Utilization Of Chia Seed Mucilage To Reduce The Fat Contents In Muffins

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Abstract
Chia is regarded as superfood due to its high concentration of polyunsaturated fatty acids (PUFAs), dietary fiber, antioxidants, and vitamins. The demand of these foods is increasing day by day due to the presence of functional ingredients. Chia mucilage usage is also increasing in food products containing high fat contents due to fat like functional properties. The aim of this study was to formulate novel cereal products *i.e.* functional muffins, by utilizing chia mucilage. For this purpose, chia mucilage was prepared and analyzed for chemical composition depicting 14.98% moisture, 6.56% ash, 27.65% fiber, 2.09% crude fat, 10.34% crude protein and 47.68% NFE. Afterwards, five formulations of muffins were prepared by gradually replacing the fat levels at the rate of 10%, 20%, 30%, 40%, and 50%, respectively, followed by their assessment for proximate, mineral, color, texture, and sensory analysis. The proximate parameters were ranged between 36.08-37.48% for moisture, 2.34-3.09% for ash, 18.11-23.44% for crude fat, 4.87-7.01% for crude protein, 0.44-1.61% for crude fiber, 31.58-32.83% for NFE. The mineral profile showed the range of calcium 24.09-79.42, potassium 71.44-109.04, phosphorus 69.63-144.64, and magnesium 8.16-38.06mg/100g sample. The color of the product ranged for lightness from 49.73 to 61.35 while a* and b* value was fall between 12.76-17.46 and 13.84-15.37, respectively. The texture depicted the hardness 6.36 to 12.49N while the energy value was decreased from 371.31 to 243.61 Kcal/100g. Later on, sensory analysis of the product showed muffins developed by 30% replacement (T_3) of fat with chia mucilage was well received and considered as best treatment.

Keywords: Chia seed, Muffins, Fat Content

Introduction

The concern about diet and lifestyle is rising among the masses these days around the globe. Functional foods, in this regard, are gaining prominence and their demand keeps on climbing (Ali and Rahut, 2019). Japan, being the pioneer in regulating functional foods, coined the term FOSHU (Food for Specific Health Use). These foods have ingredients of functional importance targeting the specific health issue. The demand for functional foods is linked with focus on overall well-being, associated health benefits and effective communication, market positioning, mass distribution, and availability at low cost (Kaur and Das, 2011). The paradigm shift is evident from market value of more than US$177 billion in 2019 and expected to reach heights of US$300 billion in 2027 (Statista, 2022).

Plant seeds have been an essential food source for many civilizations due to high levels of nutrients and dietary fiber content (Munoz *et al.*, 2012). More than 50,000 plants are available for food, but only a few are practically used as human food. *Salvia hispanica* L., commonly referred to as Chia, is an annual herb, belonging to the mint family *Lamiaceae* and *Salvia* genus. It is homegrown in North Guatemala and South Mexico apart from its commercial cultivation in Argentina, Australia, Peru, Bolivia, Europe, and America (Hrncic *et al.*, 2020). The term Salvia evolved from the Latin word “salvere” meaning to save or cure, and it includes 900 species, describing the therapeutic effects of medicative plant *Salvia officinalis*. Few of these species are still in use because of the nutritional and an array of health benefits around the globe. The dry tiny dark and white seeds of chia was presented as a testimonial to the Aztec Empire’s capital (Bochicchio *et al.*, 2015; De Falco *et al.*, 2017).

After recognition from the European Parliament, chia as a functional food had gained significant popularity, wide usage as a component of modern diets and part of research studies (Sosa *et al.*, 2016). Chia seed consists of about 26-41% carbohydrates, 25-40% fat and 15-24% protein, higher than cereals. The seeds contain both soluble and insoluble dietetic fiber, constituting more than 35% of the overall mass.

Recently, the plant gums are gaining popularity as an ingredient in food formulations as texture modifiers, dietary fiber supplements, thickeners, gelling agents, emulsifiers, and stabilizers. Chia mucilage (CM) is a white powder separated from seed coat, constituting 4-6% of dry mass and structurally composed of repeating units of tetra-saccharides and a few additional sugars like arabinose, mannose, and galacturonic acid (Timilsena *et al.*, 2016). The polysaccharides extrude to full extension from seed upon hydration. However, CM provides a promising ingredient option for the food industry in contrast to vegan thickeners. The CM is separated to exploit its full potential and the underlying structure is studied microscopically and for rheological parameters aiming the viscoelastic characteristics (Brutsch *et al.*, 2019).

Busy schedules, sedentary lifestyles, and global advancement have shifted consumer interest toward bakery products. These products are widely accepted owing to their usability, convenience, and longer shelf life. The expected manufacture of bakery items at trade prices was US$18.5 billion in 2010 while fastest growth pace was observed in 2018 with a 17% increment (BBM, 2020). The bakery industry accounts for 23% of the functional food market as it comprises a range of products *i.e.,* muffins. They are available in a variety of shapes, sizes, and flavors recording the utilization of around 46% of the savory meals consumed worldwide (Rehman *et al.,* 2016). Because of the array of health benefits associated with the consumption of chia seed, the present project has been developed to ensure its utilization around this year in the form of functional muffins. The main objective of this research include:

- Preparation of functional muffins by using different levels of chia mucilage
- Physicochemical analysis of functional muffins
- Consumer acceptability of muffins through sensory evaluation

2. Material and Methods:

2.1. Materials:

Chia seeds were obtained from Sabri Karyana Store, Gol Karyana Bazar, Faisalabad. The ingredients for muffin preparation such as oil, sugar, eggs, white flour, and baking powder were purchased from the SB Store, Faisalabad.

2.2 Methods:

2.2.1. Mucilage preparation

The mucilage of chia was extracted by following the method of Kadry *et al.* (2021), with minor modification. The seeds were soaked in water (1:10 w/w) followed by mixing for few minutes and resting for 3-4hrs prior to use. The extracted mucilage along with chia was then added in muffin formulation.

2.2.2. Proximate composition of chia mucilage

The proximate analysis of chia mucilage, on dry basis, was performed following the method described in AACC (2010).

2.2.2. Muffins preparation

The muffins were prepared by following the modified method of Rehman *et al.* (2016). Five formulations along with control were prepared by adding 10, 20, 30, 40 and 50% chia mucilage (CM). A weighed amount of sugar was mixed thoroughly with eggs unless fluffy foam formation. The CM in different combination with shortening was added during mixing. Then white flour, baking powder and milk was added gradually. After attaining desired texture, the resulting batter was poured in muffins cups followed by baking at 180-190°C for 20-25mins.

2.2.3. Proximate and mineral analysis

The functional muffins were analyzed for moisture, crude fat, crude protein, ash, crude fiber and NFE (AACC, 2010). The mineral composition was obtained using the standard procedure given in AOAC (2019).

2.2.4. Calorific value

The calorific value (Kcal/100g) was theoretically calculated (Kadry *et al.,* 2021).

2.2.5. Color and texture analysis

The color of crumb and crust of functional muffins was assessed for the *L*, *a*, and *b* values. The texture was determined according to the method of Ureta *et al.* (2012).

2.2.6. Sensory evaluation

The prepared muffins were presented for sensory evaluation in front of panel comprised of teachers and students from National Institute of Food Science and Technology, University of Agriculture, Faisalabad-Pakistan. Each member was asked to rank the quality attributes (color, taste, aroma, texture, chewiness, and overall acceptability) of all samples using 9-Point Hedonic System (1=extremely disliked, and 9=extremely liked) described by Meilgaard *et al.* (2016).

3. Results:

3.1. Proximate composition of chia mucilage

Chia seed was the principal ingredient under investigation in this study. The proximal composition of chia mucilage determined on dry basis is presented in Table 1.

Table 1. Proximate composition of chia mucilage (%)

Proximate composition	Mean value
Moisture	14.98
Ash	06.56
Crude fiber	27.65

Crude fat	02.09
Crude protein	10.34
NFE	47.68

3.2. Proximate composition of muffins

The impact of chia mucilage addition in muffins was found to be statistically significant ($P \leq 0.05$) for moisture, ash, crude fat, crude protein, crude fiber and NFE. The mean values for the proximate composition are illustrated in Table 2. The maximum moisture content (37.48) was seen in T_5 while lowest (36.08) was in T_0. The ash content ranged from 2.34 to 3.09. The control showed highest crude fat (23.44) while lowest was in T_5 (18.11), although, maximum crude protein was present in T_5 (7.01) and lowest was in T_0 (4.87). The crude fiber was maximum in T_5 (1.61) while minimum was seen in control (0.44). The NFE ranged from 31.58 to 32.83.

3.3. Mineral Composition of muffins

The minerals concentration was statically significant ($P \leq 0.01$) for calcium, sodium, potassium, magnesium, phosphorus, iron, and zinc. The mean values (Table 3) showed Ca composition ranged between 24.09g/100g for control and 79.42mg/100g for T_5. More evident variation was seen in K (71.41-109.04mg/100g), Mg (8.16-38.06mg/100g), and P (69.63-144.64 mg/100g) for control and T_5, respectively.

Table 2. Means for proximate composition (%) of functional muffins

Treatment	Moisture	Ash	Crude fat	Crude protein	Crude fiber	NFE
T_0	36.08^f	2.34^d	23.44^f	4.87^e	0.44^f	32.83^a
T_1	36.17^e	2.72^c	22.87^e	5.10^d	0.93^e	32.21^c
T_2	36.56^d	2.76^b	21.98^d	5.55^c	0.97^d	32.18^c
T_3	36.89^c	2.89^b	20.11^c	6.27^b	1.12^c	32.72^b
T_4	37.08^b	2.99^a	19.97^b	6.97^a	1.41^b	31.58^d
T_5	37.48^a	3.09^a	18.11^a	7.01^a	1.61^a	32.70^a

Table 3. Means for mineral composition of functional muffin formulations (mg/100g)

Treatment	Calcium	Potassium	Magnesium	Phosphorus
T_0	24.09^f	71.44^f	8.16^f	69.63^f
T_1	34.21^e	78.75^e	13.87^e	85.35^e
T_2	46.41^d	84.32^d	20.23^d	100.43^d
T_3	57.49^c	93.85^c	25.96^c	117.70^c
T_4	68.54^b	100.03^b	31.82^b	130.85^b
T_5	79.42^a	109.04^a	38.06^a	144.64^a

3.4. Calorific value of muffins

Table 4 presented the energy released from the low-fat muffins. All treatments are statistically significant ($P \leq 0.01$) for the calorific value. The maximum value (371.31Kcal/100g) was observed in control while T_5 showed the least value (243.61Kcal/100g).

Table 4. Means for calorific value

Treatments	Calorific value (Kcal/100g)
T_0	371.31^a
T_1	354.27^a
T_2	327.28^b
T_3	307.93^c
T_4	277.27^d
T_5	243.61^e

3.5. Color and texture of muffins

A significant ($P \leq 0.01$) impact of mucilage addition on color and texture of muffins was also noted. The control (T_0) showed highest value for *L*, *a* and *b* chrome (61.35), (17.46) and (15.37) for crust while T_5 had the lowest (49.73), (12.76) and (13.84), respectively. A similar trend was noted for color of crumb with T_0 depicted highest values with a decreasing trend up to T_5. The texture of the muffins revealed more hardness as fat was reduced. The control showed least value (6.36N) while T_5 need maximum force (12.49N). The mean values for all the parameters were documented in Table 5.

3.6. Sensory analysis of muffins

The prepared muffins presented significant difference ($P \leq 0.05$) for sensory analysis. Mean values for all the formulations were illustrated in Table 6. Among all formulations, T_3 got prominent preference in terms of color, taste, aroma, texture, chewiness, and overall acceptability.

Table 5. Means for color (*L, a and b* values) and texture analysis

Treatment	Crust			Crumb			Texture
	L*	**a***	**b***	**L***	**a***	**b***	
T_0	61.35^a	17.46^a	15.37^a	75.83^a	17.01^a	17.94^a	6.36^f
T_1	59.54^b	16.75^{ab}	15.22^{ab}	71.72^b	16.53^b	16.58^b	7.65^e
T_2	55.36^c	16.25^b	15.10^b	68.22^c	15.99^c	15.78^c	8.76^d
T_3	52.15^d	14.90^c	14.64^c	65.20^d	15.32^d	15.28^d	9.90^c
T_4	50.05^e	13.05^d	14.26^d	62.62^e	14.75^e	14.60^e	11.19^b
T_5	49.73^e	12.76^d	13.84^e	60.14^f	13.86^f	14.92^f	12.49^a

Table 6. Means for sensory evaluation of functional muffins

Treatment	Color	Taste	Aroma	Texture	Chewiness	Overall acceptability
T_0	8.02^{ab}	8.36^a	8.19^a	8.32^a	8.29^a	8.09^a
T_1	7.69^{ab}	8.15^{ab}	8.14^{ab}	7.20^{bc}	8.12^{ab}	6.78^{bc}
T_2	8.06^{ab}	8.76^a	8.09^{ab}	8.23^b	8.06^a	7.54^a
T_3	8.19^a	7.72^{ab}	8.02^{ab}	8.15^{ab}	8.03^{ab}	8.21^{ab}
T_4	7.75^{ab}	7.50^{ab}	7.26^{bc}	7.19^{ab}	7.66^{ab}	7.39^c
T_5	7.16^b	7.03^b	7.05^c	7.12^c	7.25^b	6.63^b

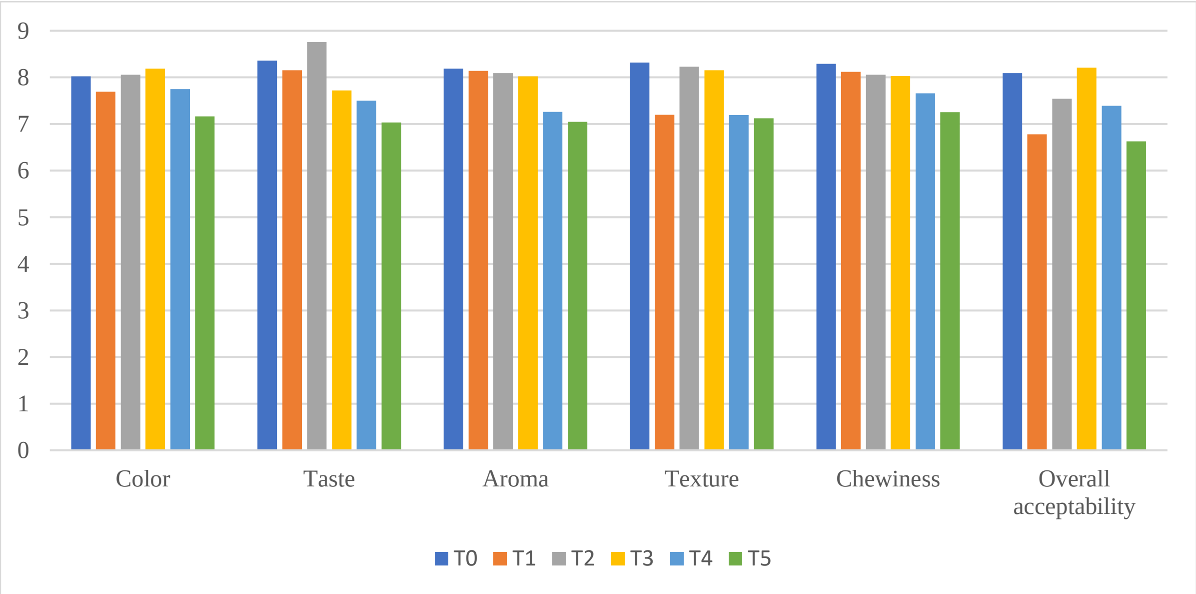

Figure 1. Graphical description of sensory evaluation of functional muffins

4. Discussion:

Chia seed was the principal ingredient under investigation in this study. Chia mucilage was investigated for its proximate composition prior to its use in product development. The findings of the study are in line with those found by Capitani *et al.* (2013) who studied the effect chia mucilage extraction on the chia meal and analyzed the chia mucilage for its proximate composition. Similar results were reported by Felisberto *et al.* (2015) working on lyophilized CM. The reported results showed a very minute concentration of crude fat, 1.03% was seen in the mucilage. Fernandas and Salas-Mellado (2017) who reported a significant abundance of carbohydrates in the extracted chia mucilage. They also found low caloric value of CM due to less fat as compared to the whole seeds. Coorey *et al.* (2014) stated the reduction of oil content in mucilage as cellular structures retained the oil and not drew out with the gel. Chavan *et al.* (2017) worked on the use of chia mucilage as stabilizer in ice cream and found a very high amount of fiber.

The functional muffins were also subjected to proximate analysis. The elevated moisture content of chia mucilage supplemented muffins in this study are in line with Pszczola (2006) who found a direct relation between fiber and moisture content. Fernandes and Salas-Mellado (2017) also documented similar results for moisture of the breads and cakes formulated using chia mucilage as a fat substitute due to more water retention ability of mucilage. A similar trend was seen in the case of protein value which shows a huge increment of 121% as compared to control when chia completely substitutes the fat in the cake formulation. There is around 68% reduction in the fat content of the cakes when 100% chia mucilage was used in place of fat. A very similar trend was also observed by Borneo *et al.* (2010) which got 57% fat reduction in cake formulations which are in line with current study. The findings comply with the results found by Chavan *et al.* (2017) who worked on the chemical composition of cookies formulated using chia mucilage and found the ash content increased (0.96-1.20%) after the addition of chia mucilage.

The mineral composition of current study is in line with those documented by Levent (2017) who found higher calcium, magnesium, phosphorus, potassium, zinc, and iron. Another study conducted by Barrientos *et al.* (2012) showed presence of sodium, calcium, and potassium in reasonable amounts 317.67mg, 110.21mg and 109.50mg per 100g, respectively. The addition of chia resulted in an elevated level of micronutrients in the product.

Calorific value is the measure of energy released when a food subjected to complete combustion usually determined by quantifying the heat released. These findings are in line with the results described the Fernandas *et al.* (2021) stating lesser caloric value in the formulation developed with chia than the margarine. Abd-el-khalek (2020) also found reduction in fat due to replacement with maltodextrin which ultimately reduced the calorific value of the cake. This reduction in calorific value depicts the approach to replace fat with the carbohydrate-based replacers.

Color has a significant impact on acceptability and quality of the final product. The findings of this study are conformed with those reported by the Fernandes and Salas-Mellado (2017) who prepared the bread and cake with adding chia at different concentrations. They found the increasing concentration of chia in batter resulted in lighter color muffins. There is an upsurge in the yellowness was observed and a decrease in redness was seen. Popov-Raljić *et al.* (2009) revealed that particle size has also influenced the color of product. The smaller the size of flour, brighter the color of the product obtained as they replaced fat with chia mucilage. Other factors influencing the color of product includes baking powder, sugar content alteration in baking conditions, temperature and cooking time, air velocity in oven and humidity level as well as chia mucilage color (Pertuzatti *et al.*, 2015).

The texture is an important parameter highlighting the quality of the baked items and plays its role in sensorial shelf life of the product. These findings are coinciding with results reported by El-Sayed *et al.* (2014) who evaluated the quality attributes low fat cake formulated using flaxseed and okra gum. The hardness of cake was also increased with the addition of gum in formulation. Huerta *et al.* (2018) who worked on the gluten free bread formulated using chia flour as partial gum replacer depicted the increase in hardness of the bread in line with chia flour percentage increment.

The scores for sensory analysis showed T_3 was well received by the consumers considering the texture, taste, chewiness, and overall acceptability. The trend for the overall acceptability among the treatments was declining with chia mucilage increment. A similar result was given by Chavan *et al.* (2017) who worked on the development of cupcakes found that the developed product was well received by the consumers and accepted overall. For fat replacement, the fat replacer needs to improve or at least maintain the sensory attributes of the food commodity for its successful usage.

Conflict of Interest:

The authors have declared no conflicts of interest.

Author’s Contribution:

Muhammad Arham Rauf and Mian Kamran Sharif designed the study. Muhammad Arham Rauf, Tanveer Ahmad and Rafaqat Ali executed the experimental trials and analyzed the samples. Muhammad Arham Rauf, Tabana Naz, Maira A. Razzak, Fareeha Shahid and Tahreem Aslam analyzed the results. Muhammad Arham Rauf wrote the original manuscript. All the authors reviewed the manuscript critically and approved the final version.

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