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Development and quality evaluation of novel biscuits by utilizing fruits and vegetables seed

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Abstract

Food supplementation is a topic of attention now since consumers are becoming more conscious of their nutritional needs. The purpose of this study was to create innovative biscuits utilizing fruit and vegetable seeds and to assess their quality. The right-shaped biscuits were prepared and baked at 170°C for 20 to 25 mins. There were six distinct varieties of biscuits made: control, date, jackfruit, bean, pumpkin, and mixed seed powder contained biscuits. When compared to other biscuits, the bean seed powder-incorporated biscuit gets a high overall acceptance score (7.88). The mixed seed powder incorporated biscuit had a sizable amount of moisture (4.70%) and ash (1.42%). Jackfruit (24.54%), pumpkin (18.46%), beans (9.03%), and date (74.19%) seed powder incorporated biscuits have quite significant levels of protein, fat, crude fiber, and total CHO. Biscuits containing jackfruit seed powder had relatively high WAC and bulk density (2.51% and 0.67%). The thickness, volume, density and spread ratio were relatively high in jackfruit (1.43 cm), mixed (18.58 cm^3), date (0.55 g/cm^3) and bean (4.74) seed incorporated biscuits respectively. The highest iron content was found in pumpkin seed-incorporated biscuits (0.41 mg/100 g). The mixed seed powder-incorporated biscuits had a high (95.06%) percentage of inhibition in antioxidant tests. According to the current study, replacing wheat powder in biscuits with fruit and vegetable seed powder up to 15% would boost the biscuit's nutritional content.

1. Introduction

Biscuits are popular baked goods with a low final water content (1–5 g/100 g) and typically three main ingredients (flour, sugar and fat). Since they have a variety of tastes, long shelf life, widespread acceptance, practicality and are relatively inexpensive, biscuits are a common food item that a wide spectrum of people eat. Due to market competition and growing consumer demand for healthy, natural, and useful products, efforts are being made to adjust the nutritional composition of biscuits to raise their nutritive value and functionality. In this regard, widely consumed biscuits may serve as an effective delivery system for bioactive substances. Because they can be fortified, biscuits are now getting greater attention for creating functional foods (Gani *et al.,* 2012; Campos-Rodriuez *et al.,* 2022). Fruit and vegetable seeds are great sources of nutrients. Seeds are a significant part of fruits and vegetables which provide most of the energy and nutrients. Humans need nutrition, bioactive compounds, antioxidant, other micronutrients and energy for the survival of life. Most part of the nutrients and energy are provided by plants. Seeds contain bioactive compounds in the form of polyphenols and flavonoids which protect against various age-related disease like aging (Amarya *et al.,* 2015). They are a source of concentrated protein that people may consume for the requirement of essential amino acids. Various phytochemicals, vitamins, minerals, essential fatty acids, polyunsaturated fats, and monounsaturated fats which are beneficial for the development brain of children can be obtained from fruit and vegetable seeds (Karrar *et al.,* 2019). In healthy diet preparation, seeds can play a vital role as they can help to reduce cholesterol levels in blood, maintain blood sugar thus control glycemic load and also regulate blood pressure. Omega-3 fatty acid is an essential polyunsaturated fatty acid present in fruit seeds that has a fruitful contribution to enhancing rapid digestion (Jędrusek-Golińska *et al.,* 2020). Seeds are another source of fiber providing the release of constipation, fighting against free radicals to destroy

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cancer cells, reducing nervousness, removing insomnia and helping in the development of mental focus. In modern civilization, man has become dependent on versatile processed food products that most of the time are not preferable to better health, in this case, a natural plant-based balanced as well as wholesome diet can be prepared utilizing various fruit and vegetable seeds (Sethi *et al.,* 2016). A food can be called an ideal menu when it becomes nutritionally enriched, safe and hygienic, non-allergic, low in fat, high in protein, fiber, and easily digestible thus we can get the required benefits from seed utilization. In spite of this nutritional convenience, seeds are falling into underutilized by-products due to the lack of proper agricultural management. If this by-product can properly be utilized, it will cover not only nutritional advantages but also facilitate the economy of our country. The research will be conducted with the aim to develop a biscuit incorporated with fruit and vegetable seeds as biscuit is a popular confectionery product and always consumed by all age groups. It is also available everywhere and people can easily take it. A biscuit is a bakery item with a better shelf life, easy to transport and store. It is not only attractive for children but also elders. Therefore, this study is undertaken to utilize various seeds to develop a nutrient-dense novel biscuit, and finally measure the sensory and nutritional quality. Bangladesh, a developing nation, has a greater frequency of malnutrition along with protein energy malnutrition (PEM). Fruits and vegetable seeds contain macronutrients, micronutrients, and nutraceutical ingredients. Therefore, an alternative source of nutrients that is incorporated in biscuits at a fair price and is called Novel Biscuit can be created by effectively using these nutrients from fruits and vegetable seeds. For instance, recent research has looked into the possibility of partially replacing the wheat flour in biscuits with four different types of fruit and vegetable seeds powder; for example date, jackfruit, country bean and pumpkin. By adding up to 15% of fruit and vegetable seeds powder to the recipe for novel biscuits, the nutritional value can be improved without degrading the sensory experience. In particular, for malnourished or undernourished persons, these biscuits are improved with nutritional value and are easily accessible to them.

2. Methodology

Four types of seeds such as jackfruit, date, country bean and pumpkin seeds were collected from the market, washed and kept for sun drying. Then roasted carefully and blended into powder. Finally, the powder was sieved, packaged in polythene bags and stored at room temperature for further use in the preparation of biscuits.

2.1 Recipe of biscuits

Wheat flour, seed powder, milk powder, sugar powder, egg, baking powder and butter were weighed accurately as indicated in Table 1. The butter, egg and sugar powder were mixed until it was turned into paste form. Then wheat flour, seed powder, milk powder, baking powder and vanilla essence were added and mixed thoroughly to make adequate dough and kept for a few minutes. The dough was rolled and cut according to the desired shape and size of biscuits and baked in the baking oven at 170°C for 20 mins, then cooled, packed and stored at room temperature (Table 1).

2.2 Proximate composition analysis

2.2.1 Estimation of moisture content

The standard reference method (Ahn *et al.,* 2014) was followed to measure the moisture content of samples. Ground sample (about 5 g) was dried in a conventional oven (air drying) at 100-105°C for 3-5 h. The sample plus crucible was placed in a desiccator and weighted. The moisture content was calculated using the formula:

$$\text{percentage of moisture content} = \frac{W1 - W2}{W1 - W} \times 100$$

Where W = weight of empty crucible; W1 = weight of crucible with raw sample and W2 = weight of crucible with dried sample.

Table 1. Basic information of seed powder incorporated biscuit on 100 g basis of total ingredients.

Ingredients	Quantity (g)					
	Control biscuit	Date seed	Pumpkin seed	Jackfruit seed	Bean seed	Mixed seed
Wheat flour	50	42.5	42.5	42.5	42.5	42.5
Seed powder	0	7.5	7.5	7.5	7.5	7.5
Sugar powder	19	19	19	19	19	19
Milk powder	3.5	3.5	3.5	3.5	3.5	3.5
Baking powder	0.5	0.5	0.5	0.5	0.5	0.5
Butter	10	10	10	10	10	10
Egg	17	17	17	17	17	17
Vanilla essence	1/2 tsp	1/2 tsp	1/2 tsp	1/2 tsp	1/2 tsp	1/2 tsp
Total	100	100	100	100	100	100

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2.2.2 Estimation of ash content

The standard reference method (Ahn *et al.,* 2014) was followed to measure the ash content of samples. The main principle of determination of ash content was incineration. Ground sample (about 2 g) was dried in a conventional muffle furnace at 600°C for 5-6 hrs. The prepared sample was weighted and interred in the furnace and finally, the residue was weighted. The ash content was calculated using the formula:

$$\text{percentage of ash content} = \frac{W2 - W}{W1 - W} \times 100$$

Where W = weight of empty crucible; W1 = weight of crucible with raw sample and W2 = weight of crucible with dried sample

2.2.3 Estimation of fat content

The total fat content of the novel biscuit sample was determined by the organic solvent extraction method as described by Feldsine *et al.* (2000). Fat was extracted semi-continuously with the organic solvent. The solvent was heated and volatilized then was condensed above the sample. The sample was dripped onto the sample and soaked it to extract the fat. At 15-20 mins intervals the solvent was siphoned to the heating flask to start the process again. The extraction was continued for 6 hrs. The extraction units were removed from the heat source and detach the extractor and condenser. The flask was replaced on the heat source and evaporated off the solvent (The solvent was distilled and recovered). Then the flask was placed in an oven at 102°C and dried the contents until a constant weight was reached. Finally, the flask was cooled in a desiccator and weighed the flask and contents. The fat content was measured by weight loss of the sample or weight of fat removed using the following calculation:

$$\text{percentage of crude fat} = \frac{W2 - W1}{S} \times 100$$

Where W1 = weight of flask (g), W2 = weight of flask and extracted fat (g) and S = weight of sample (g)

2.2.4 Estimation of crude fiber content

Crude fiber is defined as a loss on ignitions of dried residue remaining after digestion of a sample with 1.25% sulfuric acid and 1.25% sodium hydroxide solution under specific conditions. A total of 5 g of moisture and fat-free sample was weighed and 200 mL of 1.25% sulfuric acid was added to it. The solution was then boiled for 30 mins and then filtered through a buchner funnel and filtration apparatus. The residue left behind was washed with water till it was acid-free and the residue was transferred to a beaker. Then 200 mL of 1.25% sodium hydroxide was added and again boiled for 30 mins. The residues were again filtered and washed with water. Residues were transferred to the pre-weighted crucible and dried to a constant weight at 100°C in a hot air oven. The residue was then ashed in a muffle furnace and a loss in weight was recorded (Bala and Singh, 2013). The crude fiber content was calculated using the formula:

$$(\%) \text{ of Crude Fiber } = \frac{\text{Weight of residue} - \text{Weigt of ash after ignition}}{\text{Weight of sample}} \times 100$$

2.2.5 Estimation of protein content

The protein of biscuit samples was determined by following the Kjeldahl method (Abrams *et al.,* 2014). This method was developed in 1883 by a brewer called Johann Kjeldahl. At first 1 g of the prepared sample was weighed and transferred to a Kjeldahl digestion flask and 2 Kjeldahl tablet or about 15 g potassium sulphate, and 0.5 g copper sulphate were added. Then about 20 mL of sulfuric acid was added to digest the sample. The flask was gently heated at 400°C in an inclined position until frothing ceased then boiled briskly for 1.5 hrs and allowed to cool. After that, approximately 75 mL of deionized water and 50 mL of sodium hydroxide (40%) was added and mixed thoroughly. Then a piece of granulated zinc or anti-bump granules was added and carefully poured down the side of the flask of sodium hydroxide solution to make the contents strongly alkaline. Then the tube was set up in the digestion unit and the distillation process was carried out for about 6 mins the desired sample was collected in a beaker containing 4% boric acid solution with mixed indicator. After that, the solution was titrated with 0.1 HCl. The protein content was calculated using the formula:

$$\text{percentage of N } (\%) = \frac{(Vs - Vb) \times c \times 14.007}{W} \times 100$$

Where V_s = the titration volumes of the sample (mL); V_b = the titration volumes of the blank (mL), C = the concentration of HCl (Normality) and W = the weight of the sample (g) and 14.007 is the molecular weight of nitrogen (n).

After the determination of nitrogen content, it was converted to a protein content using the appropriate (6.25 for fish) conversion factor by the following equation:

$$\text{percentage } (\%) \text{ of protein} = N \times 6.25$$

2.2.6 Estimation of carbohydrate content

Crude CHO content (%) = 100 – {moisture content (%) + crude protein content (%) + crude fat content (%) + crude ash content (%)}

2.3 Functional properties of the biscuits

2.3.1 Determination of water absorption capacity

The water absorption capacity was determined according to the method of Sosulski *et al.* (1976). The sample (1 g) was mixed with 10 mL distilled water, kept

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at ambient temperature for 30 mins and centrifuged for 10 mins at 2000×g (2000 rpm). Water absorption capacity was expressed as the percentage of water bound per g of the sample. The water absorption capacity (%) was calculated using the formula:

$$\text{Water absorption capacity (\%)} = \frac{\textit{Amount of water absorbed}}{\textit{sample weight}} \times 100$$

2.3.2 Determination of bulk density

The bulk density of the sample was determined according to the method described by Narayana and Rao (1982). A known weight of the protein concentrate was added to a graduated measuring cylinder. The cylinder was gently tapped and the volume occupied by the sample was estimated.

The bulk density was calculated as weight per unit volume of sample.

$$\text{Spread ratio} = \frac{\text{Diameter of biscuit}}{\text{Thickness of biscuit}}$$

$$\text{\% spread ratio} = \frac{\text{Spread ratio of biscut}}{\text{Spread ratio of control biscuit}}$$

$$\text{Volume (cm}^3\text{)} = \frac{d2 \times \pi \times T}{4}$$

$$\text{Density (g/cm}^3\text{)} = \frac{\text{mass of sample (g)}}{\text{volome of sample(cm}^3\text{)}},$$

Where T = Thickness of biscuit (average) (cm) and d = Diameter of biscuit (cm)

2.4 Determination of iron content of novel biscuits

Iron was determined calorimetrically making use of the fact that ferric iron gives a blood red color with potassium thiocyanate was determined according to the method described in AOAC (2000). To an aliquot (6.5 mL or less) of the mineral solution, enough water was added to make up a volume of 6.5 mL followed by 1 mL of 30% H_2SO_4, 1.0 mL potassium persulfate solution and 1.5 mL 40% KCNS solution. The red color that develops was measured within 20 mins at 540 m/μ (Table 2, Figure 1).

Table 2. Absorbance of standard solution and its dilutions with concentration.

Solution	Concentration	Absorbance
Standard 3	0.0007022	0.002
standard 2	0.007022	0.016
Standard 1	0.07022	0.238
Standard	0.7022	3.687

2.5 Determination of antioxidant activity

The free radical scavenging activities of the extracts were determined by using the 2,2-Diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging method (Brand-Williams *et al.,* 1995). To prepare the sample extract 2 g of sample extract was weighed and placed in a beaker containing 10 mL methanol. Then, it was stirred to facilitate extraction by using a magnetic stirrer for 4 hrs. The extracts obtained were then filtered with whatman filter paper No. 42. A fresh 0.002% solution of DPPH was prepared in methanol and its absorbance was recorded at 515 nm. The 50 µL of the pure extract was mixed with a 3 mL solution of DPPH and allowed to stand in darkness for 15 mins. The absorbance was again recorded at 515 nm.

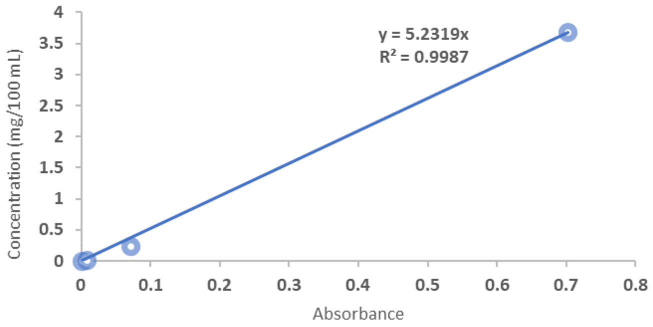

Figure 1. Calibration curve

$$\textit{Percentage of inhibition} = \frac{A - B}{A} \times 100$$

Where A is the absorbance of pure DPPH in oxidized form and B is the absorbance of the sample taken after 15 mins of reaction with DPPH.

2.6 Estimation of pH

The pH of the biscuits was measured with a pH meter (Jenway, 3330, England) by Tortoe *et al.* (2017). 5 g of biscuit was taken and crushed into powder. The powder was mixed with 20 mL distilled water to form a suspension which was stirred for 5 mins and allowed to settle for 10 mins. The pH of the water phase was then measured with the calibrated pH meter.

2.7 Sensory evaluation

The sensory attributes like appearance, color, taste, flavor, texture, and overall acceptability were evaluated by the 20 panelists among teachers and students of the Department of Food Technology and Nutritional Science of MBSTU, Santosh, Tangail, Bangladesh by 9 points hedonic score system (Table 3). The hedonic scale term used in tasting panels where the judges indicate the extent of their liking or disliking of the food (Nugent *et al.,* 2014).

2.8 Data analysis

The significance of observed differences was tested at $P < 0.05$. All the experiments were done with replication and analyzed with mean and standard deviation through Microsoft Excel 2007 and significance was analyzed by one sample T-test and one-way

ANOVA in SPSS.

Table 3. The general form of 9 points hedonic scale.

Hedonic Scale	Point
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very mcuh	2

3. Results and discussion

In terms of bakery goods, biscuits are more well-liked due to a variety of enticing attributes, superior preservation capabilities and widespread accessibility. In this study, the findings of tests on the development, value addition, evaluation of storage quality, and evaluation of customer acceptability of noble biscuits infused with fruits and vegetable seeds are described.

3.1 Proximate composition of novel biscuits

Novel biscuits were examined for proximate composition such as moisture, ash, protein, crude fat, crude fiber and total carbohydrate content. The biscuits included control, date seed powder, pumpkin seed powder, jackfruit seed powder, bean seed powder and mixed seeds powder (Table 4).

The result shows that the moisture content of date seed incorporated biscuit (1.32%) is the lowest and of mixed seed incorporated biscuit (4.70%) is the highest among all other types of biscuits. According to (Klionsky *et al.,* 2021), date seed powder incorporated biscuits have the following approximate compositions: moisture 9.12%, ash 1.53%, protein 8.46%, fat 11.65%, crude fiber 3.26% and total carbohydrate 65.98%. The ash content of mixed seed incorporated biscuit (1.42%) is the highest and of pumpkin seed incorporated biscuit (0.89%) is the lowest among all types of biscuits. According to El-Adawy and Taha (2001), chemical composition of pumpkin seed biscuit was 4.40% moisture, 3.65% ash, 28.93% protein, 21.29% crude fiber and 23.61% fat. Jackfruit seed incorporated biscuit has the highest and control has the lowest protein content (24.54% and 16.57%). Pumpkin seed incorporated biscuit and control biscuit contains the highest and lowest fat content respectively (18.46% and 0.46%). Aaij *et al.* (2014) found that all jackfruit seed flour varieties had moisture contents ranging from 6.28 to 9.16%, protein levels between 9.19 and 11.34 %, fat levels between 1.18 and 1.40 %, ash levels between 1.5 and 2.66 %, amylose levels between 26.49% and 30.21%, and starch levels between 81.05% and 82.52%. The highest crude fiber content is of bean seed incorporated biscuit (9.03%) and the lowest crude fiber content is of control biscuit (0.54%). The highest and the lowest amounts of total CHO were of the control (77.44%) and jackfruit seed incorporated biscuit (52.60%) respectively.

3.2 Functional properties of novel biscuits

The water absorption capacity and bulk density of the control biscuit are recorded as 1.66 mL/g and 0.61 g/mL, respectively (Table 5). Date seed powder incorporated biscuits have a bulk density of 0.55 g/mL and a water absorption capacity of 2.40 mL/g. Compared to control biscuits, the date seed-infused biscuit's WAC increased and its bulk density decreased. The water absorption capacity and bulk density of pumpkin seed powder incorporated biscuits are measured as 1.34 mL/g and 0.57 g/mL, respectively. In comparison to the control biscuit, the pumpkin seed powder incorporated the biscuit's WAC and bulk density both reduced. The water absorption capacity and bulk density of jackfruit seed powder incorporated biscuits are calculated to be 2.51 mL/g and 0.67 g/mL, respectively. Comparing the WAC to the control biscuit, both the WAC and bulk density are high. Bean seed powder incorporated biscuits have a bulk density of 0.66 g/mL and a water absorption capacity of 1.8 mL/g, respectively. Comparing the WAC and bulk density of the bean seed powder incorporated biscuit to the control biscuit, both the WAC and bulk density are high. The water absorption capacity and bulk density of mixed seed powder incorporated biscuits are

Table 4. Proximate composition of novel biscuits incorporated with fruits and vegetable seeds.

Composition	Novel biscuits					
	Control	Date seed	Pumpkin seed	Jackfruit seed	Bean seed	Mixed seed
Moisture (%)	4.06±0.46[a]	1.32±0.12	3.52±0.22[a]	3.24±0.78	2.55±0.27[a]	4.70±0.16
Ash (%)	1.20±0.14[a]	1.18±0.06[a]	0.89±0.04[a]	1.27±0.051[a]	1.08±0.09[a]	1.42±0.27[b]
Protein (%)	16.57±0.41	16.71±0.24	20.49±0.27	24.54±0.43	16.95±0.24	21.03±0.17
Fat (%)	0.46±0.14[b]	6.38±0.38[a]	18.46±0.28	12.51±0.19	13.50±0.27	14.41±0.29
Crude Fiber (%)	0.54±0.22	5.10±0.22[a]	1.54±0.21	6.53±0.19	9.03±0.24	2.43±0.15[a]
Total CHO (%)	77.44±0.24	74.19±0.21	56.70±0.14	52.60±0.52	65.91±0.34	58.42±0.29

Values are presented as mean±SD.
[a]statistically significant at $p<0.01$.
[b]statistically significant at $p<0.01$.

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Table 5. Functional properties of novel biscuits incorporated with various fruits and vegetable seeds.

Properties	Control	Date seed	Pumpkin seed	Jackfruit seed	Bean seed	Mixed seeds
WAC (mL/g)	1.66±0.10[a]	2.40±0.33[a]	1.34±0.24	2.51±0.29[a]	1.58±0.30[b]	1.53±0.23[a]
Bulk Density(g/mL)	0.61±0.006	0.55±0.03[a]	0.57±0.03[a]	0.67±0.03	0.66±0.04[a]	0.56±0.05[a]

Values are presented as mean±SD.
[a]statistically significant at p<0.01.
[b]statistically significant at p<0.01.

measured as 1.53 mL/g and 0.56 g/mL, respectively. Bulk density and WAC are lower than in the control biscuit. Analysis shows that the water absorption capacity (2.51%) and bulk density (0.67 g/cm^3) of jackfruit seed powder incorporated biscuit is higher than control and other biscuits. Jackfruit seed powder incorporated biscuit had the highest level and pumpkin seed powder incorporated biscuit had the lowest level of WAC (2.51 mL/g and 1.34 mL/g). The highest and lowest levels of bulk density are in jackfruit and date seed incorporated biscuit (0.67 g/mL and 0.55 g/mL) respectively which was almost similar to the findings of Onabanjo and Ighere (2014).

3.3 Physical attributes of novel biscuits

Physical characteristics have a significant role in determining how positively a product is received because the tongue doesn't taste a product until the eyes have first assessed its color and appearance. In addition, various physical factors impact the marketability, handling and customer attractiveness of a product. According to the analysis of physical attributes, the thickness, volume, density and spread ratio were relatively high in jackfruit (1.43 cm), mixed (18.58 cm^3), date (0.55 g/cm^3) and bean (4.74) seed-incorporated biscuits, respectively (Table 6). Bean seed powder incorporated biscuit had lower thickness and density (0.97 cm and 0.43 g/cm^3). Volume and spread ratio was relatively low in date seed incorporated biscuit (12.51) and mixed seed powder incorporated biscuit (2.68) respectively.

3.4 Iron content of novel biscuits

Analysis shows that the Iron content of control, date seed powder, pumpkin seed powder, jackfruit seed powder, bean seed powder and mixed seeds powder incorporated biscuits are 0.15 mg/100 g, 0.38 mg/100 g, 0.41 mg/100 g, 0.18 mg/100 g, 0.17mg/100 g, 0.17mg/100 g respectively which were similar to the findings of Khaneghah *et al.* (2020). The iron content of pumpkin seed powder incorporated biscuits is relatively higher than control and other biscuits (Table 7).

Table 7. Iron content in various novel biscuits fortified with fruits and vegetables seed.

Sample	Value (mg/100 g)
Control	0.15±0.06
Date	0.38±0.02
Pumpkin	0.41±0.30
Jackfruit	0.18±0.08
Bean	0.17±0.01
Mixed	0.17±0.01

Values are presented as mean±SD.

3.5 Antioxidant content of novel biscuits

Analysis shows that the percentage of inhibition in the antioxidant test of novel biscuits which were the control and fortified with date seed, pumpkin seed, jackfruit seed, bean seed and mixed seeds was 74.33%, 83.35%, 91.33%, 89.70%, 81.67% and 95.06% respectively (Table 8) which was similar to the outcome of Iqbal *et al.* (2015). The percentage of inhibition was higher in mixed seed powder incorporated biscuits than the control and other biscuits. The values are statistically significant at $p < 0.05$.

3.6 pH values of novel biscuits

It was found that the pH of the control biscuit was 7.52. The pH of the date seed powder, pumpkin seed powder, jackfruit seed powder, bean seed powder and mixed seed powder incorporated biscuit were 7.26, 7.04, 7.15, 7.29 and 7.34 respectively (Table 9). The pH of the

Table 6. Physical attributes of novel biscuits incorporated with various fruits and vegetable seeds.

Physical attributes	Control	Date seed	Pumpkin seed	Jackfruit seed	Bean seed	Mixed seeds
Thickness (cm)	1.20±0.05[a]	1.06±0.15	1.34±0.14[a]	1.43±0.23[a]	0.97±0.20[a]	1.33±0.18[b]
Volume(cm^3)	15.13±0.29	12.51±0.28	16.49±0.15	16.68±0.27	17.37±0.17	18.58±0.26
Spread ratio	2.87±0.68	3.84±0.18[a]	3.12±0.20	3.38±0.15[a]	4.74±0.22	2.68±0.27
Spread factor	1.00±0.00	1.20±0.11[a]	0.92±0.05[a]	1.05±0.12[a]	1.41±0.03	0.80±0.004
Density (g/cm^3)	0.55±0.04[b]	0.55±0.04[b]	0.43±0.02[a]	0.51±0.03[b]	0.43±0.07[b]	0.48±0.28

Values are presented as mean±SD.
[a]statistically significant at p<0.01.
[b]statistically significant at p<0.01.

control biscuit was slightly higher than the date seed, pumpkin seed, bean seed, jackfruit seed and mixed seed powder incorporated biscuit. All of the biscuits were slightly basic in form.

Table 8. percentage of inhibition of novel biscuits fortified with fruits and vegetables seed.

Biscuit	Percentage of Inhibition (%)
Control	74.33±0.05
Date seed	83.35±0.10
Pumpkin seed	91.33±0.03
Jackfruit seed	89.72±0.19
Bean seed	81.66±0.10
Mixed seeds	95.06±0.08

Values are presented as mean±SD.

Table 9. pH values of novel biscuits incorporated with seeds powder.

Sample	Value
Control biscuit	7.52±0.04
Date seed incorporated biscuit	7.26±0.03
Pumpkin seed incorporated biscuit	7.04±0.03
Jackfruit seed incorporated biscuit	7.15±0.01
Bean seed incorporated biscuit	7.29±0.03
Mixed seeds incorporated biscuit	7.34±0.05

Values are presented as mean±SD.

3.7 Sensory evaluation

By using hedonic scales, results of different organoleptic quality parameters of control and developed biscuits were found. The evaluation shows that biscuits fortified with jackfruit seed powder have the highest appearance among the six samples (Table 10). It also shows that the flavor of bean seed powder fortified biscuits is highly accepted by the panelist. The value is 7.89±0.33. From the evaluation, it is seen that jackfruit seed powder fortified biscuits have the most accepted color and the value is 7.89±0.33. Control and pumpkin have the same value (7.30±0.48) in their color. The texture of date seed powder fortified biscuits (value is 7.63±0.52) was highly accepted by the panelist. Both the pumpkin and jackfruit seed powder fortified biscuits are equally accepted for their taste. The value of these biscuits is 7.60±0.52. The aroma of bean seed powder incorporated biscuits is highly accepted by the panelist. The evaluation value of this biscuit is 7.88±0.35. The overall acceptability value of bean seed powder (7.88±0.35) incorporated biscuits is higher compared to other biscuits similar to the findings of Alozie and Chinma (2015).

4. Conclusion

Fruits and vegetable seeds are an excellent source of macronutrients, micronutrients, and nutraceutical ingredients in this regard. To make the best novel biscuits, 15% seed powder is added to the biscuit recipe in place of refined flour. Compared to the traditional recipe, biscuits produced with 15% seed flour offer more protein, fat and fiber. Brown in color, a tad dense, and with a gritty mouth feel, the biscuits were nonetheless tasty. To improve our society's nutritional quality generally, fruits and vegetables seeds powder may be added to biscuits. The findings of this study could aid in the creation of commercial processing technology for the effective use of fruit and vegetable seed powder.

Conflict of interest

The authors have declared that no competing of interest exist.

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Table 10. Sensory evaluation of control and novel biscuits fortified with fruits and vegetables seed powder.

Quality attributes	Control	Date seed	Pumpkin seed	Jackfruit seed	Bean seed	Mixed seeds
Appearance	7.40±0.52	7.40±0.52	7.40±0.52	7.60±0.52	7.50±0.53	6.80±0.42
Flavor	7.22±0.44	7.67±0.5	7.67±0.5	7.56±0.53	7.89±0.33	7.56±0.52
Color	7.30±0.48	6.60±0.52	7.30±0.48	7.89±0.33	7.50±0.52	7.40±0.52
Texture	7.00±0.53	7.63±0.52	7.38±0.52	7.37±0.52	7.25±0.46	7.50±0.53
Taste	7.40±0.49	7.50±0.53	7.60±0.52	7.60±0.48	7.30±0.48	7.40±0.52
Aroma	7.13±0.35	7.50±0.53	7.38±0.52	7.38±0.52	7.88±0.35	7.38±0.52
Overall Acceptability	7.18±0.52	7.38±0.52	7.25±0.46	7.50±0.53	7.88±0.35	7.25±0.35

Values are presented as mean±SD.

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