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Proximate nutritional evaluation and consumer acceptability of product prepared by rice and amla based gluten-free flour

Junaid Abid[1], Diya Khan[2], Nayab Bano[3] and Saleha Ahmed[4]
[1](*Department of Food Science and Technology/ University of Haripur, Pakistan*)
[2](*Department of Food Science and Technology/ University of the Poonch, Rawalakot*)
[3](*College of Pharmacy, University of Sargodha, Pakistan*)
[4](*Institute of Food and Nutritional Sciences, PMAS Arid Agriculture University, Rawalpindi, Pakistan*)

Abstract:
Background: *Individuals who suffer from celiac disease (CD) or other gluten-related disorders (such as wheat allergy (WA) and non-celiac gluten sensitivity (NCGS) even the ingestion of a small amount of gluten can lead to deleterious and serious health risks. Gluten-free diet is a part of treatment for celiac disease, but it is widely consumed around the world besides patient care.*
Materials and Methods: *Formulations of gluten free cupcakes based on rice flour and amla powder in three different ratios 95/5, 90/10 and 85/15 were developed. The aim of this research study was to investigate the physicochemical and rheological characteristics of rice and amla based composite flour as raw materials for gluten free cupcake formulations and its relationship to cupcake quality.*
Results: *Physicochemical and rheological analysis indicated that gluten free rice and amla based composite flours exhibited significant difference between proximate composition in comparison with rice flour. Overall sensory scores given to cupcakes were increased with increasing levels of amla powder. That reveals more consumer acceptability by increasing the concentration of amla powder. There was a significant difference in proximate composition and physical properties of cupcakes after increased content of amla powder.*
Conclusion: *Comparing the formulations containing different amounts of amla powder, it could be noticed that cupcakes enhanced with 10% of amla powder were scored better by sensory panel and have good nutritional value and good physical properties as compared to other formulations.*
Key Word: *Gluten-free; Rice flour; Amla powder; Cupcakes; Sensory evaluation.*

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I. Introduction

The principle shape-forming protein, responsible for giving flour its shape is called gluten. It also gives dough its elastic properties and crumb shape of many baked goods[1]. Gluten intolerance, or celiac disease, results in inflammatory damage to the small intestine mucosa[2]. Gluten-free diet is a part of treatment for celiac disease, but it is widely consumed around the world besides patient care. It seems clear that the vast majority of people who avoid gluten do not have undetected celiac disease. Sets of evidence, primarily serological markers, still point to gluten susceptibility as a possible factor[3]. In recent years, gluten free items have become very popular, as they are not only fulfilling the needs of people with medical needs but also to consumers who eat a gluten free diet. Different mixtures of these ingredients bring a wide difference in the nutritional composition of gluten free items with respect to gluten containing foods[4].

Oryza is the scientific name for rice, which is a monocotyledon plant. Nearly half of the world's population eats rice, as one of the most important staple foods. Rice has grown to be a significant crop in parts of North and South America, Africa, and Europe[5]. In human diets, milled rice supplements sulfur-amino-acid-deficient but lysine-rich legume proteins, resulting in a higher amino acid capacity than either rice or legume[6]. One of the best cereals for gluten-free product formulations is rice flour, due to its soft taste, properties of hypoallergenic, having no color, sodium in low quantity and easy digestible carbohydrates[7]. Rice flour has highly special nutritional qualities due to its hypoallergenic properties, colorless characteristic and bland taste. Rice grain has more quantity of lysine content than other cereals grains, and its glutelin has a more uniform amino acid profile than wheat prolamin, which contain low quantity of lysine and tryptophan[8]. The network that is required to retain the gas during the fermentation process cannot be formed by rice proteins. However, rice has a low prolamin content (2.5–3.5%) and when rice flour is mixed with water it is difficult to form viscoelastic dough[1]. To improve the properties of the protein network and make the dough as similar to wheat dough, a variety of structuring agents are usually applied to gluten-free formulations, which include hydroxypropylmethylcellulose, carboxymethylcellulose, pectin, agar, xanthan gum, and other starches[9].

Amla (*Phyllanthus emblica* L.) is also a well-known functional food with various presentations in the market. The dried and dehydrated amla fruits, mixed with sugar to suppress its natural sour and astringent taste, are used as snacks. In addition, amla fruits have been used in pickles and jams. Amla fruit pastes with proper spices are also used in several food preparations. There are also bread preparations using amla fruit powder[10]. Amla in traditional medicine is considered a potent rejuvenator and immune modulator with its effect on digestion, cough, asthma, heart diseases, hair growth, eye health, and overall body and intellect[11]. Amla fruit contains numerous phyto-constituents, including polyphenols like tannins, gallic acid, ellagic acid, amino acids, vitamins, minerals, fixed oils, and flavonoids[12]. Producers are facing problems in formulation of amla based products, consumer acceptability and evaluation of their health benefits. There is a lack of information regarding nutritional composition and health benefits of gooseberry based food products. The aim of this research is to study physic-chemical properties of rice and amla based composite flour and consumer acceptability of its product.

II. Material And Methods

Collection of materials

Rice (*Oryza sativa*) variety (Green Super Rice) was collected from Food Science Research Institute (NARC), Pakistan. Dry amla fruit (*Phyllanthus emblica* L.) powder, sodium hydrogen carbonate ($NaHCO_3$), vegetable fat, Sugar, Eggs and Milk powder were purchased from local market of Islamabad, Pakistan. Rest of the analysis was done at Food Science Research Institute, (NARC), Pakistan.

Milling of grains

All the grains were cleaned manually. Milling of rice grains was done through Perten laboratory mill 3100 (Perten instruments, Hagersten, Sweden) attached with 0.8 mm sieve. The flour obtained after milling will be used for further analysis.

Treatment plan

RF (Rice flour) was used as a control sample. Rice flour was named as RF and amla powder was named as AP. RF (Rice flour) and AP (Amla powder) were mixed together in ratios 95:5, 90:10 and 85:15 and named as S1, S2 and S3 respectively.

Moisture determination of flour

Moisture determination of amla powder, rice flour and their blends was carried out according to method[13] (AACC, 2000).

Protein determination of flour

The procedure was done by using NIR spectrophotometer including two main steps; calibration and routine tests. Some samples of commodity were selected (at least 40) to be tested, covering the full ranges of all proteins and moisture that was expected even in future testing’s. All the samples were grinded one by one, mixed thoroughly, then putted in a test cell and then raw data was recorded according to instructions of manufacturers. The Each test sample was grinded then mixed thoroughly and placed in the test cell and then readings were taken at 0-degree position and after 120-degree rotation[14].

Fat determination of flour

The fat content of the flour samples was determined by using (AACC, 2000) method[13].

Ash determination of flour

Ash determination regarding flour samples was carried out using muffle furnace according to method[13] (AACC, 2000).

Fiber determination of flour

Ash determination regarding flour samples was carried out using muffle furnace according to method[13] (AACC, 2000).

Gluten determination of flour

A Perten Glutomatic System, based on International Code Council (ICC Standard No. 155, No 158) was used for gluten determination of flour samples[13] (AACC, 2000). A special drying apparatus known as glutork was used to calculate the amount of dry gluten.

Percentage of wet gluten and dry gluten was calculated by using the following formula
% of Wet Gluten Content = (Total gluten/Weight of wheat flour sample) x100
% of Dry Gluten = (Dry gluten/Weight of wheat sample) x100

Particle size distribution of flour

The flour particle size was determined using a RoTap shaker (Seedburo Equipment Co., Chicago, IL, USA) according to method[15] (AACC, 2010). Flour (100 g) was weighed and sifted on the sieves with screen openings of 250, 200, 180, 150, 132, 105, 85 and 55 μm for 5 min. Flour fractions retained on each sieve was weighed and expressed as the percentage of flour in each particle size range.

Farinograph

Farinographic properties related to flour samples were determined by using method[13] (AACC, 2000). The tests of Brabender farinograph white and composite flour was carried out using a 50 g mixing bowl that was connected with a circulating water bath operating at a temperature of 30°C. Dough was prepared by adding water from a burette to the flour and mixed thoroughly. As the dough was prepared, the farinograph was started working and recorded a curve on graph paper. By adding the appropriate amount of water the curve was centered on the 500-Brabender Unit (BU) line ±20 BU, and it was running until the curve leaves the 500-BU line. Parameters including water absorption, dough development time, dough stability time, mixing tolerance index, douh consistency and time to breakdown were determined using Brabender Farinograph software (Version: 3.2.6).

Cupcake Preparation

Cupcake was prepared by modifying the recipe provided by Carullo *et al*. (2020)[16]. RF, S1, S2 and S3 were used as flours. Sugar, eggs, vegetable fat, milk powder, Sodium hydrogen carbonate ($NaHCO_3$) was used as ingredients in cupcake preparation. Liquid whole egg was mixed for 10 min by using mixer. Then 100g sugar and100g vegetable oil was added and mixed until clear consistency reached. 100g of the flour was mixed with 4g Sodium hydrogen carbonate ($NaHCO_3$) and added to the dough. After mixing 100g of the milk powder was added at the end and mixing was done. 100g of the dough was weighted and placed into cake pan. Samples were baked in a baking oven at 180℃ for 30 min. After baking samples were allowed to cool at room temperature.

Sensory evaluation

Cupcakes were evaluated for color, taste, flavor, texture, softness, stickiness, chewability and overall acceptability after 1 hour of baking process. Cake samples were scored according to a 9-point Hedonic Scale (1 = strongly unpleasant; 9 = strongly pleasant). Each sample was scored by 14 judges (7 males and 7 females from 30 to 47 years age). Polyethylene pouches containing cupcake will be distributed with score cards. Each sample was evaluated by trained panel of 14 judges (7 males and 7 females from 30 to 47 years age group) for sensory attributes of cupcake. Cupcakes were judged in duplicate by each judge and average value will be calculated[17].

Proximate analysis of cupcakes

Moisture and fiber content of cupcake samples were determined according to methods (AACC, 2000)[13]. Protein content of cupcake samples was estimated by the method given by using Micro kjeldhal aperture and the protein content of cake was determining by the estimating the percent of Nitrogen[18] (AOAC, 2007).
{Protein (%) =Nitrogen (%) × (6.25)}
The fat content of cupcake was determined by using (AOAC, 2007) methods[18]. By solvent extraction method using Soxhlet Apparatus the ether was evaporated and residues was weighted which represented fat content. Then % value was calculated.

Physical properties of cupcakes

Width and length were measured by vernier caliper. Weight of cupcakes was measured as average of values of flour individual cupcakes with the help of digital weighing balance[19].
Volume (cm3) = L × W × T
L= average length of cupcakes (cm)
W= average width of cupcakes (cm)
T= average thickness of cupcakes (cm)

Statistical analysis

All of the tests were repeated three times and their mean values were specified by standard deviations. Statistical analysis was carried out by using MINITAB software version 16. Variations between samples were determined by (ANOVA). Least significant difference (LSD) was undertaken to differentiate mean values at 5% level of significance.

III. Result and discussion

Proximate composition of flour

Amla powder contained 7.02% moisture, 9% ash, 5.8% protein, 15.99% fiber and 0.62% fat (Table no 1). These results were agreed with Goraya and Bajwa (2015)[20], who reported chemical composition of amla powder showed nutrient value of moisture, ash, protein, fiber and fat in dry weight as the values were 6.56%, 9.31%, 5.60%, 16.98% and 0.52% respectively. Rice flour contained 11.87% moisture, 0.32% ash, 8.67% protein, 0.83% fiber and 2.33% fat. Jamal et al. (2016) reported similar values while studying proximate composition and functional properties of rice varieties in Pakistan[21]. The values given for proximate analysis of rice varieties were ranged as (5.46-7.08%) moisture, (0.48-1.23%) ash, (8.13-9.77%) protein and (0.43-1.5%) fat respectively. An increasing trend of fiber and ash content was noticed after addition of amla powder (0-15%) to rice flour and slightly decreased values were observed for moisture, protein and fat content. Amla and its byproducts contain no gluten content and used in gluten free formulations Tangariya and Srivastava (2022)[22]. Ali and Abol-Ela (2019) reported similar values of gluten content during studying the physical and chemical properties of gluten free biscuits[19]. Blended flours of rice, corn and sorghum was used to produce gluten free biscuits and all of the blended flours except wheat flour were tested with 0.00 wet gluten content.

Table no 1: Proximate composition and gluten content of flour samples

Samples	Moisture (%)	Ash (%)	Protein (%)	Fiber (%)	Fat (%)	WG (%)	DG (%)
AP	7.02±0.02	9.00±0.08	5.80±0.12	16.98±0.13	0.52±0.04	0±0.00	0±0.00
RF	11.87±0.05	0.32±0.02	8.67±0.11	0.83±0.03	2.33±0.12	0±0.00	0±0.00
S1	11.81±0.1	0.39±0.02	8.58±0.16	1.02±0.10	2.28±0.03	0±0.00	0±0.00
S2	11.69±0.4	1.09±0.05	8.37±0.09	1.29±0.02	2.22±0.07	0±0.00	0±0.00
S3	11.38±0.1	1.33±0.03	8.29±0.21	1.77±0.04	2.13±0.11	0±0.00	0±0.00

All values are represented as Mean ± S.D (Standard Deviation), data was analyzed by one-way ANOVA (Analysis of variance) Test using Minitab software version 16, ($P<0.05$), WG (Wet gluten), DG (Dry gluten).

Particle size distribution of flour

Maximum no of rice flour particles were present on sieve >250μm which were noted as 36.00g and minimum no of particles were present on sieve >85μm which were recorded as 3.00g. Maximum particles of amla powder were present on sieve >250μm which were 26.50g and lowest no of particles were found on sieve >180μm which were 3.00g (Fig no1). Rice flour particles were greater in size as compared to amla powder. Particle size of flour decreased when amla powder added (0-15%) in to rice flour. Similar investigations were carried out by CHEN et al. (2004)[23], who studied physicochemical characteristics and particle size distribution for Taiwan rice cultivars. Size of mesh used for sieving process were > 60, 60-100, 100-150, 150-200, 200-250, and < 250 μm and flour percentage of rice variety TCW70 present on them was recorded as 80.14%, 10.40%, 7.07%, 2.02%, 0.25% and 0.12% respectively.

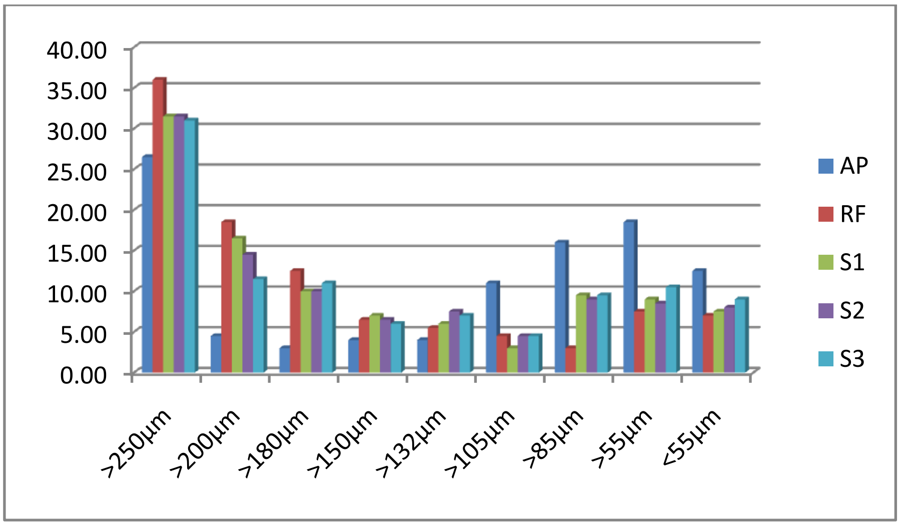

Figure no 1: Particle size distribution of flour samples.

Rheological properties of flour

The results of rheological study of rice flour were recorded as (53.20%) water absorption, (1.30min) dough development time, (0.50min) dough stability time, (506.00BU) mixing tolerance index, (506.00) consistency and (19.90min) time to breakdown (Table no 2). Addition of amla powder to rice flour significantly affects the rheological properties of rice flour. Dough development time, dough stability time and time to breakdown was increased by addition of amla powder (0-15%) to rice flour. Mixing tolerance index and consistency slightly decreased after 10% addition of amla powder and then increased again after 15% amla powder addition. Our result values are in harmony with findings of Srikanlaya et al. (2018)[24]. The values of water absorption, dough development time, dough stability time and mixing tolerance index for rice flour was recorded as 50.23%, 0.50min, 0.40min and 160.67FU respectively. Gujral and Rosell (2004) reported similar values while studying addition of glucose oxidase in rice flour and effect on bread making quality of rice flour[8]. Highest value of the dough consistency was obtained in rice flour (0% glucose oxidase and 4% hydroxypropylmethylcellulose) which was recorded as 330. Present findings are in accordance with results of Fari et al. (2010), who studied the effects of rice variety on composite flour and quality of bread[25]. Different varieties of rice were mixed separately with wheat flour. Highest value was recorded for rice variety Bw 272-6b which was 22.8min.

Table no 2: Farinographic properties of flour samples

Samples	WA (%)	DDT (min)	DST (min)	MTI (BU)	Consistency	Time to breakdown (min)
RF	53.2±0.31	1.3±0.11	0.5±0.12	506±0.22	506±0.21	1.9±0.09
S1	57.6±0.21	1.2±0.24	1.1±0.09	507±0.41	507±0.10	1.6±0.13
S2	54.1±0.12	1.4±0.14	1.5±0.11	489±0.26	489±0.24	2.7±0.11
S3	52.1±0.09	2.1±0.17	2.9±0.10	505±0.23	505±0.34	3.0±0.16

All values are represented as Mean ± S.D (Standard Deviation), data was analyzed by one-way ANOVA (Analysis of variance) Test using Minitab software version 16, ($P<0.05$). WA (Water absorption), DDT (Dough development time), DST (Dough stability time), MTI (Mixing tolerance index).

Sensory properties of cupcakes

Sensory evaluation of cupcakes was done by using 9-point hedonic scale. Sensory scores given to RF were (8.00) color, (7.00) taste, (5.10) flavor, (3.20) texture, (4.00) softness, (4.00) stickiess, (7.20) chewability and (7.25) overall acceptability (Table no 3). Our results are in harmony with findings of Ali and Abol-Ela (2019), who studied the quality characteristics and physical properties of gluten free biscuits[19]. Highest score for taste was given to wheat flour biscuits which was 18.80 out of 20 followed by blended flour of rice, sorghum and corn (1:1:1) which was 18.00 out of 20. Torbica et al. (2012) reported similar scores, while studying quality characteristics of rice and buckwheat flour-based cookies[26]. Hedonic scale of 5 points (1 — dislike very much, 5 — like very much) were used in this study to score sensory attributes. Highest score regarding flavor was given to cookies made from rice and buckwheat flour (80:20) which was 4.11 followed by cookies made from rice and buckwheat flour (70:30) which was 4.00. Our results are in harmony with findings of Ali and Abol-Ela (2019), who studied the quality characteristics and physical properties of gluten free biscuits[19]. Rice, sorghum and corn flour were used to prepare biscuits and wheat flour was used as reference flour in this study. Score for texture was given according to scale 1-20. Biscuits made from wheat flour gained 19.33 and biscuits made from rice flour gained 12.00 score.

Similar results were obtained by Jangchud et al. (2004)[27]. In this study effects of rice flours and water content on qualities of thai rice cake was determined. A 9–point hedonic scale (1 = dislike extremely; 5 = neither like nor dislike; 9 = like extremely) was used to evaluate acceptability of the product attributes. Maximum score regarding softness was 7.6, which was given to thai rice cake having jasmine rice flour and yellow-11 rice flour (20:80) and water content 0.5 times of total weight. Kim et al (2014) reported similar scores, while studying textural and sensory characteristics of rice chiffon cake formulated with sugar alcohols. 7-point Hedonic scale was used in this study to score the sensory attributes of rice chiffon cake[28]. Highest score regarding stickiness was given to rice chiffon cake (xylitol 75% treatment) which was 5.8. Similar results were reported by Rahim Monfared and Nouri (2020)[29]. In this study Sesamum indicum protein and transglutaminase was incorporated in gluten free rice flour cakes. Cake samples were scored according to a 9-point Hedonic Scale (1 = strongly unpleasant; 9 = strongly pleasant). Highest score regarding chewability was given to cake sample containing 6% sesamum indicum protein and 0.6% transglutaminase which was 4.6. These results are in accordance with the study of Turkut et al.(2016), Who investigated the effect of quinoa flour on gluten-free bread batter rheology and bread quality[30]. Sensory attribute was evaluated with a ranking test with a scale of "1"

(the least) to “5” (the most). Maximum score for color was given to control (25g rice flour+25g potato starch+50g buckwheat flour) which was 5.60 and minimum score was given to Q4 (25% rice flour+25g potato starch+50g quinoa flour) which was 2.64.
The color score of RF, S1, S2 and S3 samples was observed as 8.00, 6.00, 6.88 and 7.23 respectively. Highest score for color was given to RF and lowest was given to S1. The scores for taste given to samples RF, S1, S2 and S3 were observed as 7.00, 5.90, 6.60 and 6.50 respectively. Highest score for taste was given to RF and lowest was given to S1. Highest score for flavor was given to S3 which was 6.60 and lowest was given to RF which was 5.10. Highest score for texture was given to S2 which was 4.40 and lowest was given to RF which was 3.20. Highest score for softness was given to S3 which was 4.50 and lowest was given to S1 which was 3.50. Highest score for stickiness was recorded for RF which was 4.00 and lowest score for stickiness was observed for S3 which was 3.25. Highest score for chewability was 8.60 which was observed for S3. Overall acceptability scores recorded for samples RF, S1, S2 and S3 were 7.25, 7.00, 7.88 and 7.05 respectively. The scores for color and stickiness were observed in decreasing order after addition of amla powder (0-15%) to rice flour. Sensory scores for sample S2 were observed best as compared to all other samples (Table no 3).

Table no 3: Sensory evaluation of cupcakes

Samples	Color	Taste	Flavour	Texture	Softness	Stickiness	Chewability	Overall acceptability
RF	8.00±0.19	7.00±0.14	5.10±0.15	3.20±0.41	4.00±0.19	4.00±0.09	7.20±0.19	7.25±0.25
S1	6.00±0.22	5.90±0.15	5.70±0.18	4.02±0.27	3.50±0.26	3.40±0.24	8.00±0.33	7.00±0.14
S2	6.88±0.15	6.60±0.12	6.41±0.21	4.40±0.17	4.30±0.16	3.30±0.18	8.30±0.21	7.88±0.31
S3	7.23±0.42	6.50±0.41	6.60±0.25	4.30±0.13	4.50±0.15	3.25±0.27	8.60±0.26	7.05±0.42

All values are represented as Mean ± S.D (Standard Deviation), data was analyzed by one-way ANOVA (Analysis of variance) Test using Minitab software version 16, ($P<0.05$).

Proximate composition of cupcakes

Moisture content found in cupcakes prepared by RF was recorded as 13.79%. Moisture content gradually decreased after addition of amla powder to rice flour. Protein and fat content were less in amla powder as compared to rice flour therefore, these contents slightly decreased after addition of amla powder to rice flour. Amla contain higher value of fiber as compared to rice flour. Fiber content gradually increased after addition of amla powder to rice flour (Table no 4). Cakmak et al. (2021) reported similar range of values (17.98-20.45%) for moisture content of gluten free cupcakes while studying proximate composition of gluten free cupcakes[31]. Similar values were also reported by Hassan et al. (2017), while studying quality characteristics of gluten-free cupcakes made by rice flour fortification[32]. The range value for protein content of cupcakes was 4.32-5.27% and range value for fat content of cupcakes was 30.73-30.99%.

Physical properties of cupcakes

Weight, height and volume of rice flour were recorded as 88.00g, 4.70cm and 231.30ml respectively (Table no 4). Highest value for weight was recorded for RF which was 88.00g and lowest value was found for S3 which was 87.21g. Highest value for height was recorded for S3 which was 4.78 and lowest value was recorded for RF which was 4.70cm. Highest value regarding volume was 250.50ml which was recorded for S3 and lowest value was 231.30ml which was found for RF. Height and volume of cupcakes were increased and weight was decreased after addition of amla powder to rice flour.

Table no 4: Proximate composition and physical properties of cupcakes

Samples	Weight (g)	Height (cm)	Volume (ml)	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)
RF	88.00±0.71	4.70±0.24	231.30±0.15	13.79±0.23	4.64±0.26	20.04±0.24	0.50±0.03
S1	87.99±0.72	4.73±0.27	238.30±0.17	13.78±0.17	4.76±0.21	20.05±0.27	0.62±0.08
S2	87.53±0.39	4.76±0.12	246.75±0.25	13.29±0.11	4.60±0.10	20.01±0.25	0.75±0.05
S3	87.21±0.25	4.78±0.17	250.50±0.36	13.02±0.09	4.57±0.11	20.00±0.28	1.05±0.07

All values are represented as Mean ± S.D (Standard Deviation), data was analyzed by one-way ANOVA (Analysis of variance) Test using Minitab software version 16, ($P<0.05$).

IV. Conclusion

Measurements performed in this study revealed that mixtures of rice and amla flour can be successfully incorporated into gluten-free cereal- based products, resulting in cupcake of pleasant sensory characteristics and acceptable nutritional and physical properties. Physicochemical analysis performed on rice and amla based composite flour indicated that their mixtures expressed very similar protein, fat and moisture content to the rice flour. Dietary fiber and ash content of flour mixtures were increased after addition (0-15%) of amla powder to rice flour. It can be clearly seen from results that amla powder addition decreased the water absorption value and increased the values for dough stability time and dough development time. There was not a significant increase in mixing tolerance index and consistency values after addition of amla powder. Smaller size particles absorb more water as compared to larger one. There was not a significant decrease or increase in particle sizes after addition of amla powder to rice flour. After addition of amla powder to rice flour, it also increased the nutritional quality, sensory scores and acceptability of the cupcakes. Considering the physical, nutritional and rheological properties of flour and quality of cupcakes blend S2 (90% rice flour: 10% amla powder) exhibits a great potential for application in gluten-free bakery products.

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