Functional and nutritional assessment of sorghum (*Sorghum bicolor* L.) based muffins

Abstract

The research investigation entitled "Functional and nutritional assessment of sorghum (*Sorghum bicolor* L.) based muffins" was conducted in the Department of Food Technology, Parul Institute of Applied Sciences, Parul University, Vadodara, Gujarat, during the year 2022 under different experiments. In order to achieve the purpose of the study, a number of laboriously carried out experiments were standardized and carried out in sequence. During chemical analysis of developed product, the storage research in ambient temperature and refrigeration temperature could be examined including the general decrease in protein and fat in the ranged of (8.28% to 7.38%) and (7.48% to 6.58%). Whereas, moisture would rosed by (3%) ranged from (27% to 27.9%). Respectively in refrigeration temperature the overall fat and protein were increase in ranged (8.28% to 9.18%) and (7.48 to 8.38%) and moisture content were decreased by (3%) can be ranged (27% to 26.1%). Whereas, overall ash can be identified in ranged from (1.4% to 0.5%). While analysing produced goods with different mineral concentrations, such as calcium (27.91%), utilising flame photometry. Throughout the experiment, iron (6.42%), zinc (20.48%), and magnesium (1.94%), respectively, will be investigated using colorimetric methods. We also performed, microbiological quality of the created product, sugar-free sorghum muffins, was assessed using the total plate count (TPC) technique, which revealed an overall quantity of 5200 Cfu/100g. Whereas, another test will be FT-IR analysis, the data depicts a peak in the absorbance wave length spectrum that was detected between 2925cm^{-1} in ranged 2928 cm^{-1} with presence of methyl group. A set of proteins were seen in the strong peak at 1646.18 cm^{-1} in the region of 1651 cm^{-1}. Starch was the main cause of the vibration of C-C and C-O at 1019.7cm^{-1}, respectively the strong peak 1417cm^{-1} and 1150.04cm^{-1} ranged from 1400 to 1150.04 cm^{-1} O-C-H; C-C-H; C-O-H with presence of starch.

Keywords: Muffins, Sorghum, Bioactive compounds, FT-IR

1. Introduction

Muffins are simple, comprehensible, and sweet, making them comfort food even in their newly acquired worldliness. Most individuals find that eating muffins or even simply having one put next to them, helps them feel content and at home **[8].** Miniature loaves of bread cooked into paper or plastic cups are known as muffins. Like the greatest loaves, icing and frosting are optional. Baking is a

millennia-old process, and bakery products range in complexity from the simple ingredients of a plain pastry to the numerous components of a cake. The term baking applies not only to the production of bread but to all food products in which flour is the basic material and to which heat is applied directly by radiation from the walls and top and bottom of an oven or heating appliance. Baking more specifically refers to the process of creating baked goods such as bread, cake, pastries, biscuits, crackers, cookies, and pies where the main ingredient is flour. The toppings, icings, fillings, and other components used to finish baked items are also referred to as baking. Although there are numerous variances across bakery goods, they all have two significant baking technology problems **[15]**.

Tropical cereal grass called sorghum (*Sorghum bicolour* L.) Moench) is farmed. Though not completely agreed upon, most people believe that it was initially domesticated in North Africa, maybe in the Nile or Ethiopian areas as recently as 1000 BC **[19].** The fifth-most significant cereal in terms of global output is sorghum **[29]**. The main cereal grain is eaten in Asia and Africa is sorghum. Both adults and children's cuisine may be prepared using it. In tropical areas, millet and maize gruels are combined with sugar to make prenatal meals **[22].** Other cereals, sorghum is an excellent source of B vitamins like thiamine, riboflavin, vitamin B6, biotin, and niacin. However, refining results in losses of all B vitamins **[14].**

Because sorghum doesn't contain gluten, it can partially replace wheat flour in cooking to meet the needs of those with celiac disease **[6].** In terms of its chemical makeup, sorghum is typically comparable to corn and millet and contains mostly sugar, fat, protein, non-starch polysaccharides, phytosterols, and phenolic chemicals **[10 - 32].** The primary bioactive components of sorghum are phenolic compounds, which are found in all types of this grain **[10]**. Compared to wheat, barley, rice, maize, rye, and oats, sorghum has a more varied phenolic component profile and greater phenolic compound concentration **[25].** Proanthocyanidin, 3-deoxyanthocyanidins, and flavan-4-of concentrations in resistant sorghum varieties were found to be greater on average than those of susceptible varieties **[9]**. (Dicko *et al.*, 2005). These outermost layers of the crop contain the majority of the sorghum's flavonoids. As a result, variations in the pericarp's colour and thickness as well as the existence of the testa affect the flavonoid profile and concentration **[2 -11].** Sorghum contains significant amounts of anthocyanins, flavones, and flavanones, three types of flavonoids. Sorghum anthocyanins, which are 3-deoxyanthocyanidins, contribute up to 79% of the flavonoids in the crop **[10, 30- 34].**

Over the past 20 years, the number of persons with diabetes has more than risen globally. The rise of type-2 diabetes in kids, teens, and young people are one of this rapid increase's most concerning trends **[16 - 5]**. As a worldwide epidemic and a danger to both human health and the world economy, diabetes is high on the international health agenda **[5].** Diabetes in poor nations comes with a number of difficulties that are different from those faced by developed nations. First off, rather than old

individuals, those under the age of 60 are seeing a dramatic rise in diabetes in emerging countries. Second, compared to white populations of European descent, the major ethnic groups in the majority of developing countries frequently have a wider range of complications, such as kidney attack and diabetes, and far less coronary artery disease **[17].**

Health food is considered to be food which is beneficial to health, beyond a normal healthy diet required for human nutrition. It is also referred to as functional food, i.e., food for which a specific claim of health benefits is made, such as that consumption of the food may prevent diseases. Jaggery a product of sugarcane, is such a product which is rich in important minerals such as Calcium(40-100 mg), Magnesium(70-90 mg), Potassium(1056 mg), Phosphorus(20-90 mg), Sodium(19-30 mg), Iron(10-13 mg), Manganese(0.2-0.5 mg), Zinc(0.2-0.4 mg), Copper(0.1-0.9 mg), and Chloride(5.3 mg per 100 g of jaggery) and vitamins like Vitamin A(3.8 mg), Vitamin B1(0.01 mg), Vitamin B2 (0.06 mg), Vitamin B5(0.01 mg), Vitamin B6(0.01 mg), Vitamin C(7.00 mg), Vitamin D(2-6.50 mg), Vitamin E(111.30 mg), Vitamin PP(7.00 mg) and protein(280 mg per 100 g of jaggery). India is the largest producer and consumer of jaggery. Out of total world production, more than (70%) is produced in India **[28].**

Because a chemical absorbs infrared radiation according to its concentration, infrared spectroscopy is a potent technique for quantitative examination. Nonetheless, IR spectroscopy's use in both the qualitative and quantitative examination of food has been relatively underutilised until lately **[18]**. There are many applications for infrared (IR) or Fourier transform infrared (FTIR) spectroscopy, ranging from the study of cells and tissues to the study of tiny molecules or chemical complexes. One of the most recent advancements in infrared spectroscopy is the imaging of tissues, which makes use of infrared microscope and synchrotron IR radiation. Cellular component mapping is done using it carbohydrates, lipids, proteins **[20 - 24].**

2. Materials and methods

The research investigation entitled "The research investigation entitled "Functional and nutritional assessment of sorghum (*Sorghum bicolor* L.) based muffins" was conducted in the Department of Food Technology, Parul Institute of Applied Sciences, Parul University, Vadodara, Gujarat, during the year 2022 under different experiments.

2.1 Procurement of raw materials

During research study, wheat, sorghum flour and other ingredients were procured from the local market of Vadodara, including baking powder, baking soda, cocoa powder, jaggery powder, oil, milk and plastic pouches, containers.

2.2 Preparation of muffins

Sorghum muffins are made using a component, including sorghum flour. A variety of ingredient combinations were tested. The flour and other ingredients were weighed in weighing balance and sieved properly. After sieved all fours and the other ingredients add milk thoroughly and mix it properly to form a batter and respectively add oil with moderate consistency to avoid lumps, after mixing all ingredients properly then pour the bater into the muffins mould and kept into the microwave oven at 140^0C for 25 minutes. After baking the developed product were cooled at room temperature.

Flour and other ingredients

Addition of all ingredients

Mixing of dry ingredient

Sieving all dry ingredient

Mixing batter with the addition of milk gently and smoothly

Addition of oil in batter and mix batter again

Pouring the batter into the muffins mold

Put into the microwave oven for Baking at140^{o}C for 25 mins.

Product developed

Figure1. Unit operations of product development

Table 1 Standardization of proportion of two grain flour blends (Wheat flour and Sorghum flour)

Treatments	Sorghum flour (gm)	Wheat flour (gm)	Jaggery Powder (gm)	Baking powder (gm)	Baking soda (gm)	Cocoa powder (gm)	Milk (ml)	Oil (ml)
T_0	-	100	50	1.60	1.21	5	168	15
T_1	100	-	50	1.60	1.21	5	160	15
T_2	**100**	**-**	**60**	**1.60**	1.21	**5**	**82**	**10**
T_3	80	20	12	1.60	1.21	5	110	12
T_4	90	10	12	1.60	1.21	5	82	12
T_5	50	50	12	1.60	1.21	5	82	12
T_6	95	5	12	1.60	1.21	5	82	12
T_7	85	15	12	1.60	1.21	5	82	12
T_8	75	25	12	1.60	1.21	5	82	12
T_9	60	40	12	1.60	1.21	5	82	12
T_{10}	64	36	12	1.60	1.21	5	82	12
T_{11}	65	35	12	1.60	1.21	5	82	12
T_{12}	55	45	12	1.60	1.21	5	82	12
T_{13}	73	27	12	1.60	1.21	5	82	12
T_{14}	67	33	12	1.60	1.21	5	82	12
T_{15}	74	26	12	1.60	1.21	5	82	12
T_{16}	51	49	12	1.60	1.21	5	82	12
T_{17}	77	23	12	1.60	1.21	5	82	12
T_{18}	68	32	12	1.60	1.21	5	82	12
T_{19}	82	18	12	1.60	1.21	5	82	12
T_{20}	71	29	12	1.60	1.21	5	82	12

2.3 Chemical analysis

During research, we analysed the different parameters such as moisture, ash, fiber and carbohydrate was estimation done by **[27]**. Whereas, protein and fat were determined by **[1]**. Respectively, energy value of the developed products was also examined and measured in bomb calorimeter and also the dry ash method was used for mineral estimation given by **[26]**. They can be analysed with varied levels of minerals, such as calcium via Flame Photometry, Iron by Colorimetric methods whereas,

zinc and magnesium examined by LAB SOP method, FSSAI Manual, 2016 can be done as per test methods and FT-IR also analysed and given by **[33].** (Stuart, 2004).

2.3 Sensory evaluation

A gauge of like used to assess preference is the 9-point hedonic scale. On the "words alone" scale, there are nine verbal categories that are often given numbers from 1 to 9 given by **[23].**

3. Results and discussion

The research investigation entitled "Functional and nutritional assessment of sorghum (*Sorghum bicolor* L.) based muffins" was conducted in the Department of Food Technology, Parul Institute of Applied Sciences, Parul University, Vadodara, Gujarat, during the year 2022 under different experiments.

3.1 Proximate composition of muffins (sugar-free)

Table 2 Chemical analysis of muffins (sugar-free)

Sno.	Parameters	Amount (%)
1.	Protein	7.48
2.	Fat	8.28
3.	Fiber	2.24
4.	Carbohydrate	80.6
5.	Energy	326.76Kcal/100g

During chemical analysis of developed product, the specified characteristic should be examined, such as crude protein (7.48%). According to other genetic, environmental, and managerial parameters, protein content in sorghum flour might range from 6 to 20%) **[3]**. Crude fibre (2.24%), crude carbs (80.6%), crude fat (8.28%), and crude energy (326.76%) will be observed.

Table 3 Minerals contents of muffins

Sno.	Minerals	Amount(mg/100g)
1.	Calcium (ca)	27.91
2.	Iron (Fe)	6.42
3.	Zinc (Zn)	1.94
4.	Magnesium (Mg)	20.48

While using flame photometry to analyse manufactured items with varying mineral contents, such as calcium (27.91%). Using colorimetric techniques, iron (6.42%), respectively zinc and magnesium (20.48% and 1.94%), will be examined during the experiment, respectively we conclude that iron and zinc are essential trace element in sorghum which effect human nutrition and their deficiencies are major health treats worldwide **[36].**

3.2 Microbial evaluation-Total Plate Count (TPC)

According to **[27]**.Using autoclavable inoculate 0.1 g of serial dilution samples in total plate count/standard plate count agar medium. According to the microbial analysis of the developed product including total plate count (TPC) method showed overall amount 5200 fu/100g.

3.3 Fourier Transform- Infrared Spectroscopy (FT-IR)

The vibrations of particles are examined via infrared spectroscopy. Several infrared absorption spectra that correspond to different functional categories can be linked **[7 - 13].**

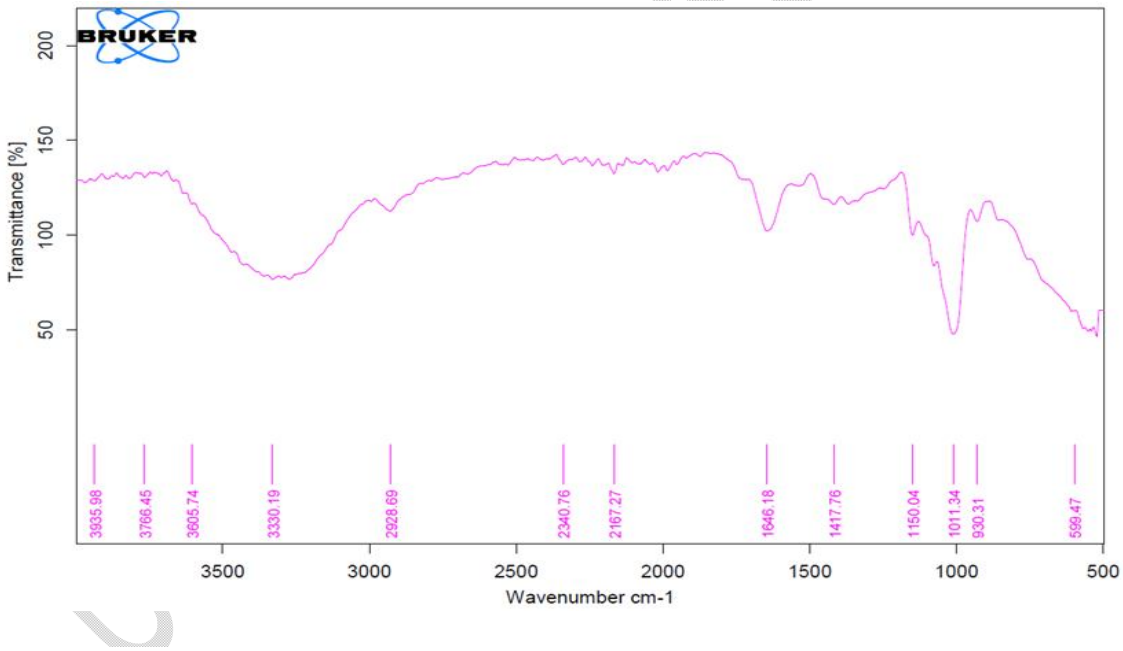

Figure 2. FT-IR peak of developed Infrared spectrum of muffins

In Figure 2, data depicts a peak in the absorbance wave length spectrum that was detected between 2925cm^{-1} in ranged 2928 cm^{-1} with asymmetrical stretching and aliphatic chains that indicated the presence of methyl groups **[31]**. A set of proteins were seen in the strong peak at 1646.18 cm-1 in the region of 1651 cm^{-1}, which reflects the amide I band from C=O extending (80%), with a slight contribution from C-N stretching **[4].** Starch was the main cause of the vibration of C-C and C-O at

1019.7 cm^{-1}, respectively the strong peak 1417cm^{-1} and 1150.04cm^{-1} ranged from 1400 to 1150.04 cm^{-1} O-C-H; C-C-H; C-O-H demonstrating bending vibration with starch as the primary contributor **[31]**.

3.4 Storage study of developed muffins

In order to monitor changes throughout timescales of 0 to 10 days, we kept the product in polyethylene pouches during the product development process at varying ambient and refrigerator temperatures.

Table 4 : Storage study of ambient temperature at (25-38 ^{0}C)

Sno.	Parameters	0 (days)	3 (days)	6 (days)	10 (days)
1.	Fat	8.28	7.98	7.68	7.38
2.	Protein	7.48	7.18	6.88	6.58
3.	Moisture	27	27.3	27.6	27.9
4.	Ash	1.4	1.1	0.8	0.5

We exhibit the storage researched in ambient temperature, including the general decrease in protein and fat in ranged (8. 28% to 7. 38%) and (7. 48% to 6. 58%). Were protein molecules splitting as a result of the degradation of peptide bonds by protease enzymes may been the cause of protein loss during storage **[35]**.The hydrolysis of triglycerides while preservation may be the cause of the muffins' declining fat content. Whereas moisture would rose by (3%) ranged from (27% - 27. 9%) due to their air porosity.

Table 5: Storage study of refrigeration temperature at (4^{0}C)

Sno.	Parameters	0 (days)	3 (days)	6 (days)	10 (days)
1.	Fat	8.28	8.58	8.88	9.18
2.	Protein	7.48	7.78	8.08	8.38
3.	Moisture	27	26.7	26.4	26.1
4.	Ash	1.4	1.1	0.8	0.5

Respectively in refrigeration temperature the overall fat and protein would slightly increase in ranged (8. 28% to 9. 18%) and (7. 48 to 8. 38%) and moisture content would decrease by (3%) could been ranged (27% to 26. 1%). Whereas, overall ash could be identified in ranged from (1. 4% to 0. 5%). Similar observations were found by **[12 - 21].**

3.5 Cost production

Table 6 Cost production of developed muffins

Sno.	Ingredients	Rate/100g	Quantity required (g/ml)	Amount
1.	Sorghum flour	26	100g	26
2.	Baking powder	32	1.60g	0.512
3.	Baking soda	20	1.21g	0.242
4.	Cocoa powder	60	5g	6
5.	Jaggery powder	18	100g	18
6.	Milk	27	82ml	5.4
7.	Oil	195	7ml	1.3
	Miscellaneous charges	-	-	10
	Profit charge	@ Total 10% of cost		**6.74**
Total Cost = Rs. 74.19				

In table 6, shows that the cost of basic goods including sorghum flour, baking powder, baking soda, cocoa powder, jaggery powder, milk and oil was taken into account. The cost of the machinery and equipment, the overhead expense, and the production cost were calculated. The cost incurred in preparation of functional food products was calculated by taking into consideration the cost of all inputs. The processing cost and other expenses including depreciation is added to the total expenditure. The sale price per 100 g of the products was calculated after adding 10 per cent processing cost. The data represented, that the overall cost of production of developed product will be found Rs. 74.19 with profit charge of total 10 % of cost.

4. Conclusion

The research study investigated on preparation of sugar-free muffins. The sugar-free muffins developed by using (100%) sorghum flour, baking powder, baking soda, jaggery powder, cocoa powder, milk and oil were mixed to form smooth consistency batter. During the Experiment we found

that the muffins have the moisture, protein, fibre, ash, carbohydrate and fat was recorded as (8.28%), (7.48%), (80.6%), (2.24%), (27%) and (1.4%), respectively. Further, it was found that the muffins had 27.91mg/100g, 6.42mg/g, 1.94mg/g and 20.48mg/g for calcium, iron, zinc and magnesium respectively. The Fourier transform infrared spectroscopy of muffins showed the presence of certain functional groups, indicating the presence of chemical compounds. During FT-IR we found that the peak in the absorbance wave number spectrum range vibration was observed 2925cm^{-1} in range of 2928cm^{-1} with presence of methyl group, 1646.18 cm^{-1} in the range of 1651cm^{-1} which represents groups of proteins, 1019.7 cm-1 was observed which showed that presence of starch and The sharp peak 1417cm^{-1} and 1150cm^{-1} in the ranged 1400 to 1150.04cm^{-1} O–C–H; C–C–H; C–O–H showed bending vibration mainly contribution of starch. During storage research in ambient temperature, including the general decrease in protein and fat in ranged in (8.28% to 7.38%) and (7.48% to 6.58%), we observed that at ambient temperature the overall increase in moisture content of muffins ranged from (27% 27.9%) respectively, whereas ash can be ranged from (1.4% to 0.5%). During refrigeration temperature the overall fat and protein will slightly increase in ranged (8.28% to 9.18%) and (7.48 to 8.38%) and moisture content will decrease can be ranged (27% to 26.1%), respectively whereas ash can be ranged from (1.4% to 0.5%). Hence, finally we conclude that sorghum muffins can be best in nutritional profile and its helps to enhance the nutritional content and health benefits with overall carbohydrate and proteins and also can be best storage at refrigeration temperature.

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