Control sample (S4) and 4% ALP (S3) shows appetizing flavor though 6 and 8% ALP enriched cake shows slight bitter flavor. Subjective analysis also suggested that closely bounded grain was noticed for control (S4) and 4% ALP (S3), whereas less airy for both S2 (6% ALP) and S1 (8% ALP). Size and shape of the crumb's grain lost its uniformity due to increasing of ALP (**Table 4**).

Table 4. Effect of addition of Aloe Vera leaf powder (ALP) on symmetry, crust and crumb characteristics of plain cakes

Cake	Symmetry			Bloom	Crust Characteristics		Crumb Characteristics			
	Evenness	Edges	Centre		Color	Consistency	Color	Texture	Flavor	Grain

								Lumps and hardness	Surface		Close or airy	Shape and size
S_4	Even	Medium	Medium	Slightly dull	Brownish dark	Tender	Darkish	Free	Smooth	Appetizing	Close	Uniform
S_3	Even	Low	Low	Shining			Darkish brown					
S_2	Medium even			Slightly dull	Brown (slight black)	Medium tender	Brownish yellow (less)	Present (less)		Slight bitter	Less airy	Slightly non uniform
S_1	Medium even	Medium	Medium	Dull	Brown		Brownish yellow					Non uniform

S_4, Control (Refined wheat flour); S_3, 4% ALP (Aloe Vera leaf powder); S_2, 6% ALP (Aloe Vera leaf powder); S_1, 8% ALP (Aloe Vera leaf powder).

3.4 Effect of ALP on the textural properties of cakes

Textural profile of plain cake samples is shown in **Table 5**. It can be observed that the hardness of the plain cake samples increased with the increasing percentage of ALP from 0 to 8%. Hardness of ALP enriched cakes was directly correlated to the volume of the testing materials. Decreasing the volume increased the hardness due to lack of gluten in the mix. Springiness value of plain cake was in the range 0.79-0.92. 8% ALP fortified cake (S1) had significantly lower springiness than the other cake samples. There was no significant difference among the three samples (S2, S3, and S4). Again, cohesiveness, gumminess, chewiness, and resilience of plain cake samples are 0.68-0.77, 4.87-5.12, 4.09-4.48, and 0.37-0.38, respectively. However, the result indicated that that only sample S1 (8% ALP) was significantly different with other plain cake samples in cake resilience values.

Table 5. Effect of addition of Aloe Vera leaf powder (ALP) on textural properties plain cakes

Samples	Hardness	Cohesiveness	Springiness	Gumminess	Chewiness	Resilience
S_4	$6.91^c \pm 0.44$	$0.77^a \pm 0.05$	$0.92^a \pm 0.58$	$4.87^b \pm 0.54$	$4.48^a \pm 0.44$	$0.37^b \pm 0.01$
S_3	$7.08^c \pm 0.91$	$0.76^a \pm 0.06$	$0.90^a \pm 0.76$	$5.08^b \pm 0.60$	$4.45^a \pm 0.36$	$0.37^b \pm 0.01$
S_2	$7.15^b \pm 1.31$	$0.77^a \pm 0.02$	$0.87^a \pm 1.11$	$5.12^a \pm 0.86$	$4.34^a \pm 0.19$	$0.38^{ab} \pm 0.05$
S_1	$7.88^a \pm 1.87$	$0.68^b \pm 0.04$	$0.79^b \pm 1.46$	$5.11^a \pm 0.75$	$4.09^b \pm 0.28$	$0.38^a \pm 0.07$

Values are presented as Mean ± SD; means in the column with different superscripts are significantly different ($p<0.05$); S_4, Control (Refined wheat flour); S_3, 4% ALP (Aloe Vera leaf powder); S_2, 6% ALP (Aloe Vera leaf powder); S_1, 8% ALP (Aloe Vera leaf powder)

3.5 Organoleptic parameters of ALP supplemented cakes

On-way analysis of variance (ANOVA) suggested that there was significant ($p<0.05$) difference in color acceptability among the cakes. Sample S3 was most acceptable by the panelist than other cakes. In case of flavor preferences, one-way ANOVA showed that there was significant ($p<0.05$) difference in flavor acceptability. Sample S1 was most preferred and S3 was least preferred relative to other sample at 5% level of significance. ANOVA analysis suggested that there was significant texture difference ($p<0.05$) between control cake and cakes containing ALP. Control cake (S4) was more acceptable and significantly different from the other cake samples. For overall acceptability, ANOVA analysis suggested that Sample S3 (4% ALP) was the most preferable relative to others (**Table 6**).

Table 6. Effect of addition of Aloe Vera leaf powder (ALP) on sensory attributes of plain cakes

Cake	Sensory attributes			
	Color	Flavor	Texture	Overall acceptability
S_4	6.60 ± 0.48^{b}	6.87 ± 0.54^{b}	7.93 ± 0.76^{a}	6.93 ± 0.70^{ab}
S_3	7.87 ± 0.49^{a}	7.80 ± 0.49^{a}	6.93 ± 0.72^{b}	7.53 ± 0.61^{a}
S_2	6.67 ± 0.63^{b}	6.13 ± 0.74^{bc}	6.20 ± 0.86^{b}	6.20 ± 0.89^{bc}
S_1	5.80 ± 0.71^{b}	6.10 ± 0.67^{c}	6.20 ± 0.57^{b}	5.80 ± 0.96^{c}

Values are presented as Mean ± SD; means in the column with different superscripts are significantly different ($p<0.05$); S_4, Control (Refined wheat flour); S_3, 4% ALP (Aloe Vera leaf powder); S_2, 6% ALP (Aloe Vera leaf powder); S_1, 8% ALP (Aloe Vera leaf powder).

3.6 Changes in weight during storage of developed cakes

During the storage period, the weights of cakes gradually decreased at room temperature (30±2°C) due to the removal of moisture from cakes (**Figure 2**). On the other hand, a weight gain was observed in the refrigerated condition (5±1°C) (**Figure 3**). This might be due to high humidity in refrigerated conditions. The changes in weight of control cakes and ALP enriched cakes were found to minimum. This was probably due to the vacuum packing of samples, which almost ceased the gain or loss of moisture [29].

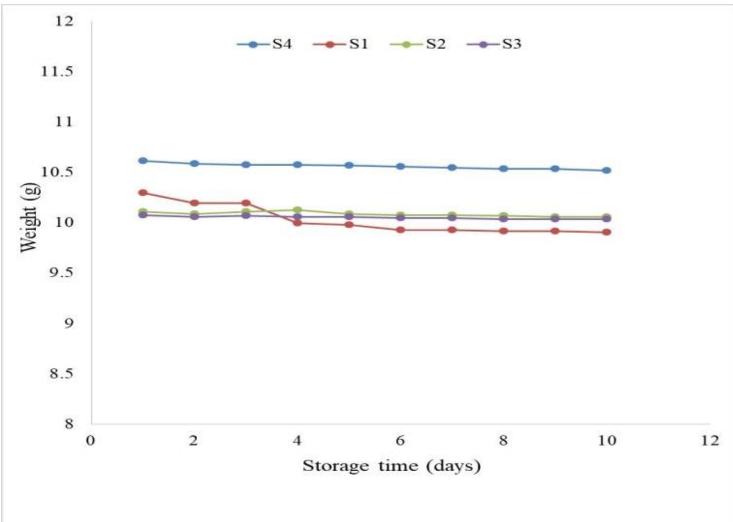

Figure 2. Changes in weight of control and Aloe Vera leaf powder (ALP) incorporated plain cakes during storage period at room temperature (30±2°C)

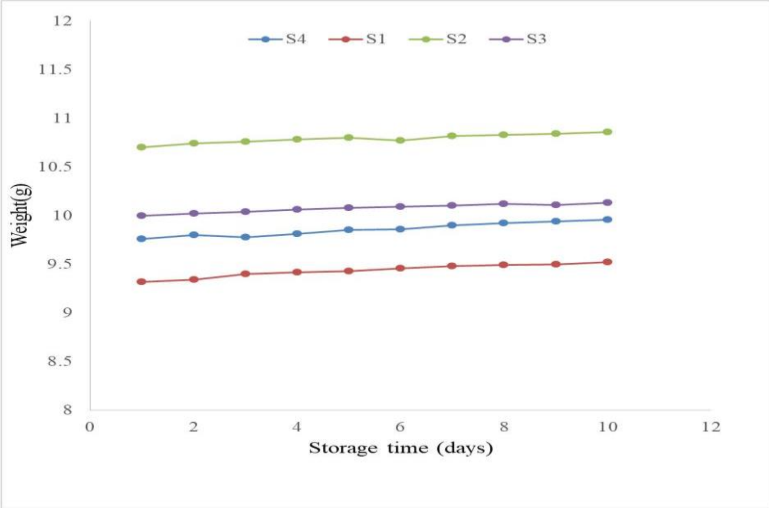

Figure 3. Changes in weight of control and Aloe Vera leaf powder (ALP) incorporated plain cakes during storage period at refrigeration temperature (5±1°C)

5. Conclusion

Cakes are one of the useful food items for fortification by different nutritional rich functional ingredients in the human diet. Addition of polyphenol, antioxidant and protein rich ingredients to bakery products increase the consumer acceptance and protein intake but decrease calorie density and total carbohydrate in the diet. This research studied the physic-chemical, nutritional and functional properties of Aloe Vera powder and substituted wheat flour by Aloe Vera powder. It was observed that ALP is a good source of protein, mineral, flavonoid and anti-oxidant. In the processed cakes, increase in moisture, ash, protein, iron and calcium with increasing ALP percentage. However, physical and sensory quality was inversely correlated with ALP incorporation, though 4% incorporation did not affect the quality significantly. This study concludes that plain cakes may be supplemented with up to 4% Aloe Vera powder to improve its nutritional and functional properties, without any change in the physical characteristics and consumer acceptability. Further study can be conducted on sorption, storage stability, and process optimization analysis.

Author Contributions: Conceptualization, M.A.R.M., D.S. and M.F.J.; methodology, D.S., K.D. and D.A.; software, D.S., and M.T.R.; writing—original draft preparation, M.F.J, M.A.R.M., and T.V.R.; writing—review and editing, T.V.R. and M.A.R.M; supervision, M.A.R.M. All authors have read and agreed to the published version of the manuscript.”

Funding: This research received no external or third party funding.

Data Availability Statement: All of the data used to generate the results is included in the article, and no additional source data is required.

Acknowledgments: The authors acknowledge department of Food Technology and Rural Industries, Bangladesh Agriculture University for technical support and assistance in this MS research.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Surjushe, A.; Vasani, R.; Saple, D.G. Aloe Vera: A short review. *Indian Journal of Darmatology*, **2008,** 53(4), 163-166. https://doi.org/10.4103/0019-5154.44785
2. Atherton, P. Aloe Vera revisited. *The British Journal of Phototherapy*, **1998**, 4, 76-83.
3. Esmaili, S.; Hosseini, M.; Shojaee Aliabadi, S.; Mirmoghtadaie, L. Improving Qualitative and Texture Characteristics of Fat-Free Sponge Cake Using Aloe Vera Gel Powder. *Iranian Journal of Nutrition Sciences & Food Technology*, **2018,** 12(4), 111-119.
4. Khaing, T.A. Evaluation of the antifungal and antioxidant activities of the leaf extract of Aloe vera (Aloe barbadensis Miller). *World Academy of Science, Engineering and Technology*, **2011**, 75, 610-612.
5. Shin, S.; Shin, G.M. Studies on quality characteristics of sponge cake made with aloe Vera powder. *Culinary Science and Hospitality Research*, **2018**, 24(7), 10-18. https://doi.org/10.20878/cshr.2018.24.7.002
6. Sonawane, S.K.; Gokhale, J.S.; Mulla, M.Z.; Kandu, V.R.; Patil, S. A comprehensive overview of functional and rheological properties of aloe Vera and its application in foods. *Journal of Food Science and Technology*, **2020,** 1, 10. https://doi.org/10.1007/s13197-020-04661-6
7. Chopra, S.A.R. Use of Aloe Vera gel as a fat replacer in the preparation of cakes. *International Journal of Agriculture and Food Science*, **2017,** 7(1), 5-11.
8. Lucky, A.R.; Al-Mamun, A.; Hosen, A.; Toma, M.A.; Mazumder, M.A.R. Nutritional and sensory quality assessment of plain cake enriched with beetroot powder. *Food Research*, **2020**, 4(6), 2049-2053. https://doi.org/10.26656/fr.2017.4(6).268
9. Momin, M. A.; Jubayer, M. F.; Begum, A. A.; Nupur, A. H.; Ranganathan, T.V.; Mazumder, M. A. R. Substituting wheat flour with okara flour in biscuit production. *Foods and Raw Materials*, **2020**, 8(2), 422–428. https://doi.org/10.21603/2308-4057-2020-2-422-428
10. Tasnim, T.; Das, P.C.; Begum, A.A.; Nupur, A.H.; Mazumder, M.A.R. Nutritional, textural and sensory quality of plain cake enriched with rice rinsed water treated banana blossom flour. *Journal of Agriculture and Food Research*, **2020**, 2, 100071. https://doi.org/10.1016/j.jafr.2020.100071
11. Sudha, M.L; Vetrimani, R.; Leelavathi, K. Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. *Food Chemistry*, 2007, 100(4), 1365-1370. https://doi.org/10.1016/j.foodchem.2005.12.013
12. Ahlawat, K.S.; Khatkar, B.S. Processing, food applications and safety of aloe vera products: a review. *Journal of Food Science and Technology*, **2011**, 48(5), 525-533. https://doi.org/10.1007/s13197-011-0229-z
13. Elaveniya, E.; Jayamuthunagai, J. Functional, physicochemical and anti-oxidant properties of dehydrated banana blossom powder and its incorporation in biscuits. *International Journal of ChemTech Research*, **2014**, 6(9), 4446-4454.
14. Khetarpaul, N.; Grewal, R.B.; Jood, S. *Quality control in bread making, bakery science and cereal technology*. Daya Publishing House: New Delhi, India, 2005; pp. 171.
15. Agrahar-Murugkar, D.; Gulati, P.; Kotwaliwale, N.; Gupta, C. Evaluation of nutritional, textural and particle size characteristics of dough and biscuits made from composite flours containing sprouted and malted ingredients. *Journal of Food Science and Technology*, **2015**, 52(8), 5129-5137. https://doi.org/10.1007/s13197-014-1597-y
16. AOAC. *Official Methods 950.46 Moisture in meat and meat products*, Twenty-first edition; Gaithersburg, MD, USA, **2019a**.
17. AOAC. *Official Methods 981.10 Crude protein in meat and meat products*, Twenty-first edition; Gaithersburg, MD, USA, **2019b**.
18. AOAC. *Official Methods 922.06 Fat in grain and flour*, Twenty-first edition; Gaithersburg, MD, USA, **2019c**.
19. AOAC. *Official Methods 920.153 Ash in meat and meat products*, Twenty-first edition; Gaithersburg, MD, USA, **2019d**.
20. FAO. Food energy methods of analysis and conversion factors. 2003. Retrieved from: http://www.fao.org/uploads/media/FAO_2003_Food_Energy_02.pdf
21. Poitevin, E. Determination of calcium, copper, iron, magnesium, manganese, potassium, phosphorus, sodium, and zinc in fortified food products by microwave digestion and inductively coupled plasma-optical emission spectrometry: single-laboratory validation and ring trial. *Journal of AOAC International*, **2012**, 95(1), 177-185. https://doi.org/10.5740/jaoacint.CS2011_14
22. Singleton, V.L.; Rossi, J.A. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American journal of Enology and Viticulture*, **1965**, 16(3), 144-158.
23. Nejatzadeh-Barandozi, F. Antibacterial activities and antioxidant capacity of Aloe Vera. *Organic and medicinal chemistry letters*, **2013**, 3(1), 1-8. https://doi.org/10.1186/2191-2858-3-5
24. Marinova, D.; Ribarova, F.; Atanassova, M. Total phenolics and total flavonoids in Bulgarian fruits and vegetables. *Journal of the University of Chemical Technology and Metallurgy*, **2005**, 40(3), 255-260.
25. Bilgen, S.; Coşkuner, Y.; Karababa, E. Effects of baking parameters on the white layer cake quality by combined use of conventional and microwave ovens. *Journal of Food Processing and Preservation*, **2004**, 28(2), 89-102. https://doi.org/10.1111/j.1745-4549.2004.tb00813.x
26. SAS. *SAS users guide*: Statistics, 5th edition.; SAS Institute Inc., Cary, NC, **1985**.
27. Gomez, K.A.; Gomez, A.A. *Statistical procedures for agricultural research*, John Wiley & Sons, **1984**; pp. 187-240.

28. Hamman, J.H. Composition and applications of Aloe Vera leaf gel. *Molecules*, **2008**, 13(8), 1599-1616. https://doi.org/10.3390/molecules13081599
29. Huq, S.; Das, P.C.; Islam, M.A.; Jubayer, M.F.; Ranganathan, T.V.; Mazumder, M.A.R. Nutritional, textural, and sensory quality of oil fried donut enriched with extracted dietary fiber and okara flour. *Journal of Food Processing and Preservation*, **2021,** 45(3), e15310. https://doi.org/10.1111/jfpp.15310
30. Das, P.C.; Khan, M.J.; Rahman, M.S.; Majumder, S.; Islam, M.N. Comparison of the physico-chemical and functional properties of mango kernel flour with wheat flour and development of mango kernel flour based composite cakes. *NFS Journal*, **2019**, 17, 1-7. https://doi.org/10.1016/j.nfs.2019.10.001
31. Marufa, M.A.; Das, P.C.; Iqbal, A. Utilization of Jamun seed powder in composite cake formulation. *Journal of the Bangladesh Agricultural University*, **2019**, 17(4), 599-605. https://doi.org/10.3329/jbau.v17i4.44632
32. Menon, L.; Majumdar, S.D.; Ravi, U. Mango (Mangifera indica L.) kernel flour as a potential ingredient in the development of composite flour bread. *Indian Journal of Natural Products and Resources*, **2014**, 5(1), 75-82.
33. Palatnik, D.R.; Porcel, M.V.O.; González, U.; Zaritzky, N.; Campderrós, M.E. Recovery of caprine whey protein and its application in a food protein formulation. *LWT-Food Science and Technology*, **2015**, 63(1), 331-338. https://doi.org/10.1016/j.lwt.2015.03.027
34. Yu, J.; Ahmedna, M.; Goektepe, I. Peanut protein concentrate: Production and functional properties as affected by processing. *Food Chemistry*, **2007**, 103, 121-129. https://doi.org/10.1016/j.foodc hem.2006.08.012
35. Wilson, J.D.; Bechtel, D.B.; Todd, T.C.; Seib, P.A. Measurement of wheat starch granule size distribution using image analysis and laser diffraction technology. *Cereal Chem*, **2006**, 83(3), 259-268. https://doi.org/10.1094/CC-83-0259
36. Gaines, C.S.; Donelson, J.R.; Finney, P.L. Holding Time and Temperature on Cookie Dough Handling Properties and Cookie Size. *Cereal Chem*, **1988**, 65(5), 384-389.
37. Manley, D. *Technology of biscuits, crackers and cookies*, Woodhead Publishing Ltd, **2000.**
38. Gernah, D.I.; Chinma, C.E. Breadmaking potentials of cassava-maize-soyabean flour blends. *Journal of Sustainable Agriculture and the Environment*, **2006**, 8(2), 196-206.
39. Khan, S.A.; Saqib, M.N.; Alim, M.A. Evaluation of quality characteristics of composite cake prepared from mixed jackfruit seed flour and wheat flour. *Journal of the Bangladesh Agricultural University*, **2016**, 14(2), 219-227.
40. Akter, N.; Alim, M.A. Preparation of wheat-potato-peanut composite flour cakes. *Journal of the Bangladesh Agricultural University*, **2018**, 16(2), 315-321. https://doi.org/10.3329/jbau.v16i2.37988
41. Al-Attabi, Z.H.; Merghani, T.M.; Ali, A.; Rahman, M.S. Effect of barley flour addition on the physico-chemical properties of dough and structure of bread. *Journal of Cereal Science*, **2017**, 75, 61-68. https://doi.org/10.1016/j.jcs.2017.03.021