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Development of Muffins from Kodo Millet Flour using Fructooligosaccharide with the incorporation of *Clitoria ternatea*

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Abstract

The study aims to investigate 3 types of muffins that were prepared and named T1, T2, and T3 increase according to blue pea flower powder content. (T12%, T2 3%, T34%). After the completion of the experiment, it was found that T3 results were better in comparison to other muffins. As elucidated from proximal analysis, the control sample shows less acceptance compare to fortified muffins. Simultaneously texture control sample was found more than Kodo millet muffins. They are important in the networking of muffins after the addition of Xanthan Gum in muffins. Overall it indicates that Xanthun gum provides networking to muffins and enhances the structure of muffins with nutritional quality.

Keywords: Kodo Millet; Fructooligosaccharide; Xanthan gum; *Clitoria ternatea* (blue pea flower); Muffins

1. Introduction

Due to the small-intestinal mucosa's irritation from gluten ingestion, which also results in nutrient loss, Celiac disease is an autoimmune illness [1]. Since roughly 1% of the world's population has a gluten intolerance, the demand for gluten-free (GF) products (having less than 20 ppm of gluten protein) is rising [3]. According to Mustahti et al. (2010), this condition affects one in every hundred persons worldwide. The project's goal was to create muffins made with Kodo Millet, a gluten-free flour, Gluten is a crucial structural protein that helps baked goods keep their elasticity, gas capacity, and crumb structure[5].

Starches, dairy proteins, hydro-colloids, and other ingredients are often used in the production of gluten-free products to replicate the properties of gluten. It has a low volume, hard texture, dry gritty mouth-feel, and bland aroma in GF products [6]. In comparison to items having gluten, GF bakery products manufactured with gluten-free cereals and commercial grain products are weak in proteins, B vitamins, iron, and fiber[7]. Many people eat muffins for breakfast or as an after-work snack. Muffins are popular among customers because they are dense in calories, have a delicious flavor, and have a spongy texture [7].

To enhance the qualitative attributes of GF products, it has been suggested to use hydro-colloids like gums, proteins, and fibers. The polysaccharide Xanthan Gum (XG), which is released by the bacterium *Xanthomonas campestris,* is frequently employed as a thickening ingredient in food products. Due to its high water binding capacity, which raises the values of batter moduli, XG has been found to improve the quality of GF cakes and muffins by raising the viscosity of batters.(Gomez et al. 2007; Preichardt et al. 2011; Singh et al. 2015).XG has been found to improve the quality of GF cakes and muffins by raising the viscosity of batters. [10]. Additionally, Lacto-vegetarians can eat eggless muffins, notably in India where a sizable portion of the population is vegetarian. [8].

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According to Ashwini et al. (2009), the viscosity of egg-less cake mixtures rose when XG was added, which is a desired characteristic for gluten-free muffins.[13]

Consumers choose functional or value-added foods with higher levels of antioxidants and dietary fiber [14]. Although these products are quickly gaining appeal in the dairy and confectionery industries, the baking industry is still relatively underdeveloped [15]. Millets are still used in food; however, this is declining rapidly for several reasons. Therefore, to improve the nutritional value of consumers' diets, it is necessary to revive these significant food groups that promote health. Among the Millets, Kodo millet (paspalum scrobiculatum), also known as kodara, varagu, haraka, arakalu, and Japanese Kodo millet, is a significantly neglected grain. It serves as the foundation for meeting dietary nutritional needs. It has a lot of fiber (14.3%), little fat (4.2%), and a lot of protein (11%). Kodo millet is quite simple to digest, has a lot of lecithins, and works wonders for boosting the nervous system. Niacin, B6, and folic acid, as well as minerals like calcium and iron, are abundant in Kodo millet. Kodo millet is suitable for those who are allergic to gluten because it is gluten-free. For postmenopausal women showing symptoms of cardiovascular diseases, such as high blood pressure and high cholesterol levels, regular ingestion of Kodo millet is particularly helpful. Additionally, it can combine with most conventional and experimental foods without adding any of its flavors. Kodo millet is a traditional food that aids in weight loss and has a taste that is like rice. It is quickly absorbed and rich in phytochemicals and antioxidants, which aid in preventing many ailments linked to a sedentary lifestyle. Additionally, Kodo millet eases hip and knee discomfort and helps woman's periods become more regular. [9].

Oligosaccharides called fructooligosaccharides (FOS) are found naturally in a variety of plants, including artichoke, asparagus, onion, chicory, garlic, and banana [16]. The small intestinal glycosidases do not hydrolyze dietary FOS, therefore it enters the cecum intact. The intestinal bacteria there process them to produce short-chain carboxylic acids, L-lactate, CO2, hydrogen, and other metabolites. FOS has a variety of intriguing characteristics, such as a low sweetness intensity, as well as being calorie-free, non-cariogenic, and classified as soluble dietary fiber. FOS can be detected from sucrose, fructose, and glucose using thin-layer chromatography (TLC)[17]

Clitoria ternatea contains a variety of bioactive substances, including anthocyanin compounds, flavonoids, glycosides, steroids, resins, and phenols. These bioactive components from the CT plant include anti-diabetic, antioxidant, bacterial, anti-inflammatory, and analgesic properties[21,22]. The anthocyanin pigment responsible for the intense blue hue of the CT flower is found in abundance in *Clitoria ternatea*. As a result, it is utilized in the food industry as a food colorant. One of the most unstable food colorings in existence, anthocyanin is affected by temperature, pH, and other enzymatic activity. [20].

This present study was thus undertaken to utilize Kodo millet flour for human consumption as a source of dietary fiber and protein.

Development of muffins by addition of Kodo millet flour, along with FOS and Blue pea flower. To assess the effect of adding Kodo Millet Flour and FOS to muffins on sensory and nutritional characteristics. To enhance the nutritive value of the finished product to fulfill the nutritional demand.

2. Material and methods

2.1. Preparation of Kodo Millet Flour

For the preparation of Kodo Millet flour, grains were polished and cleaned. After cleaning of grains, it was transferred to a small bowl (attached to an electric decorticator) to remove the bran. After the debranning of Kodo millet grains were ground into the grinder. (Usha, Mumbai). Kodo millet grain flour passed through the sieve of 80 mm for uniformity.

2.2. Preparation of *Clitoria ternatea* flower powder

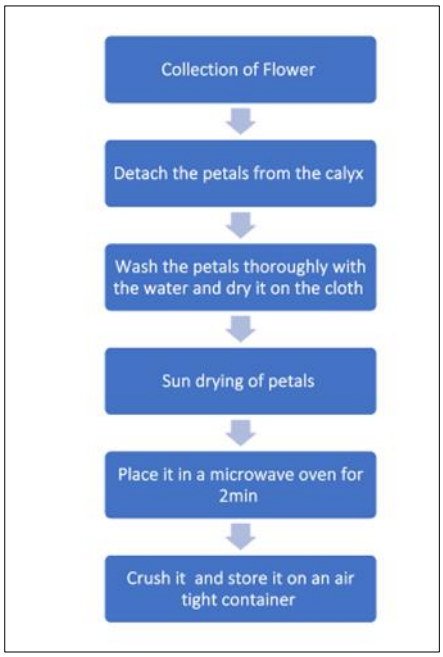

Figure 1 Flowchart of process of drying of blue pea flowers (*Clitoria ternatea*)

2.3. Preparation of Kodo millet muffins

The fundamental ingredients of muffins are Kodo millet flour (90 gms), Fructooligosaccharide(75 gms), vegetable oil(60 ml), milk (20 ml), Blue pea flower (3 gms), baking powder(2 gms), baking soda (1.5 gm), Yogurt (142 gms), Xanthan Gum and vanilla essence(6 ml). The addition of blue pea flower in the formulation is processed with 2%, 3%, and 4%. The mentioned parameters can be recognized as S1, S2, and S3, and control blue pea flower, were added to the mixture (dry ingredients), and other ingredients for each parameter were measured accurately and mixed.

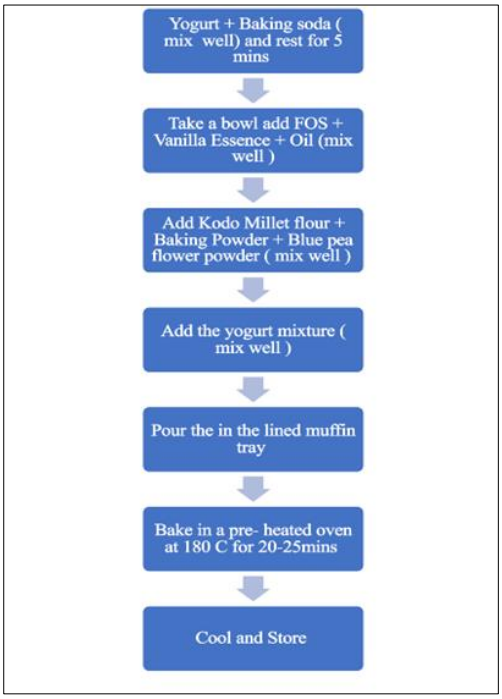

Figure 2 Flowchart of preparation of Muffins

2.4. Proximate analysis

The nutritional value of the components was evaluated using conventional AOAC techniques. The moisture content of the formulated muffin samples was assessed using AOAC 2010 guidelines. A sample of about 5 g was placed in a pre-weighted, 130 ℃ preheated crucible. The sample was dried for one hour at 130 ℃ in an air oven. The sample's weight loss was found, and the moisture content was computed. With the help of AOAC, protein, ash, fat, and crude Fiber were found. The sample's total carbohydrate content was calculated as total carbohydrate by difference, which is calculated by deducting the measured amounts of protein, fat, ash, and moisture from 100 g of the substance.

2.5. Sensory Evaluation of Standardized muffins

When a portion of food is subjected to forces like cutting, shearing, chewing, compression, or stretching, the texture response to those forces is measured. Food rheological characteristics affect the texture of the food. An indirect assessment of a food's rheological qualities is provided by the subjective measurement of texture.[18].

Using a 9-Point Hedonic Scale, fifteen panelists assessed the control sample and samples of muffins made with equal amounts of Kodo Millet Flour and FOS for their sensory aspects of color, scent, taste, texture, and overall acceptability. Samples were graded from 1 for least acceptable to 9 for most acceptable. The scores from the fifteen panelists were then averaged to determine the mean value. The nutritional content of the muffins with the best reviews will be examined.

3. Results and discussion

3.1. Sensory evaluation of muffin

The mean scores for sensory of T1, T2, and T3 samples are shown in Table 3. Sample T3 containing 4% blue pea flower had the highest scores for color, texture, aroma, taste, and overall acceptability. The increase in the quantity of flower powder seems to have contributed to improvements in color, aroma, and taste. The addition of flower powder play important role in higher overall acceptability of the finished product.

Kawai, et al.,(2016)[23], each kind of cake has a unique texture, flavor, and aroma, ingredients, processing, and maturation level all play a role. The cake's texture, flavor, and aroma all have an impact on the cake's quality, which ultimately determines whether or not consumers would accept it. Soft, chewy, wet, and watery are a few types of cake textures. While certain aromas come in faint, moderate, and powerful varieties. Then there are three types of flavors: salty, sweet, and spicy.

A slightly low acceptable taste was observed in samples T1 and T2 respectively. The scores for these samples for color and aroma were lower than Sample T3 containing 4% blue pea flower. Sample T3 which was more acceptable than the other two samples was then compared with the control sample for its physical properties and chemical composition.

3.2. Proximate Analysis of Muffins

Table 1 Different formulations of muffins by increasing the percentage of blue pea flower

Treatments	**T_1**	**T_2**	**T_3**
Kodo Millet Flour	30 gm	30 gm	30 gm
Blue Pea Flower	2 gm	3 gm	4 gm
FOS	30 gm	30 gm	30 gm
Milk	20 ml	20 ml	20 ml
Oil	15 ml	15 ml	15 ml
Baking Powder	1.5 gm	1.5 gm	1.5 gm
Baking Soda	1 gm	1 gm	1 gm
Vinegar	5 ml	5 ml	5 ml
Vanilla Essence	1..2 ml	1.2 ml	1.2 ml
Xanthan Gum	1/8 tsp	1/8 tsp	1/8 tsp

The sample was analyzed for the contents of moisture, protein, fat, ash, sugar, energy, and carbohydrate by the methods of AOAC. The results of the analysis are shown in Table 3. The sample found moisture content was 20.75%. The protein content was significantly found to have 9.05%. the fat content was found to be 7.32%. The sugar content was found to have 2.66% because of the Fructooligosaccharide being added to the product. The energy content was found to have 350.48 k cal/gm because of the Kodo millet flour used in the muffin. The carbohydrate content was significantly found to have 62.10%. The ash content was found to have 0.78%. The moisture content was found to have 20.75% because yogurt and milk are used in muffins as binding agents. The use of a substitute for Kodo millet flour affects the nutritive value of the product. Thus the substitution of Kodo millet flour for flours, such as refined wheat flour, slightly increases the protein content. Therefore, the incorporation of Kodo millet flour and *Clitoria ternatea* powder into muffin wheat flour improves thus improves the nutritional status of food items such as bakery products made from that refined wheat flour.

Table 2 Mean score for the sensory evaluation of muffins

Sensory qualities	T1	T2	T3
Colour	7	8	9
Texture	9	9	9
Taste	8	8	9
Aroma	7	7	9
Overall acceptance	7	8	9

Note: 9.Like extremely 8. Like very much 7. Like moderately 6. Like slightly 5. Neither like nor dislike 4. Dislike slightly 3. Dislike moderately 2. Dislike very much 1. Dislike extremely

Table 3 The Nutritional Composition of muffin was analyzed using AOAC methods

Parameters	Results
Fat	7.32%
Protein	9.05%
Sugar	2.66%
Energy	350 K cal/ 100 gm
Carbohydrate	62.10%
Ash	0.78%
Moisture	20.75%

3.3. Effect of Fructooligosaccharide in Muffins

Low-sugar or low-calorie labels are a top market trend for the bakery industry, primarily because excessive sweet consumption is linked to rising childhood and adult obesity as well as other health issues. In this regard, substituting other natural sweeteners for sugar is a blatant attempt to lead a healthier lifestyle and has a significant impact on the bakery industry's ideas for the creation of novel products. The market strives to eliminate harmful ingredients from formulations, especially sugars but also prioritizes customer satisfaction. Manufacturers of baked goods are currently substituting powerful and abundant artificial sweeteners for traditional sugar. But with the advantage of offering some healthful benefits, the opportunity to use alternative natural sweeteners like Stevia, oligofructose, and isomaltulose is now emerging.

Oligofructose and low-calorie sweeteners were also incorporated into the food compositions, and comparable sensory evaluations of the muffins were conducted. This work produced novel muffins that were simple, rich in nutritional value, and satisfying to the senses, with the potential to lower the risk of diabetes and obesity.

Because of their prebiotic status and increased interest in low-intensity sweeteners like oligosaccharides, oligosaccharides from various sources (fungi, algae, bacteria, and others) are frequently used as food additives. The non-digestible oligosaccharides have several uses in confections, such as sweeteners, dietary fiber, and weight-controlling agents. On the other hand, functional oligosaccharides have proven to be quite helpful in the control of blood sugar in diabetics and the prevention of dental caries. According to Patel and Goyal., (2011) [19]address the physiological features, natural sources, and types of these chemicals in light of their significance. They also go through modern synthesis, purification, and analytical techniques. Additionally, promising recent advancements in this field are noted to facilitate their continued exploitation.

The use of Fructooligosaccharide (FOS) as emulsifiers was shown to improve component aeration and emulsification, save manufacturing time, and enhance the physical and sensory qualities of sponge cake. Furthermore, compared to the control sample, it had a favorable impact on the final cake's quality. The samples with Fructooligosaccharide were classified as having higher sensory performance in the sensory evaluation of sponge cakes. Fructooligosaccharide can be employed as emulsifiers to improve the quality of sponge cakes, according to the studies.

4. Conclusion

These results indicate that muffins made from Kodo millet flour using Fructooligosaccharide with incorporation of *Clitoria ternatea* have more health benefit than the common muffins available in the market which are made from refined wheat flour. It is evident from the chemical properties that the muffins can be enjoyed by diabetic people as these muffins are made from Fructooligosaccharide.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

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