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Development and Nutritional Assessment of Red Rice (*Oryza Longistaminata*) Based Muffins

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ABSTRACT

The present research development of gluten-free red rice muffins was carried out at the Department of Food Technology, Parul Institute of Applied Sciences, Parul University, Vadodara. The main objective of the study was to develop gluten-free muffins. Red rice is a type of whole-grain rice that is high in antioxidants, bioactive compounds, fiber, vitamins, and minerals. The main goal of this study was to develop muffins that are fully nutritious. These muffins can be a great option for those who have gluten intolerance or celiac disease, as well as for anyone looking for a healthier breakfast or snack option. The key ingredient of these muffins was red rice flour and jaggery powder. And other ingredients were milk, vegetable oil, cocoa powder baking powder, baking soda, vanilla essence and lemon juice. Twenty different formulations were prepared and T20 treatment was found to be the best formulation after sensory evaluation with 9 hedonic point scale. Then further chemical analysis was done in the developed muffins. It showed (17.8%) moisture content, (2.2%) Ash content, (7%) protein content, (8.94%) fat content, (83.55%) carbohydrates content, (0.4%) fiber and 340.9 kcal/100g. The mineral content of muffins was Calcium (14%), Magnesium (11.26%), Iron (5.12%) and Zinc (1.85%). During the 7 days of storage trials, red rice muffins showed an increase in moisture content but ash, fat and protein contents decreased significantly at ambient and refrigeration temperatures. An increase in moisture may be due to the permeability of air and a decrease in fat and protein may be due to the oxidation of fat and denaturation of proteins. Better retention of nutrients was noted for refrigeration temperature. Hence could be preserved for a longer time. FT-IR analysis showed the wavenumbers 928 cm-1, 2935 cm-1 and 1646 cm-1 which represent HC=CH, methyl (CH3), and C-O peak of ester and phenol was observed accordingly. Thus, the developed red rice muffins have improved nutritional value and should be suggested to individuals of all ages.

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1. INTRODUCTION

According to recent studies (Gao *et al.,* 2018; Wardy *et al.,* 2018), more people are becoming sensitive to, intolerant to, or suffering from autoimmune diseases like Celiac Disease (CD) caused by gluten. Major gluten-containing grains include wheat, barley, and rye, all of which harm the villi in the small intestine in CD sufferers. While just 1per cent of the population has received a CD diagnosis, it is believed that five to ten more persons go undiagnosed for every person who receives a diagnosis (Jones, 2017). A lot of people believe that eliminating gluten will lower cholesterol, support digestive health, and boost energy levels. Even if a person does not have a CD or a wheat allergy, the media has the power to persuade them to eat less food that contains wheat (Brouns *et al.,* 2013). 30Per cent of Americans expressed interest in eliminating gluten in 2013, according to the market research firm NPD (National Purchase Diary) (Jones 2017). According to a 2013 survey, 27per cent of American people choose gluten-free (GF) meals to help them lose weight. 65per cent of American adults said GF foods were healthier (Gaesser and Angadi, 2015; Jones, 2017). In research on young individuals, it was discovered that those with healthier lives

consumed more nutritious foods, and 13Per cent thought that GF food was healthy (Christoph *et al.,* 2018). Gluten in Celiac patients induces intestinal mucosal inflammation, which results in unpleasant and even highly painful symptoms in the gastrointestinal tract and/or extraintestinal areas. Although nonceliac gluten sensitivity shares many of the same signs and symptoms as celiac disease, it can be challenging to identify and estimate how common it is (Leonard *et al.,* 2017).

Adopting a GF diet is the main strategy recommended by medical professionals to prevent symptomatic gluten reactions. There is a relationship between consumers with CD following a GF diet and paying attention to the labels of these products. To find out how people with and without celiac disease differ in their adherence to a GF diet, more study is required (Xhakollari *et al.,* 2019). Because of their high pricing and limited availability, consumers' acceptance of and views on GF products have seen certain unfavourable reactions. Although consumers may be largely content with the flavour and texture of the GF items that are now on the market, attempts to make these products more palatable are nevertheless encouraged.

The word "Functional Food" is becoming more common as a general description of the advantages of consuming food that go beyond those explained only by the nutrients provided (Milner, 1998). Simply said, functional foods are any food or dietary component that offers health benefits above and beyond those of basic nutrition. The Institute of Medicine of the US National Academy of Sciences defines functional foods as "any modified food or food component that may give a health advantage beyond the regular nutrients it supplies" (Thomas and Earl, 1994). Although the idea of functional foods is just slowly gaining public acceptance, these foods have a lot of potential given people's current lifestyles. Interest in foods with health benefits has grown as a result of rising medical costs (Hanks, 1992). Additionally, the legislative changes that permit statements about food and its component (Clydesdale, 1997; Kottke, 1998), and the appearance of novel and fascinating scientific discoveries have argued in favour of consumers' need for functional foods (Farr, 1997; Milner, 1998) have additionally promoted the value of functional foods for consumer.

Muffins are available in many bakeries as a morning item or an afternoon snack. Due to their delicious taste and soft texture, muffins are greatly favoured by consumers. They are sweet, calorie-dense baked goods. Muffins have a spongy texture because of their inherent porous structure and large volume. A stable batter that can accommodate a lot of small air bubbles is necessary to produce this final structure (Martínez-Cervera *et al.,* 2012). Wheat flour, milk, sugar, vegetable oil/butter, and eggs are the classic ingredients for muffins. Due to the fact that they are manufactured with wheat flour, this type of baked good is inedible by people with celiac CD. Meanwhile, wheat-free muffins are becoming popular, to exclude wheat from someone's diet, among those who are interested in GF meals as well as those who are gluten-sensitive (Nachay, 2010). Additionally, eggless muffins are suitable for Lacto-vegetarians, particularly in India, where a substantial majority of the people are vegetarian (Singh *et al.,* 2015).

A significant technological challenge for bakers is the production of baked foods without gluten. In fact, a large number of GF products on the market frequently have poor technological quality, showing low volume, poor colour, and disintegrating crumbs in addition to a wide range in nutrient composition, with high fat and low protein contents (Matos and Rosell, 2011), especially in comparison to their wheat equivalents (Mariotti *et al.,* 2009). For the developed product to expand, rise in volume, and have the desired texture, the presence of gluten is essential for retaining the released gas during baking (Alvarez *et at.,* 2009). In order for the flour batter to have the desired viscoelasticity, a coherent protein network must be formed. The major components that produce gluten are glutenin and gliadin (prolamin). Prolamin and glutenin both contribute to the dough's extensibility and viscosity during wet mixing of wheat flour, whereas prolamin also gives the dough its elastic and cohesive properties (Agboola *et al.,* 2005). So, the crumb structure and look of items made from cereal are due to gluten. The total removal of gluten from cereal-based items including bread, breakfast cereals, pasta, cake, and biscuits remains a significant issue, despite recent improvements in the creation of products of equivalent quality that are gluten-free. The total removal of gluten from cereal-based items including bread, breakfast cereals, pasta, cake, and biscuits remains a significant issue, despite recent improvements in the creation of products of equivalent quality that are gluten-free.

Because it is a natural, hypoallergenic, colourless, and bland-tasting product, rice flour is a viable cereal ingredient for the creation of gluten-free products. Previous researchers frequently used physical alteration of rice flour (Gujral and Rosell, 2004a; Hagenimana *et al.,* 2006). Demands for GF foods that are comparable to conventional gluten-containing foods are rising among consumers who continue to

buy GF items. As a result, there has been a lot of research done recently to create sweet bakery items that are devoid of gluten in order to enhance their structure, mouthfeel, acceptability, shelf life, and nutritional value (Turabi *et al.,* 2008a; Gularte *et al.,* 2012a; Park *et al.,* 2012).

2. MATERIALS AND METHODS

The present study entitled **"Development and nutritional assessment of red rice (*Oryza longistaminata*) based muffins"** was conducted under different experiments in the Department of Food Technology, Parul Institute of Applied Sciences, Parul University, Vadodara, Gujarat, India during the year 2022-2023.

2.1. Procurement of raw materials

Red rice, jaggery powder, milk, cocoa powder, vegetable oil, baking powder, baking soda, vanilla essence and lemon juice were procured from the local market of Vadodara, Gujrat and brought to the product development laboratory of the Department of Food Technology, Parul University, Vadodara.

2.2. Preparation of product

Red rice flour, jaggery powder, cocoa powder, milk, oil, baking soda, baking powder, vanilla essence, lemon juice was used for the preparation of muffins. First of all, the dry ingredients (red rice flour, cocoa powder, baking soda, baking powder, salt) were taken and sieved them. Then after milk (lukewarm) and jaggery powder were mixed and then other wet ingredients like oil and vanilla essence were mixed properly. Then this mixer was poured in dry ingredients and mixed with the whisker properly until no lumps. And in the last lemon juice was mixed in the batter. The batter was poured into a muffin mould. An oven is preheated at 175° C for 10 min. Then these moulds were put in the oven for baking at 170° C for 22 min. After 22 min muffin moulds were taken out from the oven and cooled down for 10 min and de-mould them. The prepared muffin was packed in a container.

Figure 1: Unit operation of developed red rice muffins

2.3. Treatment details

The present research was focused on the production and standardization of muffins fortified with red rice (*Oryza longistaminata)*. The whole investigation was divided into various experiments and sub-experiments. The experiment details are given below.

Table: 1 Standardization of treatment blends

	Red rice flour (g)	Wheat flour (g)	Jaggery powder	Cocoa powder (gm)	Milk (ml)	Oil (ml)	Vanilla essence (ml)	Baking powder (gm)	Baking soda (gm)	Salt (gm)	Lemon juice (ml)
T_0	-	100	85	18	125	40	5	1.2	0.6	0.5	2.5
T_1	5	95	85	18	125	40	5	1.2	0.6	0.5	2.5
T_2	10	90	85	18	125	40	5	1.2	0.6	0.5	2.5
T_3	15	85	85	18	125	40	5	1.2	0.6	0.5	2.5
T_4	20	80	85	18	125	40	5	1.2	0.6	0.5	2.5
T_5	25	75	85	18	125	40	5	1.2	0.6	0.5	2.5
T_6	30	70	85	18	125	40	5	1.2	0.6	0.5	2.5
T_7	35	65	85	18	125	40	5	1.2	0.6	0.5	2.5
T_8	40	60	85	18	125	40	5	1.2	0.6	0.5	2.5
T_9	45	55	85	18	125	40	5	1.2	0.6	0.5	2.5
T_{10}	50	50	85	18	125	40	5	1.2	0.6	0.5	2.5
T_{11}	55	45	85	18	125	40	5	1.2	0.6	0.5	2.5
T_{12}	60	40	85	18	125	40	5	1.2	0.6	0.5	2.5
T_{13}	65	35	85	18	125	40	5	1.2	0.6	0.5	2.5
T_{14}	70	30	85	18	125	40	5	1.2	0.6	0.5	2.5
T_{15}	75	25	85	18	125	40	5	1.2	0.6	0.5	2.5
T_{16}	80	20	85	18	125	40	5	1.2	0.6	0.5	2.5
T_{17}	85	15	85	18	125	40	5	1.2	0.6	0.5	2.5
T_{18}	90	10	85	18	125	40	5	1.2	0.6	0.5	2.5
T_{19}	95	5	85	18	125	40	5	1.2	0.6	0.5	2.5
T_{20}	**100**	**-**	**85**	**18**	**125**	**40**	**5**	**1.2**	**0.6**	**0.5**	**2.5**

The standardization was done using 9 point hedonic scale which provides the score on the basis of colour, texture and taste. The overall acceptability is marked with score between 9-1. For the optimization of recipe, a total of 20 different combinations of treatment were carried out. After analysis of all the score cards, **Treatment-20** was selected as the best treatment.

2.4. Chemical analysis

To characterize food products in terms of chemical composition, traceability, safety, quality, sensory perception and nutritional value various parameters were analyzed. Moisture content, ash, crude fibre and carbohydrate were calculated by (Ranganna, 2009). Energy value was measured by bomb calorimeter. Crude fat and crude protein were estimated by (2012). Fourier Transform - Infrared Spectroscopy (FT-IR) was carried out as per the guidelines given by Stuart (2005) to identify the functional group present in the red rice muffins.

2.5. Sensory evaluation

Nine-point Hedonic scale method as given by Amerine *et al*. (1965) was followed for conducting the sensory evaluation of the sample.

2.6. Cost of production of functional muffins

The cost incurred for the purchase of raw materials like red rice flour, jaggery powder, milk, oil, cocoa powder, polyethylene pouches and other materials was considered. An overhead charge on expenditure, manufacturing cost on machinery and equipment, building, etc. were included for the calculation of unit cost on the product sale price of functional spread was calculated.

3. RESULT AND DISCUSSION

The present research entitled "**Development and nutritional assessment of red rice (*Oryza longistaminata*) based muffins**" was conducted under different experiments in the Department of Food Technology, Parul Institute of Applied Sciences, Parul University, Vadodara, Gujarat, India. The results of the study have been presented and discussed under different heads and sub-heads:

Standardized treatment of functional spread

Table: 2 Standardized blends for preparation of muffins

Sr. no.	Treatment	T_{20}
1	Red rice flour	100
2	Jaggery powder	85
3	Cocoa powder	13
4	Milk	125
5	Oil	35
6	Vanilla essence	5
7	Baking powder	1.2
8	Baking soda	0.6
9	Salt	0.6
10	Lemon juice	2.5

3.1. Chemical analysis

Various parameters such as ash content, Moisture**,** crude protein, crude fat, crude fibre, carbohydrates and energy value were determined in order to understand the chemical composition of developed muffins. The data in table 3 and 4 represents the chemical composition of developed muffins.

Table: 3 Chemical composition of developed muffins

Parameter	Result (%)
Moisture	17.8
Ash	2.2
Protein	7
Fat	8.94
Crude fibre	0.4
Carbohydrates	83.55
Energy	340.9 (Kcal/100)

Table: 3 Depict moisture and ash content as 17.8 per cent and 2.2 per cent respectively. The obtained value of protein, fat, carbohydrates and fibre were7, 8.94, 83.55 and 0.4 per cent respectively. The energy value obtained was 340.9 Kcal/100g. These results are closely related to Jeong and Hyun (2018).

3.2. Minerals content of developed Muffin

Table 4 Mineral content in developed muffins

Minerals	Results (mg/100g)
Calcium	14
Magnesium	11.26
Iron	5.12
Zinc	1.85

Table 4 depicts the calcium, magnesium, iron and zinc content as 14, 11.26, 5.12 and 1.85 mg/100g respectively. The above result mentions that the red rice muffin is rich in minerals.

3.3. FT-IR analysis

A well-known method for the identification and structural study of chemical compounds is Fourier-transformed infrared (IR) spectroscopy. The peaks in the IR spectrum of a sample corresponding to the molecules' different chemical bonds and functional groups because they are caused by the molecules' vibrational modes being excited by the sample. Consequently, a compound's IR band is one of its most distinctive physical characteristics and can be thought of as its "fingerprint." Because a compound absorbs infrared energy proportionally to its concentration, infrared spectroscopy is a potent instrument for quantitative analysis. FTIR analysis was carried out for the identification of functional groups and chemical compounds present in the developed spread and its results are discussed here under.

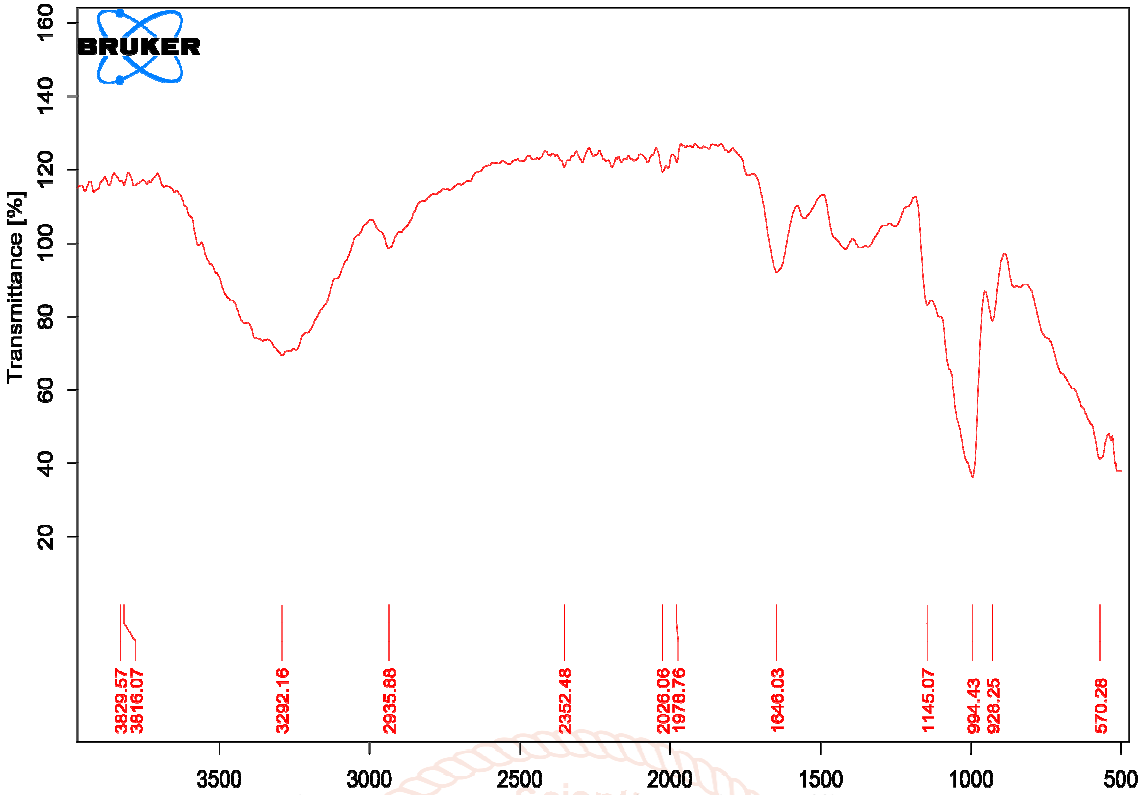

Figure:2 FT-IR analysis of red rice muffins

The data presented in figure 2 FT-IR spectrum was used to identify the active component present in red rice muffins. It showed the wave numbers 928 cm^{-1} and 2935 cm^{-1} which represent HC=CH and methyl (CH_3) respectively. (Bulut and Aydin, 2006). Wave number 1646 cm^{-1} shows C-O peak of ester and phenol was observed (AI-Degs *et al.,* 2008).

3.4. STORAGE STUDY

Table: 5 Storage studies of red rice muffins at ambient temperature (25-27ºC)

Parameter (%)	0th day	2nd day	4th day	7th day
Moisture	17.8	17.9	18.2	18.4
Ash	2.2	2.0	1.98	1.95
Fat	8.94	8.92	8.90	8.89
Protein	7	6.98	6.97	6.95

The red rice muffins showed a significant rise in their moisture content from 17.8 per cent to 18.4 per cent. The rise in moisture content may be due to the permeability of air and water. The ash content, fat and protein showed a decreasing trend from 2.2 per cent to 1.95 per cent, 8.94g to 8.89g/100g and 7g to 6.95g/100g.

Table: 6 Storage studies of red rice muffin at refrigeration temperature (4°C)

Parameter (%)	0th day	2nd day	4th day	7th day
Moisture	17.8	17.9	18.0	18.2
Ash	2.2	2.1	1.99	1.97
Fat	8.94	8.93	8.92	8.90
Protein	7	6.99	6.97	6.96

The increase in moisture was less at refrigeration temperature from 17.8 per cent to 18.2 per cent. Also, the fat, protein and ash content decreased from 8.94g to 8.90g/100g, 7g to 6.96/100g and 2.2 per cent to 1.97 per cent respectively. Thus, refrigeration temperature could be regarded as a better storage temperature as it could retain the maximum amount of nutrients.

3.5. Microbial evaluation

Initially, microbial growth was absent. But as the storage period time increased, slow microbial growth was recorded and the total plate count (TPC) of functional obtained was 5800 cfu/g.

3.6. Cost of production

Table:7 Cost of production of Developed functional spread.

Ingredients	Rate/100g	Quantity required (g)	Amount (≠)
Red rice flour	19	100	19
Jaggary powder	12.8	85	10.88
Cocoa powder	123	13	15.94
Milk	5	125	6.25
Oil	17.7	35	6.19
Vanilla essence	528.5	5	26.42
Baking powder	35	1.2	0.42
Baking soda	30	0.6	0.18
Salt	2.4	0.6	0.14
Lemon	5/piece	5	2
Miscellaneous	-	-	10
Processing charge	@ 10% of total cost		
Total Cost=107.24 ≠			

The prices of all ingredients were considered while calculating the expense incurred in the production of functional food products. The total price includes the processing fee as well as additional costs. The selling price was calculated after adding a 10 per cent profit margin. The total cost of 100 g of red rice flour ≠19. By using 100 gm of red rice flour and other ingredients, 250 gm muffins were obtained and the total price of the final product was ≠107.24. The cost of 100 g of muffins is ≠42.90. The data in Table 7 represents the production cost of developed red rice muffins.

4. CONCLUSION

Gluten-free diets can be challenging, especially when it comes to baked goods. However, this recipe for gluten-free muffins fortified with red rice is an excellent option for those looking for a nutritious and tasty alternative. Red rice adds fibre, antioxidants and bioactive compounds to these functional muffins, and makes them a healthier option than traditional muffins which are made up of all-purpose flour muffins. These gluten-free muffins with red rice flour, jaggery powder, milk, cocoa powder, and vanilla essence create a delicious, fluffy muffin that's sure to satisfy any sweet tooth. Though it is gluten-free, so gluten intolerance and celiac disease people can also eat them happily. Diabetic patients can eat jaggery so it is also beneficial for them. These functional muffins are way better than other muffins available in the market.

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