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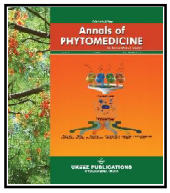

Review Article : Open Access

Study of functional properties of sorghum and their utilization in development of value-added functional bakery products

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Abstract

Cupcakes are small loaves of bread baked in paper or plastic bowls. Icing and decorating are optional, as they are with the best loaves. Normally woman uses staples like fat, carbohydrates, and flour (sorghum crushing and wheat crush into fine grains).The recipe yields a good layer loaf that can be turned into cupcakes. Cupcakes are typically baked in muffin tins with a nonstick surface made of metal, silicon rubber, stoneware, or another material. Muffin tins usually hold six cups. A typical cup measures 3 inches (76 mm) in diameter and holds 4 ounces. Cupcake batter can be flavor-infused or contain additional ingredients such as raisins, cherries, and nuts. Sorghum flour can be used in place of wheat flour. The particle size and shape of sorghum flour frequently make baked goods like cakes and bread appear grittier. However, sorghum and wheat flour mixes have been used to make non-gluten-free baked goods such as flatbreads, cakes, muffins, cookies, and biscuits. Gluten, non-starch polysaccharides, and lipids are among the numerous compounds found in wheat flour, and they all have a significant impact on both the processability of the raw material and the quality of the finished goods. Wheat flour contains a high concentration of carbohydrates as well as other ingredients such as proteins and lipids, which influences its properties. Lipids account for only 1% to 3% of the total composition of wheat flour. They can be divided into two types: free lipids and bound lipids. In this paper, gluten-free and sugar-free cupcakes made with composite flour (wheat and sorghum) are reviewed for celiac disease patients.

1. Introduction

Sorghum and wheat flour are used to make a delicious baked good with a fluffy top known as a cupcake. These have a wonderful aroma, sweetness, and flavour. The antihyperlipidemic, antioxidant, and antiatherosclerotic effects of a number of plants with potent medicinal components, such as fibres, sterols, saponins, polyphenols, flavonoids, *etc*., have been studied (Vanitha *et al*., 2018). The cupcake made with both wheat and sorghum flour contained more fat, protein, ash, and calories than the control cake. Cakes are frequently served as children's food at birthday parties. It is a manufactured product high in sugar and saturated fat that should only be consumed in moderation. These delectable treats are ideal for anyone trying to reduce their sugar intake. They are an excellent dessert option for anyone trying to lose weight because they contain fewer calories than traditional cakes. They are less expensive. Sugar-free cakes are less expensive than traditional cakes because fewer ingredients are required. Sugar-free cakes are ideal, if you enjoy baking but dislike additional sweets. The origin and sensory characteristics of the cupcake influence its quality. Cakes are baked goods made from a combination of liquids such as milk or water and ingredients such as wheat flour, sugar, eggs, and fat or oil. A cupcake is defined differently in different parts of the world.

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Cupcakes are popular in baked goods in both small and large-scale businesses. Utilizing nutritious foods has received more attention in recent years (Durga *et al.*, 2020). Cupcakes are popular among both amateur and professional bakers. They are miniature speciality desserts. Cupcakes were initially popularly consumed and recognized as a culinary item only in Western countries. When civilization is revived; however, they become more important everywhere. Cupcakes are available in a variety of flavors and styles, including strawberry, chocolate, vanilla and butterscotch (Mane and Mayur, 2021). A digestive condition, celiac disease also known as celiac sprue or gluten-sensitive enteropathy. Gluten-containing foods cause celiac disease patients' immune systems to attack the gut lining. This causes the villi, which are hair-like structures on the lining of the small intestine, to be destroyed and inflames and swells the intestines. Gluten-related illnesses, including celiac disease, are treated in both adults and children. Celiac disease has become more common in the last 50 years, and many people are misdiagnosed. On a gluten-free diet, diagnostic tests such as serology and biopsy should be performed. When making gluten-free and sugar-free cupcakes, composite flour (made of wheat and sorghum) will be used to accommodate the celiac patients. The remainder of the article will examine the physiochemical properties of manufactured goods, sensory evaluation, shelf-life evaluation, and developed product cost calculation.

2. Sorghum flour

It can be difficult to obtain 100 per cent sorghum goods that are palatable when yeast is added because sorghum flour lacks the

proteins that give wheat its viscoelastic properties. However, a range of baked foods, including flatbreads, cakes, muffins, cookies and biscuits, are made using sorghum and wheat flour combinations and include gluten. The amount of sorghum used to replace wheat flour depends on the quantity and quality of gluten present in wheat flour, what constitutes an acceptable cupcake, colour, flavour, aroma and any additional additives. Wheat flour can be partially replaced by sorghum flour. Sorghum flour's particle size and shape frequently make baked goods like cakes and bread seem grittier.Sorghum is a crucial crop for future human use due to the rising global population and diminishing water resources. While sorghum is an essential food crop for millions of people in some regions of Africa and Asia, it is largely used as animal feed in most affluent nations making it an underutilized resource (Pontieri, 2016).

2.1 Sorghum health benefits

Sorghum flour contains substances that decrease cholesterol. Sorghum flour is a trustworthy gluten-free option or flour replacement for those with celiac disease. Sorghum flour has a high antioxidant capacity because sorghum wax and its polyphenolic component are linked. These substances contain policosanols, which are crucial for maintaining healthy heart function and preventing cancer. Sorghum's protein and starch are more difficult to digest than those of other comparable foods. Those with diabetes can benefit greatly from its slow digesting because it has a very low glycaemic index (Ratnavathi and Komala, 2016).

2.2 Composition

Sorghum has large amounts of potassium and phosphorus. Only minimal amounts of salt and iron are present, but it has a considerable quantity of calcium. It has a lot of proteins, fibre and iron. Although, all of the vitamin's B are lost during refining, sorghum is still a significant source of thiamine, riboflavin, vitamin B_6, biotin and niacin. Both millet and sorghum contain comparable mineral compositions. Potassium and phosphorus are the two main minerals in sorghum grain although calcium is scarce (Ratnavathi and Komala, 2016).

2.3 Structure of sorghum

The endosperm of both sorghum and maize has a floury and a corneous component. The anatomy of a sorghum kernel is similar to that of a corn kernel, although a sorghum grain is typically smaller (Awika *et al*., 2005). Sorghum field in Horsching Austria. However, the pericarp's colour is not necessarily a good indicator of how sorghum flour will look. A sorghum kernel, for instance has a light-coloured endosperm and a scarlet pericarp. To obtain proper food appearances, sorghum fraction is therefore included together with particular food colour (Rumler *et al*., 2021).

2.4 Classification of sorghum

Sorghum is the fifth-most-produced cereal in the world. Sorghum is regarded as the most significant cereal in Africa, mostly produced in India, the United States, Australia and Argentina outside of Africa, where it is primarily utilized as animal feed. Under sorghum both bicolour and guinea are recognized. The phrase "intermediate race" refers to all mixtures of the aforementioned races. Most of the *Sorghum bicolor* Moench is grown (Elkhalifa and El Tinay, 2002). Taylor asserts that there are many classifications for sorghum. Some of them like wheat and maize are complicated which shows that sorghum belongs to the grass family Poaceae. Sorghum is a member of the Andropogoneae tribe and the Panicoideae subfamily just as maize. Sorghum's phylogenetic tree modified in Taylor's opinion (Taylor, 2019).

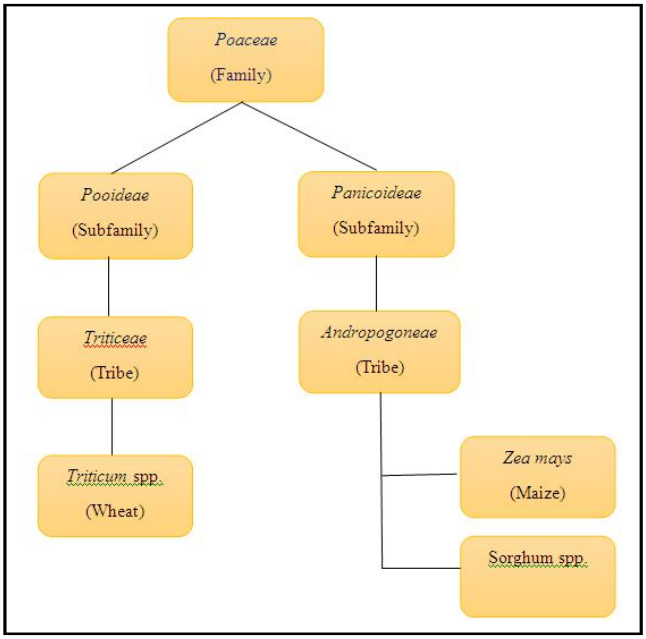

Figure 1: Classification of sorghum.

2.5 Phytase activities

The phytic acid concentration of sorghum flours are decreased by (40-60%) during lactic fermentation. Calcium, magnesium, manganese and iron are produced in stable molecules with great bioavailability by phytic acid. Microbial acidification solubilizes phytate complexes containing divalent cations in wheat and rye sour dough, promoting phytate hydrolysis by cereal enzymes (Michael and Clarissa, 2009).

2.6 Production of sorghum in India

Sorghum is India's third-largest crop producer after rice and wheat. In 2014-15, sorghum was cultivated on 6.16 million hectares producing 5.45 million tonnes in total. According to the 4th advance estimates, 5.65 million hectares were planted with sorghum in total in 2015-16 and 4.41 million tonnes were produced overall. The majority of India's sorghum is produced in the state of Maharashtra. Maharashtra produced up to (40.90%) of the nation's total sorghum output in the fiscal year 2013-14, according to the Government of India 2016, followed by Karnataka (23.77%), Tamil Nadu (8.10%), Rajasthan (6.42%) and Andhra Pradesh (6.80%). In the state, high-yielding varieties of sorghum are grown on more than two million hectares of land or around (49.40%) of the total area under cultivation. Sorghum is the second-largest producer after rice. Sorghum is largely farmed in Maharashtra during the kharif season. Maharashtra State's total sorghum output reached an all-time high in 1965-1966 at 2294.8 thousand tonnes before declining to 2109 thousand tonnes by 2014-15. A growth trend study revealed that throughout the same time period, the state's sorghum output climbed at a compound annual growth rate of (0.14%) (Gautam and Singh, 2018).

2.7 Nutritional composition of sorghum

2.7.1 Protein

The protein content in sorghum is comparable to content of wheat (Istianah *et al.*,2018). The prolamin fraction known as kafirin predominates in sorghum protein. According to research, the albumin and globulin fraction made up 24.1% of the sorghum protein, followed by the kafirin fraction (18.8%) and the glutelin fraction (50.7%). Because of their potential, particularly when cooked, sorghum proteins have attracted a lot of interest (Emmambux and Taylor, 2009; Taylor, 2003). Sorghum proteins can link with tannins and tannic acids but are not able to form complexes with one other (Vander and Schussler, 1984).

2.7.2 Carbohydrate

The amount of carbs in several whole grain sorghum types from Ethiopia ranges from (67.5-76.4%) (Tasieand Gebreyes, 2020). The endosperms primary source of carbohydrates is starch (Srichuwong *et al.*, 2017). According to the study, white and red whole grain sorghum had dry matter starch concentrations of (72.2%) and (73.8%) and amylose values of (25.8%) and (24.6%), respectively. Sorghum bran fraction had the highest value with 41.38 g/100 g, followed by 26.34 g/100 g in whole grain sorghum and 11.53 g/100 g in hulled sorghum when authors evaluated the fibre content in all three types of sorghum (Moraes *et al.*,2015).

2.7.3 Fat

Sorghum whole grain has a high fat level of 3.5 (%) per cent as opposed to wheat is (2%), fat content (Salim *et al.*,2006). The germ of the sorghum contains fats. Linoleic acid (18:2), oleic acid (18:1), and palmitic acid (16:0) are the most prevalent fatty acids, with average amounts of (43.86%, 37.98%, and 13.07%) in refined sorghum flour (Pontieri *et al.*,2011). The expandable storage time of sorghum flour from 15 days to several months by means of heat treatments (Meera *et al.*, 2011). The ratio of saturated to unsaturated fatty acids was found to be (0.27-0.37) (Shea *et al.*, 2014). Sorghum is known for having a valuable micronutrient profile (Istianah *et al.*, 2018). Regarding the micronutrients, phosphorus concentrations ranged from 112.5 to 327.7 mg/100 g, salt concentrations were 2.2 to 6.2 mg/100 g, magnesium concentrations were 62.0 to 207.5 mg/100 g, and calcium concentrations were 9.5 to 67.2 mg/100 g.

2.7.4 Starch

The characteristics of sorghum and corn starch are comparable. Sorghum starch granules are a little bit larger but have the same shape as the others. The swelling capacity and paste viscosity of the starch varies slightly in terms of rheological properties. Sorghum starch gelatinizes at a temperature between 71 and 80°C, which is higher than the gelatinization temperature for corn starch which is between 62 and 72°C (Pontieri *et al.*,2011).

2.7.5 Fibre

Sorghum has (6.5-7.9%) and fibre (86.2%) of which is insoluble. This fibre functions as both a structural and protective element. The pericarp of cereal grains is usually where one may find dietary fibre, which is made up of soluble and insoluble portions. Sorghum has insoluble fibres that are high in glucuronoarabinoxylan's. Compared to wheat, which possesses both soluble and insoluble arabinoxylans, barley is abundant in soluble b-glucans (Pontieri, 2016).

2.7.6 Lipids

The germ of the sorghum plant is where most of the lipids are found. These lipids' fatty acid makeup is quite close to that of corn oil. The following fatty acids in decreasing order of concentration, make up the majority of the sorghum oil: linoleic, oleic, palmitic, stearic, myristic and hexadecenoic.

2.8 Chemical composition of sorghum

In Argentina, sorghum was produced by dry milling 20 commercial hybrid cultivars, and the samples' typical chemical makeup is as follows:

Table 1: Chemical composition of sorghum

S.No.	Chemical composition (sorghum)	Sample percentage
1.	Ash	0.68%
2.	Fat	3.67%
3.	Protein	12.21%
4.	Total carbohydrate	83.5%
5.	Starch	79.77%
6.	Tannic acid	34.9 mg per 100 g flour

Source: Palavecino *et al.*, 2016

2.8 Quality of protein in sorghum

Compared to maize or wheat, sorghum demonstrated a wider range of protein or amino acid digestibility values. Most often, sorghum makes up all or some of the cereal grain. A healthy diet contains around 30% protein from sorghum and it is likely that the quality of its protein and amino acids has an impact on how well children develop. Sorghum likely has a wider range of digestibility and amino acid concentrations than other cereal grains. The two main sorghum proteins, kafirin and glutelin, are located in the endosperm. However, because of the bisulfide linkages and low lysine concentration, it is an inadequate source of amino acids. Kafirin is found in protein bodies, and the protein matrix in sorghum endosperm is made up of glutelin. The endosperm protein was made up of kafirin, glutelin, globulin, and albumin in that order (54.1%, 33.4%, 7.0%, and 5.6%). The amount of kafirin rises at the expense of sorghum protein as levels rise (Xiong *et al.*, 2019).

2.9 Health benefits

In addition to being used for human food, sorghum is also utilised as an alternative to wheat that does not contain gluten as well as for biofuel and animal feed. However, these uses are rapidly increasing. They have a lot of nutrients, are high in soluble fibre and antioxidants and may lower the risk of developing certain diseases (McGinnis *et al*., 2020). Sorghum is the most significant staple grain in the world rich in nutrients and phenolic compounds that are good for your health. According to recent research, sorghum's phenolic compounds can serve as antioxidants *in vitro* and eating the whole grain may enhance gut health and reduce the chance of developing chronic illnesses (Xiong *et al.*,2019). Additionally, sorghum grain contains high levels of bioactive phenolic compounds like luteolin, apigenin, ferulic acid, gallic acid, vanillic acid, caffeic acid, p-coumaric acid, and 3-deoxyanthocyanidins (3-DXA), which have antioxidant, anti-inflammatory, antiproliferative, antidiabetic and antiatherogenic properties.

2.10 Compounds of phenolic in sorghum

It is known that plants spontaneously biosynthesize secondary metabolites, including phenolic chemicals. The sorghum grain contains a sizable number of flavonoids and phenolic acids. The subgroups of flavonoids include flavanone, flavanol, anthocyanins and condensed tannins often known as proanthocyanins. Among the phenolic acids contained in sorghum grains and caffeine acid predominates. Typically, phenolic chemicals in sorghum grain are extracted using the following methods such as maceration, refluxing, water, Soxhlet and organic solvent extraction (Jingwen and Weiqun, 2021) of glutelin. The amino acid content of sorghum is impacted by the reciprocal relationship between kafirin and glutelin since they have distinct amino acid profiles (Selle, 2011).

2.11 Potential molecular mechanism of phenolic compounds

2.11.1 Antioxidant activity

The author claims that dietary polyphenols contain antioxidants that can neutralise free radicals to avoid chronic diseases. This field typically focuses on the *in vitro* and *in vivo* antioxidant properties of phenolic chemicals extracted from sorghum grains (Selle, 2011).

2.11.2 Antidiabetic action

Diabetes is one of the most common chronic diseases. Hyperglycaemia and inappropriate glucose metabolism, which are brought on by insulin resistance and pancreatic b-cell are the causes of diabetes. Phenolic, which is extracted from sorghum begins to effectively manage diabetes by decreasing blood glucose, total cholesterol and triglycerides (Jingwen *et al*., 2021).

2.12 Sorghum food products

The main cuisines that include sorghum are tortillas (Latin America), thin porridges like bouillie (Africa and Asia), stiff porridges like (West Africa), couscous (Africa), injera (Ethiopia), nasha and kisra. Sorghum may be used to make tortillas either on its own or in conjunction with maize and cassava. Traditional, new-born porridge known as nasha is prepared from (Pontieri, 2016).

2.13 Effects of sorghum in baking products

2.13.1 Bread

According to studies, typical bread qualities include doughs made with up to 40% sorghum to replace the wheat (Shea *et al*., 2014). Researchers also discussed how the volume of bread decreased when sorghum flour was used in place of wheat flour, with the proportion of sorghum appearing to steadily increase. After 15 per cent of sorghum was added, volume loss was noticed (Elkhalifaand El Tinay, 2002). Researchers looked even higher sorghum-to-wheat ratios (30% and 40%). In addition to assessing the physical properties of wheat-sorghum bread products, successful sensory results were also discovered. In the study, control breads made with 100 per cent wheat were contrasted with loaves that contained up to 30% sorghum in terms of flavour, texture, and scent (Sibanda *et al.*, 2015).

2.13.2 Cake

Wheat cake, which is formed from flour, sucrose, baking powder, vanilla, and water, did not alter in weight or volume as a result of the addition of 15 per cent sorghum (Sibanda *et al.*, 2015). Consumers' perceptions of cake quality are heavily influenced by colour (Slade *et al*., 2021). Due to non-enzymatic chemical reactions like maillard browning and caramelization, which affect not only colour but also flavour, aroma, and nutritional aspects and are influenced by functional ingredients in product formulations, product specifications, baking time and temperature, colour formation (also known as "browning") occurs during the baking of sweet baked goods like cakes and cookies (Godefroidt *et al*., 2019).

2.13.3 Biscuits

Due to the lack of gluten in sorghum dough, biscuits prepared from this grain have a comparable feel to those made from wheat. Using polarised light microscopy, it was demonstrated that the sorghum biscuits' starch granules are not gelatinized. Sorghum biscuits' breaking strength and brittleness rose as dough water was increased. Increasing the amount of pre-gelatinized sorghum flour in the dough, however, decreased the strength of the sorghum biscuits, demonstrating that starch gelatinization compromised the structure of biscuits. Conversely, increasing the amount of sucrose in the dough also boosted sorghum biscuit strength (Adedara and Taylor, 2021).

2.14 Germination and temperature effect on sorghum flour

The nutritional and functional characteristics of sorghum flour that had through germination were evaluated and contrasted with sorghum flour that had not undergone germination. Sorghum was germinated for various lengths of time (12, 24, 36 and 48 h) at different temperature (25, 30 and 35°C). The content grain crude protein, fat, fibre and ash are negatively affected by germination. As the germination duration increased enzymatic starch modification was seen to reduce water absorption and swelling power and improve oil absorption capacity. In comparison to native flour, sorghum germination enhanced the gel consistency while decreasing the paste clarity. The longer germination time and temperature caused proteins to be altered by the activity of enzymes, greatly increasing the protein solubility of germinated sorghum flour and improving its foaming and emulsifying capabilities (Singh *et al.*, 2017).

3. Wheat flour

Wheat is a valuable source of natural antioxidants and dietary fibre (Nidhi *et al*., 2012). For the recovery of bioactive chemicals from various agricultural products, methanol and ethanol have been widely used (Sharma *et al*., 2019). Most cakes and cupcakes are usually made using wheat flour, which includes a significant amount of starch. Gluten, non-starch polysaccharides and lipids are among the many different compounds found in wheat flour and they all have a significant impact on both the raw material's processability and the quality of the finished goods (Goesaert *et al*.,2005). A major ingredient in baking items is wheat flour. Starch and other ingredients like proteins and lipids are abundant in wheat flour, which impacts the characteristics. Only (1% to 3%) of wheat flour's entire composition is made up of lipids. They fall into one of two categories: lipids both free and bound (Sindhu *et al*., 2021). The majority of biscuits have wheat as their primary component and the growth of the biscuit business paralleled notable advancements in the science of grain milling. Wheat was crushed between stones to generate flour before roller milling was invented. This meal was difficult to extract the bran from, resulting in an abrasive black flour. The first roller flour mill was erected in Budapest in 1840, whereas Henry Simons developed the first one in Britain (Manley, 2011).

3.1 Composition of wheat flour

Wheat flour containing wide variations in chemical composition and characteristics are measured in different values such as starch: 74-86%, crude protein: 9-18%, ash: 0-5% and dietary fibre: 2.7-7%. The influenced in harvest year it affects the ratio of soluble and insoluble non-starch polysaccharides, with spring wheat flours often having a greater ratio (Andersson *et al.*, 1993).

3.1.1 Glutenases

When gluten is digested by proteases produced by bacteria or fungi, it becomes less harmful and changes the texture of wheat flour. Wheat flour degraded by glutenases can be combined with other flours, such as millets, to enhance its viscoelastic properties, flavour, and other qualities (Shakiraand Govind, 2022). Although, wheat proteins come in at least 70 different types, they can be categorised into four main groups based on how effectively they dissolve in various liquid mediums in order to assess how well they function (Millar and Tucker, 2012).

Table 2: Wheat proteins and plant protein osborne fractions

S.No.	Solubility	Plantprotein fraction	Wheat protein fraction
1.	Water soluble	Albumins	Albumins
2.	Saline soluble	Globulins	Globulins
3.	Aqueous soluble	Prolamins	Gliadins
4.	Remaining soluble fraction	Glutelins	Glutelins

Source: Millar and Tucker, 2012.

3.2 Outcome of storage temperature on quality of wheat flour

According to the Journal of Nutritional Sciences, wheat flour can typically be stored at temperatures between (27.5°C to 37.5°C) for durations of 3, 10, 20 and 30 days, relative humidity levels, wheat's chemical characteristics, such as moisture content and the percentage of wet gluten, as well as its physical characteristics. From this experiment, two additional findings demonstrate that increasing storage temperature from 27.5°C and 37.5°C has led to a decrease in the moisture content of flour when stored at a relative humidity of (38%-70%), and that increasing the storage period from 1-10 days has led to an even greater decrease in the moisture content of flour (Muneer, 2015).

4. Gluten-free

People with gluten sensitivity can only be treated with a gluten-free diet. Numerous gluten-related diseases including celiac disease, dermatitis herpetiformis (the cutaneous manifestation of celiac disease), gluten ataxia and non-celiac gluten sensitivity are caused by consuming gluten this concept given by Al Toma *et al*. (2019). According to some accounts, gluten-free doughs and batters are more challenging to work with than their grain-based counterparts. They are also less cohesive and bendable and they have a weaker memory for holding vapours. According to the maker, these batters and doughs have a tiny volume, a pale coating, a brittle texture, a thick morsel structure, a bland, stiff flavour, very little nutritional value and a rapid rate of burn. As foundation flours because of their neutral flavour and lack of impact on baked goods, gluten-free flours include maize, potato, rice and starch. These flours and starches often have very little capacity for constructing structures and are generally poor in nutrients. Food scientists have provided evidence for the use of gluten-free ingredients like starches, hydrocolloids, proteins, enzymes, fat sources, faux cerealsand sourdough (Ognean, 2015).

4.1 Gluten free bread and bakery products

In baking technology, rye, barley and oats are significant derivatives of gluten a protein component from wheat. As more individuals throughout the world become gluten-intolerant. There is a rising need for items that are suited for a gluten-free diet. A daily diet must include bread and other bakery goods. The goal of current research is to increase the bread and bakery goods' ability to be distributed in a fresh form as well as their shelf- life. For a consumer used to traditional wheat or wheat-rye bread, gluten-free bread and other gluten-free bakery items are relatively uncommon have demonstrated that (70.8%) of the customers polled were unsatisfied with the texture and flavour of gluten-free loaves (Toth and Koris, 2020).

4.2 Gluten-free bakery and pasta products (Alternative treatments)

Sorghum flour underwent a number of heat treatments to see if it could be used in gluten-free cake. The flour was dried for 15, 30,

and 45 min in a micro-oven set at 95 and 125 degrees Celsius. Using a rapid visco analyzer, the peak and ultimate viscosities of the flour were evaluated following heat treatment. The largest volume and greatest number of cells per square inch were found in the cakes produced by heating flour at a higher temperature (125°C) for a longer period of time (Brites, 2018).

4.3 Gluten free eggless cake using gluten free made from sorghum flour

The goal of the study was to develop a gluten-free eggless cake for celiac disease sufferers using a composite gluten-free flour made of sorghum millet. The physical, textural, rheological, and nutritional properties of prepared gluten-free eggless cakes were investigated. An acceptable substitute for eggless cakes made with refined flour and composite flour is a gluten-free eggless cake with outstanding nutritional value. Gluten-free foods are the greatest choice for those with celiac disease because they are naturally higher in minerals thanks to the ingredients germinated state (Agrahar *et al*., 2018).

4.4 Effect of sorghum flour on gluten free cake

As demand for gluten-free goods rises using sorghum flour is a wise choice. Worldwide consumption of sponge cakes makes them a good candidate for formulations that might sub in wheat flour. The size of the flour particles has the greatest impact on the quality of sponge cake. In this work, we milled white and brown sorghum grains to generate various flours described them and assessed how the features of the flour affected the qualities of the batter and gluten-free sponge cake.The composition, density and viscosity of the batters as well as the sponge cake's specific volume and crumb characteristics were assessed. The findings demonstrated that the milling operations changed the characteristics and content of flour. Smaller-particle brown or white sorghum flour created high-density, viscous batters with uniformly sized air bubble dispersion. Smaller flour particles regardless of the kind of sorghum used to produce sponge cakes with a large volume and low degree of stiffness (Maria, 2021).

5. Effect of freezing on cake quality

Layer cakes and sponge cakes are the two types of cakes. These cakes may be refrigerated for between 60 and 120 min before baking kept for between 30 and 100 days and frozen at temperatures between (18 and 26°C). In contrast, batter characteristics such as pH, density, viscosity and microstructure were investigated for cakes. As a result, a cake's volume drops but its hardness improves when it is frozen. In comparison to storage or freezing conditions or resting time, the freezing process has a stronger impact on batter and quality features. While freezing mostly changed the colour and volume of layer cakes it primarily affected the body texture of sponge cakes (Manuel *et al.*, 2011).

6. By-products of gluten free flour

By-products of food have been highlighted as a possible underused element due to their mechanical and digestive qualities. These by-amounts might be represented as the residue left over from crop production and product manufacture. They consist of the product's seeds, peel, pips, skins, stems and cores. Green banana flour was used to make gluten-free pasta (a banana industry by-product). The authors chose green banana flour because of its resistant starch and high phenolic acid content. Two further by-products under investigation are defatted strawberry seeds and blackcurrant seed the material remaining after the oil has been removed. These by-products' potential for nutrition including their protein, fibre and bioactivity has piqued researchers' curiosity. In comparison to loaves containing defatted strawberry and blackcurrant seeds is control it was discovered that adding defatted strawberry to a gluten-free bread formulation dramatically increased the loaf volume (Ognean, 2015).

7. Effect of sorghum on quality properties of gluten-free bread

To make flours with both varied compositions, sorghum is milled to flour with various extraction rates (60, 80, and 100%) and milled at various speeds (no pin-milling, low, and high). Characteristics of the flour included the amount of total starch, particle size, distribution, colour, and grain water absorption. Bread was described using specific volume, crumb structure, and crumb stiffness. Breads created with (60%) extraction of flour have higher specific volumes, better crumb properties, and lower crumb stiffness when compared to breads made with all other extractions and wheat types (Trappey *et al*., 2015).

8. Effect of heat treatment on sorghum products

We investigated the impact of heat treatment on sorghum's performance in gluten-free bread and cake. Dry heating the sorghum flour for 15, 30, and 45 min at 95°C and 125°C. Heat treatment of the flour affects viscosity, which has a big impact on the final quality of cakes and breads. By heating the flour at (125°C) for 30 min, the loaf with the highest specific volume (3.08 ml/g) and the greatest cell density per slice (50.38 cells/cm^2) was produced. The breads and cakes created with the control sorghum flour had thick textures, low volume, and poor crumb characteristics. Additionally, cake and bread made using this heat treatment outperformed the controls in consumer tests (Kathryn and Hanna, 2016).

9. Microwave heating also effects on the sorghum grains

Microwaves were used to warm sorghum grains for 15, 30, and 45 sec at 350 and 500 W of power. The effects of microwave heating on the protein content, *in vitro* digestibility, functional, and antioxidant properties of sorghum grains. By heating the grain in the microwave at 350 and 500 W, the fungus incidence in the grain was significantly reduced to between (26.2 %) and (33.4 %). The sorghum's crude protein content, protein digestibility, water holding capacity, or oil holding capacity did not vary noticeably. However, using 500 W of microwave radiation for 30 and 45 sec significantly decreased the solubility of proteins (8.2-7.6%). These revealed that sorghum seed might potentially be cooked alongside at 350 and 500 W for around 45 and 15 sec, respectively in account of claimed improved attractiveness functional and digestive features. In light of this, microwave heating, especially at low power, may be a successful new technique for enhancing the physicochemical and nutritional qualities of sorghum grain (Salah *et al.*, 2021).

9.1 Physical properties of microwave baked cupcake

The physical properties of the cupcakes such as density, porosity, colour and height as well as the textural characteristics of crispness, hardness, cohesiveness, springiness, resilience, gumminess and chewiness were all varied depending on the microwave power used

(150, 300, 450 and 600 W) as well as the operational time (3.5, 5, 8 and 16 min). This feature shows that as microwave power increased, colour intensity and total colour deviations from the reference batter increased. The 600 W-baked cupcake had the shortest baking time, the lowest values for hardness, density, chewiness, and gumminess, and the highest values for cohesiveness, resilience, porosity, height, and browning index when compared to the other microwave powers. Therefore, 600 W was the ideal operating power for achieving desired baking quality (Soleimanifard *et al.*, 2018).

10. Different ingredients to improve the nutritional value

Due to the difficulties in including sources of calcium, such as dairy products due to lactose intolerance, celiac disease has a high prevalence of osteoporosis. the impact of adding two different calcium supplements-calcium citrate and calcium caseinate on a gluten-free recipe's baking abilities. The strongest beneficial impacts of calcium citrate supplementation on bread properties were shown at (2%) (Ognean, 2015).

10.1 Physiochemical parameter reduced sugar in cake

It is challenging to reduce sugar in baked goods like pound cake because of the many roles that sugars provide. Temperature, batter rheology, protein denaturation, starch gelatinization and flour pasting behaviour are all influenced by sucrose. Consequently, switching sugar for sugar can substantially alter the structure and texture of baked goods. According to this study, phase transitions in batter rheology during baking and a 50% sugar substitution both affect the physical properties of baked cakes. The study is based on a relationship between three physicochemical parameters and the physical characteristics of batter and cakes, including the volumetric density of available effective H-bonding sites in the sugar-water phase, the number of effective H-bonding sites within a sugar's molar volume, and the volume averaged interaction parameter of the sugars with water (Renzetti *et al.*, 2022).

10.2 Alternate way to sugar reduces in cake

Substituting a natural sweetener for sugar in meals is a good approach to cut calories. The World Health Organization advises keeping added sugar intake to less than 10% of total calories consumed. Food items include glucose syrup, molasses, fructose syrup, invert syrup and malt extract all contain sugar analogues. Dates are a perfect product to substitute for additional carbohydrates in cuisine and are an essential part of many people's daily diets in dry regions. These products are rich in phenolic compounds, minerals, vitamins and dietary fibre in addition to antioxidant substances. When manufacturing date syrup which is used to manufacture various types of sugar compounds dates are an excellent alternative. They include a lot of carbohydrates and minerals and are high in energy but they also contain a complex blend of amino acids, organic acids, polyphenols and carotenoids includes fructose, glucose and sucrose as well (Ayoubiand Mahda, 2017).

11. Replacement of eggs effects on cake batter and properties

According to the most recent study, egg replacement is getting more and more valuable. This is a result of consumer dietary preferences (vegan and vegetarian), religious convictions, and health issues including phenylketonuria, egg allergy, or concerns about cholesterol and avian influenza. The food industry is thus looking for egg substitutes to create products that are either entirely, partially, or altogether eggless. Therefore, current research has concentrated on the use of egg substitutes from various sources in bakery goods, especially in cake compositions. The most popular egg substitutes are whey and soy-based proteins; when combined with additional food additives like emulsifiers and hydrocolloids, they can mimic the qualities of eggs.These egg substitutes can have an impact on cake quality parameters like moisture content, baking loss, specific volume, external properties, colour, texture, crumb structure, and sensory preferences as well as batter properties like specific gravity, viscosity, textural properties, rheological properties, and bubble size distribution. Additionally, they are simple to store and have a long shelf life (Gamzeand Mehmet, 2021).

12. Shelf-life of packaged bakery goods

As many of the items are for subsequent use, the packaging requirements for unique culinary businesses where baked goods are created are minimal. However, the wrap may play a significant role in extending the usable life of extra rice-located items (toast, stopped fruit, biscuits, loaves and pastas). Some amount of the fabric changes and flavour deficit manifest over the shelf life of a compassionate-stewed good can commonly be underrated or deferred by effective use of bundle fabrics (Galic *et al.*,2009). Cakes typically have a shelf life of one to four weeks although due to the usage of specific ingredients, industrial cakes typically have extended shelf lives. The development of certain microorganisms, starch retrogradation events, water migration from internal to exterior zones and subsequent loss of the water to the atmosphere are some of the reasons that contribute to quality degradation (Manuel Gomez *et al.*, 2011). Starch declining is the primary mechanism to find the shelf life of the crop. This crop is microbiologically safe which adversely effects on starch granules on textural properties so this is main reason of product is cut by the customer which leads to big economical losses (Sozer *et al.*, 2011).

13. Factors affecting the microbial growth in food products

Food's surroundings can either support or inhibit bacteria ability to develop, establish, and change. Each one seems to be a typical food component that either occurs naturally or is artificially managed. Two requirements must be met in order to maintain a system of microbiologically safe food. The environment to which the food product is exposed can contain extrinsic elements like temperature, relative humidity, gaseous conditions, or the presence of microbes. However, internal elements, such as nutrient content, pH levels, water activity, redox potential, and other antimicrobial components acting as defences against pathogens, are intrinsic to the food product **(**Rolfe and Daryaei, 2020**)**.

13.1 Antioxidant and antimicrobial of date seed extract effect on cupcake

By-products of date seed can be used in a variety of ways. The extracted antioxidant was evaluated using the 2,2-diphenylpicrylhydrazyl radial scavenging technique. The findings showed that increasing antioxidant activity extraction enhanced its concentration. The IC_{50} of the date seed extract was found to be 1568.93 mg/l. Using minimum inhibitory concentrations and minimum bactericidal concentrations of 0.08 and 0.4 mg/ml, respectively the extraction of antibacterial activity against

Salmonella typhimurium was assessed. The cupcake configuration now includes extracts at four different levels are (0, 0.05, 0.1and 0.2%). Additional tests were performed on cupcake samples including those for peroxide number, acidity, pH, proximate analysis and sensory assessment. Therefore, all cakes are extracted in the standard range for physicochemical qualities at various level sincluding (0, 0.05, 0.1 and 0.2 g/ml.). The sample comprises (0.2%) date seed extract and both the sensory features and the microbiological count were satisfactory. Overall, the study found that date seeds can be employed as an affordable natural preservative in food compositions due to their inclusion of phenolic compounds, antioxidants and antibacterial activity (Baghbani and Shirazinejad, 2019).

14. Effect of sorghum grain on protein digestibility

Sorghum, but not maize contains less digestible protein after cooking. Before *in vitro* pepsin digestion, boiling sorghum and maize whole grain and endosperm flours were smoothed with alpha amylase to improve protein digestibility. Sorghum protein was less digestible after cooking, while overall polyphenol levels in the samples remained unaffected. It was shown that the pericarp, germand gelatinized starch could act as digestive inhibitors for sorghum protein. This study used both raw and cooked high-tannin sorghum variety 6043, a hybrid maize grown in both have low protein amounts which has been shown. Unprocessed whole grains have *in vivo* and *in vitro* digestibility's of 9 and 10, respectively. The sorghum sample show ever were broken up in a lab hammer mill and other cultivars with comparable tannin contents may have varying degrees of protein digestibility (Duodu *et al*., 2002).

15. Effect on sorghum starch and sorghum flour by heat-moisture treatment

Sorghum starch and flour received heat-moisture treatment at (20% and 25%) moisture levels. According to the findings, the treated materials solubility and swelling power reduced. The altered samples had a higher level of crystallinity than the control samples. Heat and moisture treatment had a substantial impact on sorghum flour's solubility, swelling power, setback viscosity, through viscosity, enthalpy, and crystallinity when compared to sorghum starch.The crucial physical process known as heat moisture treatment, which is notably helpful for food applications, improves the insufficient functional qualities of native starch. Starch alteration with heat moisture treatment is a cheap and sustainable process. Through comprehensive investigation, they were able to show that heat moisture treatment dramatically changes the physicochemical characteristics and molecular structure of early Indica rice, chestnut corn, rice, and potato starches (Sun *et al*., 2014).

16. Conclusion

Continued debate makes it evident that wheat and sorghum flour millets may be utilised to create sugar-free improved cupcakes. Certain types of wheat flour can be substituted with sorghum flour. The particle size and form of sorghum flour usually give baked foods like bread and cakes a gritty appearance. During lactic fermentation, the phytic acid content of sorghum flours is reduced by (40-60%). The production of phytic acid results in stable molecules with excellent bioavailability of calcium, magnesium, manganeseand iron. Sorghum flour to several heat treatments and confirmed the usefulness of the flour in gluten-free cake. The flour was placed in a micro-oven and dried heated for 15, 30 and 45 minutes at 95 and 125°C.We were observed in this review how heat treatment affected sorghum's ability to function in gluten-free bread and cake. In the previous research, we were found that heating of sorghum flour for 15, 30, and 45 min at 95°C and 125°C and it was found better. Microwaves were used to warm sorghum grains for 15, 30, and 45 sec at 350 and 500 W of power. The effects of microwave heating on the protein content, *in vitro* digestibility, functional, and antioxidant properties of sorghum grains. The cupcakes' physical characteristics, such as density, porosity, colour, and height, as well as their textural qualities, such as crispness, hardness, cohesiveness, springiness, resilience, gumminess, and chewiness, varied according to the microwave power (150, 300, 450, and 600 W) and the operating time (3.5, 5, 8 and 16 min).

Conflict of interest

The authors declare no conflict of interest relevant to this article.

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