RESEARCH ARTICLE II

Enhancing Functional and Nutritional Characteristics of Multigrain Mix by Incorporating Jamun Seed Powder

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Abstract

The jamun seeds are considered as waste products from industry and are usually thrown out. The jamun seeds have enormous nutraceutical properties as they contain bioactive compounds. The present study was designed to develop a multigrain mix incorporating jamun seed powder. Efforts were made to prepare jamun seed powder ing multigrain mix combinations of whole wheat flour, defatted soya flour, foxtail millet flour, and jamun seed powder. The multigrain mix was prepared by incorporating jamun seed powder at 2, 4, 6, 8, 10 % levels and were subjected to organoleptic evaluation. The sensory results showed that 4 % incorporation of jamun seed powder multigrain mix secured a high score for taste, flavor and overall acceptability. The 4 % incorporation of jamun seed powder multigrain mix was analyzed for nutritional properties and found to contain 11.21 percent moisture, 3.23 percent ash, 59.79 percent carbohydrate,1.65 percent fat, 19.45 percent protein, 3.25 percent fiber, 105.62 mg/100g calcium, 6.32 mg/100g iron. The glycemic index of jamun seed powder incorporated in multigrain mix was found to be 51 (low glycemic index) and it is suitable for consumption by diabetic people.

Keywords: *Jamun seed powder; Multigrain health mix; Glycemic index; Bioactive compounds*

Introduction

Diabetes is one of the major metabolic disorders and a leading health problem in the world, characterized by glucose intolerance and hyperglycemia. There are about 425 million people who have been suffering from diabetes in 2017 and this will be expected to rise up to 552 million by 2030 around the world. There is a need for therapeutic measures for the management of diabetes because of the side effects and cost of commercial medications and drugs people are interested in need of traditional and complementary medicines. Jamun, *Syzygium cumini* is an underutilized fruit crop it is also known as *Eugenia cumini* and belongs to Myrtaceae Family. Jamun seed is widely used in the treatment of different diseases, particular diabetes. when there is an optimum amount of sugar already present in the blood, the jamboline, is a glycoside compound present in the jamun seed, which helps in controlling the blood sugar level by switching off the mechanism of conversion of starch into sugar. Jamun seed powder is good source of fiber, vitamin-B complex (B1, B2, B3 and B6), vitamin-C, iron, and potassium as well as a potential source of bioactive compounds such as total phenolics and anthocyanins and they are low in cholesterol and fat. The jamun seed powder can be blended with a multigrain mix containing foxtail millet flour, defatted soyabean flour, whole wheat flour which are low in bioactive compounds, to increase the functional and nutritional characteristics of the multigrain mix. Supplementation of multigrain mix with jamun seed powder could be the best way to improve the functional and nutritive value and cater to the health therapeutic needs of diabetic people

Materials and methods

Formulation of jamun seed powder incorporated multigrain mix

The jamun fruits were cleaned thoroughly in running tap water to remove dust and dirt particles.

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The jamun seeds and edible pulp were separated using a hand pulper. Then, jamun seeds were dried in a hot air oven at 60˚C for 8 hours. The dried seeds were ground into a fine powder using an electric churner and sieved using BS 60 mesh sieve. Thejamun seed powder was incorporated into a prepared multigrain mix containing whole wheat flour, foxtail millet flour, and defatted soybean flour. To standardize multigrain mix, preliminary trials were conducted and prepared by incorporating 2,4,6,8 and10% jamun seed powder into multigrain mix presented in Table 1. Based on organoleptic evaluation after preparing products 4% incorporation of jamun seed powder was found to be highly acceptable. The prepared multigrain mix was sieved to remove any inedible matter and stored in airtight container for further analysis.

Sensory evaluation:

Acceptance was tested by sensory evaluation using 9-point hedonic scale at Food Science and Nutrition Department, Community Science College and Research Institute, TamilnaduAgricultural University, Madurai. Where a product is made with multigrain mix was used for sensory evaluation. The product made with different treatments of multigrain mix was coded with three-digit number and is tested by 10 semi-trained panelists. They were asked to score the product prepared from multigrain mix based on sensory parameters like color, flavor, texture, taste, and overall acceptability. They were provided water to rinse the mouth to avoid overlapping of taste and scored from 1 – 9 with 1 being “I dislike extremely” i.e., very bad, and 9 being “I like extremely” i.e., the product is excellent in that particular attribute.

Proximate Analysis of jamun seed powder incorporated Multigrain mix

Moisture

The moisture content of food items is directly related to the dry matter of such food items with implications on storage life and economics to processors and consumers. The moisture content of food samples was determined by the hot air oven dry method. For moisture determination, the empty Petri dish with a lid was weighed and 5.0 g of food sample was weighed into the Petri dish and evenly spread for uniform drying at 110 °C for 2 hours with an open lid in triplicates to obtain concordant value. After that, the Petri dish was cooled in a desiccator and further the weight of the Petri dish with sample was noted.

$$\text{Moisture \%} = \frac{\text{Initial weight} - \text{Final Weight}}{\text{Initial weight}} \times 100$$

Ash:

Ash content of food samples was determined by using a muffle furnace. The muffle furnace temperature was set to 600 °c in which the empty crucibles were kept for 1 hour and cooled in a desiccator and weighed (W_1). Then, 2.0 g of food samples were weighed into the crucible and weight was noted in triplicates (W_2). The crucibles with food samples were kept on flame for charring to remove organic matter and incinerated in muffle furnace at 600 °c for 3 hours. The crucible was transferred into the desiccator for cooling after complete ashing of the sample. Finally the weight was noted (W_3).

$$\text{Ash \%} = \frac{\text{Weight of the ash } (W_3 - W_1)}{\text{Weight of the food sample taken } (W_2 - W_1)} \times 100$$

Where

W_3-W_1= Weight of the ash

W_2-W_1 = Weight of the food sample taken

Carbohydrate

The total carbohydrate content of the food sample was determined. The carbohydrates are first hydrolyzed into simple sugars using dilute hydrochloric acid. The glucose in a hot acidic medium was dehydrated to hydroxymethyl furfural. The hydroxymethyl furfural compounds with the addition of anthrone reagent form a green-coloured product with maximum absorption at 630 nm.

100 mg of food sample was transferred into a boiling tube and hydrolyzed with 5 mLmL of 2.5 N HCL for three hours using a boiling water bath and cooled at room temperature. The sodium chloride was added to neutralize the solution. Then the solution was made upto mL100 mL and centrifuged to collect the supernatant. 0.5 mLand 1.0 mlmL mL of the supernatant solution from the centrifuge tubewere taken as the test solution. Glucose solution was prepared and used as a working standard and it was taken into different concentrations such as 0, 0.2, 0.4, 0.6, 0.8, and 1 mLmL. The volume of all the test tubes was made up to 1 mLmL with distilled water. Then 4 mLmL of anthrone reagent was added to all the test tubes and heated for 8 minutes. Cooled it rapidly and read at 630 nm. The standard graph was drawn by plotting the concentration of standard against absorbance and the amount of carbohydrate present in the food sample using was calculated using graph.

$$\text{Amount of glucose present in 100 mg of the sample} = \frac{\text{mg of the glucose}}{\text{Volume of test sample}} \times 100$$

Protein

The amount of nitrogen present estimated the protein content of the food sample in the sample by using the Micro Kjeldahl method. 0.1 g of sample was taken and added into 250 mLmL digestion tube with 10 mLmL of concentrated sulfuric acid and 3 g of catalyst mixture containing potassium or sodium sulphate and copper sulphate in the ratio of 5:1. The sample was digested for 3 hours at 40°C until the solution become colorless. After digestion was completed to recover ammonia content, the sample was placed in the distillation unit. The solution was distilled and the receiver side ammonia was collected. The solution was titrated after distillation against 0.1N hydrochloric acid for the end point until the color changed. To get a blank titre value again the same procedure was repeated and to calculate the nitrogen content in the sample by multiplying by factor 6.25, through which the crude protein of the sample in percent was obtained (Ma and Zuazaga 1942).

$$\text{Ash \%} = \frac{\text{Weight of the ash } (W_3 - W_1)}{\text{Weight of the food sample taken } (W_2 - W_1)} \times 100$$

Where

W_3-W_1= Weight of the ash

W_2-W_1 = Weight of the food sample taken

Protein % = Nitrogen % × conversion factor (6.25) other foods

Fat

The fat content of the sample was determined by using soxplus apparatus. The oil content was extracted from the sample with solvent petroleum ether (60-80°C) for two hours using sox plus apparatus. After extraction the solvent was evaporated for 1 hour in hot air oven and the remaining residue was weighed for fat percent in the sample.

$$\text{Fat (\%)} = \frac{W3 - W2}{W1} \times 100$$

W1 – Weight of the sample taken for estimation
W2 – Weight of the flask
W3 – Weight of the flask with fat residue

Crude fibre

The defatted sample of 1.0 g was taken into the weighed glass crucible (W_1), and with the glass extractor, it was fixed in the crucible holder. 150 mLmL of pre heated 1.25 % of H2SO4 was added to the extractor and the sample was boiled at 500 °C for 30 minutes and 400 °C for 30 minutes. Through the fibra flow system, the acid solution was sucked from the extractor. The residue was washed with distilled water to remove the acidity in the sample. Then digested at 500 °C for 30 minutes followed by 400 °C for 30 minutes by adding 150 mLmL of preheated 1.25 % NaOH. Then drained out the solution from the extractor and washed with distilled water to remove the alkalinity. The sample was dried in the hot air oven at 100 °C for one to two hours, cooled and weighed.

$$\text{Crude fiber (\%)} = \frac{(W3 - W2)}{W1} \times 100$$

W1 = Weight of sample
W2 = Weight of crucible
W3 = Weight of residue with crucible

Iron

The iron in foods is estimated by converting iron to ferric form by using oxidizing agents like hydrogen peroxide or potassium persulphate and thereafter treated with potassium thiocyanate to form red ferric thiocyanate, which was measured calorimetrically at 480 nm. The ash solution of the sample was used for color development.

Color development into three stoppered measuring cylinders, pipette the solutions as given below

S. No	Particulars	Blank (mLmL)	Standard (mLmL)	Sample (mLmL)
1.	Standard iron solution (mL1mL =0.1mg of Fe)	0.0	1.0	0.0
2.	Sample ash solution	0.0	0.0	5.0
3.	Water	5.0	4.0	0.0
4.	Conc.H_2SO_4	0.5	0.5	0.5
5.	Potassium persulphate	1.0	1.0	1.0
6.	Potassium thiocyanate	2.0	2.0	2.0

In each of the above cases, the volume was make up to 15 mLmLwith distilled water. The color was measured at 480 nm by setting the blank at 100 % transmission.

$$\text{Iron mg/100g} = \frac{\text{OD of sample} \times 0.1 \times \text{Total volume of ash solution} \times 100}{\text{OD of standard} \times 5 \times \text{Weight of the sample taken for ashing}}$$

Calcium

An aliquot of the ash solution obtained by dry ashing was pipette out to a 250 mLmL beaker. 10 mL of saturated ammonium oxalate solution and 2 drops of methyl red indicator were added. Then dilute ammonia was added to make the solution slightly alkaline and then added with a few drops of acetic acid to make the solution slightly acidic until the color is faint pink (pH 5.0). The solution was heated to the boiling point and it was kept at room temperature overnight. The solution is filtered through Whatman No.42 and washed with water, till the filtrate was oxalate free. Break the point of the filter paper with a pointed glass rod or platinum wire. Then the precipitate was washed with hot dilute H_2SO_4 from the wash bottle into the beaker in which calcium was precipitated. Then it was washed with hot water and titrated while still hot(temperature 70 ^{o}C) with 0.01 N $KMnO_4$ to the permanent pink colour. Finally, the filter paper was added to the solution and completed the titration.

$$\text{Calcium mg/100g} = \frac{\text{Titre} \times 0.2 \times \text{total volume of ash solution} \times 100}{\text{Volume taken for estimation} \times \text{Weight of sample taken for ashing}}$$

Predicted glycemic index (pGI)

100 g of ground sample was incubated with 10 mL HCL – KCL buffer (pH 1.5) and 200 µL pepsin solution at 40 ^{o}C for 1 hour with constant shaking. 200 µLµL pancreatic α-amylase (1.5mg/10mL phosphate buffer; pH 7.8) was added to raise the pH and incubated for 45 minutes at 37^{o}C. 70 µL Na_2Co_3 solution was added to stop the enzyme reaction and samples were diluted to 25 mL with tris-maleate buffer (pH 6.9). Thereafter, 5 mL of pancreatic α-amylase solution (3U/5 mL tris-maleate buffer) was added to the sample and incubated at 37 ^{o}C with constant shaking. To inactivate the enzyme reaction, aliquots of 1mL were taken at 30, 90, and 120 minutes from the samples and placed into the boiling water for 5 minutes with vigorous shaking. After each inactivation, the samples were kept in refrigerator (4^{o}C) until the end of incubation time(180 min). All aliquots were treated with 60 µL of amyloglucosidase (3300 U/mL) and 3 mL of 0.4 M sodium acetate buffer (pH 4.75) then incubated for 45 minutes at 60^{o}C with constant shaking. After incubation, volume was adjusted to 10 mL with distilled water and centrifuged before transferring 0.1 mL aliquots of the solution into test tubes for glucose measurement. The glucose oxidase-peroxidase (GODPOD) kit (K-GLOX, Megazyme Bray, Co. Wicklow, Ireland) was used to measure the released glucose. UV-vis spectrophotometer was used to measure the absorbance at 510 nm against the reagent blank. The area under the concentration-over-time (AUC) was determined by plotting values on graph. The hydrolysis index (HI) was calculated as a percentage of total glucose released from the samples and it was compared to that released from standard glucose (0-180 minutes). The predicted glycemic index of the samples was determined according to the equation.

$$pGI = 39.71+0.549HI$$

Statistical analysis

The data obtained from the sensory evaluation of jamun seed powder incorporated multigrain mix was subjected to statistical analysis with a Completely Randomized Design(Gomez and Gomez, 1984).

Results

Chemical characteristics

From the results, the jamun seed contains 48.71 percent moisture, 2.23 percent ash, 87.34 percent carbohydrate, 4.63 percent protein, 1.20 percent fat, 1.23 percent fibre, 4.11 mg/100g iron, 133.31 mg/100g calcium. Kshirsagar, (2008) reported that jamun seed contains 53 g/100g moisture, 1.51 g/100g ash, 31.62 g/100g carbohydrate, 3.84 g/100g protein, 1.02 g/100g fat, 7.01 g/100g fiber. Raza *et al.,* (2015) determined that jamun seed contains 16.34±0.49 % moisture, 2.18±0.06 % ash, 1.97±0.59 % crude protein, 0.65±0.01 % crude fat, 4.19±0.12 % crude fiber.

Table 3. showed the jamun seed powder incorporated multigrain health mix contains 11.21 percent moisture, 3.23 percent ash. 59.79 percent carbohydrate, 19.45 percent protein, 1.65 percent fat, 3.25 percent fiber. 6.32 mg/100g iron, 105.62 mg/100g calcium.

Itagi and Singh, 2012 stated that the moisture content of the multigrain composite mixes varied from 10 to 12 per cent. Pradeep *et al.,* (2014) reported that multigrain ready-to-eat snack mix from cereals contain ash content of 1.63 percent respectively.

Shilpa and Pushpa, (2014) reported that the pla mix contains 60.53% of carbohydrate content. Syeda

and Zubaida, (2018) stated that 17.06 to 19.32 percent of protein was present in the developed multigrain flour mix. The fat content of the dhokla mix prepared from the foxtail millet contain 3.9 per cent respectively (Prabhakar, 2006). Sethy and Mogra, (2020) determined that the fiber content of Dalia premix contain 1.28 percent, respectively. The multigrain ready to eat snack mix from cereals contain 6.6 percent iron. (Pradeep *et al.*, 2014).

Among the six samples, the highest mean sensory scores for colour was given to T0 (8.5±0.13) followed by T2(8.0±0.01), and the lowest mean sensory scores for colour were given to T5(5.5±0.06). The ascending order of mean sensory scores for flavor was .0±0.17(T5) <6.5±0.17(T4)< 7.5±0.20(T3)< 8.0±0.00(T1)<8.0±0.04(T0) <8.5±0.08(T2). The highest mean sensory score for taste were given to T2(8.5±0.02) and the lowest mean sensory score for taste was given to T5(5.5±0.10). The highest mean sensory scores for texture were given to T0(8.5±0.21) followed by T2(8.5±0.09) and the lowest mean sensory score for texture was given to T5(6.5±0.06). The highest overall acceptability of mean sensory scores was given to T2(8.5±0.03) and lowest overall acceptability of mean sensory scores was given to T5(6.0±0.08). The treatment T2 secured a maximum score for flavor, taste, and overall acceptability respectively.

The glycemic index was determined using the predicted glycemic index method. The GI value of the control (T0) sample was observed to be 62.42 and the GI value of the multigrain mix was found to be 51. According to the glycemic index classification (GI>70 : high, GI 56-69 : intermediate, GI<55: low) (Brand Miller *et al*., 2002). Hence, control can be considered a moderate GI food and multigrain mix (T2) can be considered a low GI food. Nasreen and Azeem, (2020) reported that chapathi prepared from multigrain flour had 45.61 GI values wereas basic chapathi made with wheat flour had 61.41 GI values.

Conclusion

The jamun seed powder incorporated multigrain mix had enormous nutritive values, nutraceutical properties, and significant effect on sensory properties.4% incorporation of jamun seed powder into the multigrain mix was highly acceptable for the preparation of products. The jamun seed powder was incorporated into the multigrain mix to enhance its functional properties and it can be used to prepare a different kinds of products it is highly preferred by people who are suffering from diabetes. The development of products from jamun seed powder incorporated with multigrain mix is also advantageous for diabetic patients seeking alternative products containing healthy ingredients.

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Ethics statement

No specific permits were required for the described field studies because no human or animalsubjects were involved in this research.

Originality and plagiarism

Authors should ensure that they have written and submit only entirely original works, and if they have used the work and/or words of others, that this has been appropriately cited. Plagiarism in all its formsconstitutes unethical publishing behavior and is unacceptable.Consent for publication

All the authors agreed to publish the content.

Conflicts of Interest

There were no conflict of interest in the publication of this content

Data availability

All the data of this manuscript are included in the MS. No separate external data source is required. Ifanything is required from the MS, certainly, this will be extended by communicating with thecorresponding author through corresponding official mail; sharikadb1595@gmail.com

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Table 1. Composition of jamun seed powder incorporated multigrain mix

S.No	Composition (g)	Treatments					
		T0	T1	T2	T3	T4	T5
1.	Whole wheat flour	100	58	56	54	52	50
2.	Foxtail millet flour	-	10	15	20	25	30
3.	Soya flour	-	30	25	20	15	10
4.	Jamunseed powder	-	2	4	6	8	10

(Include in results before first paragraph)

Table 2. chemical characteristics of jamun seed

Parameters	Results
Moisture (%)	48.71
Ash (%)	2.23
Carbohydrate (%)	87.34
Protein (%)	4.63
Fat (%)	1.20
Fiber (%)	1.23
Iron (mg/100g)	4.11
Calcium (mg/100g)	133.31

(Include in results after first paragraph)

Table 3. Chemical characteristics of jamun seed powder incorporated multigrain health mix

Parameters	Result of Sample
Moisture (%)	11.21
Ash (%)	3.23
Carbohydrate (%)	59.79
Protein (%)	19.45
Fat (%)	1.65
Fibre (%)	3.25
Iron (mg/100g)	6.32
Calcium (mg/100g)	105.62

(Include in results after fourth paragraph)

Table 4. sensory evaluation of jamun seed powder incorporated multigrain mix product

Treatment (Sample)	Sensory Attributes				
	Colour and appearance	Flavour	Taste	Texture	Overall acceptability
T0	8.5±0.13	8.0±0.04	8.0±0.20	8.5±0.21	8.0±0.20
T1	7.5±0.11	8.0±0.00	8.0±0.23	7.5±0.12	8.0±0.25
T2	8.0±0.01	8.5±0.08	8.5±0.02	8.5±0.09	8.5±0.03
T3	7.0±0.05	7.5±0.20	7.5±0.09	7.0±0.10	7.0±0.07
T4	6.5±0.18	6.5±0.17	6.0±0.07	7.0±0.10	6.5±0.15
T5	5.5±0.06	6.0±0.17	5.5±0.10	6.5±0.06	6.0±0.08

Values are the mean ±standard deviation. All the samples were taken in triplicates

(Include in results after fifth paragraph)

Table. 5 Glycemic index ofjamun seed powder incorporated multigrain mix

Sl. No	Product	Glycemic index
1.	Control sample (T0)	62.42
2.	Multigrain mix (T2)	51