Middle East Journal of Applied Sciences 3(4): 196-204, 2013
ISSN 2077-4613

Quality And Sensory Evaluation Of Free Gluten Pizza

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ABSTRACT

The present trend in population growth indicates that the wheat gap may continue to increase in the future unless well-planned measures are taken to tackle the situation through replaced other wheat cereal in bakery production. On the other hand, celiac disease is a well known status in numerous countries and represented highly significant population detected. The trade mark, market and consumption of quick service pizza is growing fast and has increased as population are spending more on food away from home. Therefore, the current paper aims to utilize sorghum, in addition to estimate other treatments, fermentation process, gum addition (either 0.5 or 1.0%) only individually or combined togther in production of pizza instead of wheat flour. It was undertaken (1) to determine the nutrient contents of the tested sorghum; (2) to estimate the chemical and mineral constituents of the resulted pizza and (3) to compare the quality characteristics (antinutitional and sensory properties of the prepared pizza). It was concluded that all the tested treatments organoleptically and nutritionally developed the tested products and produced pizza superior in terms of protein, fiber, ash and mineral contents. This will help in improving status of sorghum among cereals in economic of implementation producers and will contribute for the health of the population.

Key wodrs: Sorghum, celiac disease, gluten-free, chemical and sensory attributes, pizza.

Introduction

Sorghum is closely related members of the subfamily Panicoideae in the family Gramineae. Sorghum originated in Central Africa with various hypotheses placing the domestication of sorghum sometime between 4500 and 1000 BC, after which it spread to Asia and India (Kimber, 2000). Sorghum (*Sorghum bicolor* L Monech) is the major food grain in semi-arid tropics of Africa, India and South America and ranks fifth amongst the world cereals following wheat, maize, rice, and barley. Sorghum is a physiological marvel. It can grow in both temperate and tropical zones. It is among the most photosynthetically efficient plants. Sorghum thrives on many marginal sites. Its remarkable physiology makes it one of the toughest of all cereals. Sorghum is perhaps the world's most versatile crop. Some types are boiled like rice, some cracked like oats for porridge, some malted like barley for beer, some baked like wheat into flatbreads and some popped like popcorn for snacks.

Sorghum is grown throughout the world, with the majority (~55%) produced in Asia and Africa. The United States produces approximately 30% of the world production, with the majority of the remainder being produced in South America (Smith, 2000; Rooney and Serna-Saldivar, 2000). Little sorghum is produced in Europe. Sorghum is an important food staple in many arid parts of the world due to its drought tolerance; it often grows where other cereal crops fail. Sorghum kernels are typically thought of as round, though most have at least one flat surface (Reichert *et al*., 1988). Due to the genetic diversity of sorghum, kernels can vary widely in size and shape, with 1000 kernel weight for sorghum varying from 30 to 80 g (Rooney and Serna-Saldivar, 2000). Commercial sorghum hybrids on average have kernels weighing from 25 to 35 mg and are around 4 mm long, 2 mm wide, and 2.5 mm thick (Rooney and Serna-Saldivar, 2000). Anatomically, the sorghum grain is made up of the pericarp, endosperm, and the germ. Sorghum is unique in that it is the only cereal grain to have starch granules present in the pericarp. The outer edge of the sorghum endosperm is composed of the aleurone layer containing lipids, enzymes, and protein bodies. Under the aleurone layer is the outer corneous (hard, sometimes referred to as vitreous) endosperm fraction surrounding an inner floury (soft) core (Rooney and Serna-Saldivar, 2000). The outer corneous endosperm is tightly packed with protein bodies covered with a continuous protein matrix (Seckinger and Wolf 1973). Starch granules in this area of the sorghum kernel often show indentations where protein bodies were pressed into the sides of the granules (Rooney and Serna-Saldivar, 2000). In contrast, the floury endosperm in the center of the kernel is loosely packed with a discontinuous protein matrix and round starch granules (Seckinger and Wolf 1973and Rooney and Serna-Saldivar, 2000). The relative proportions of corneous to floury endosperm can vary widely in sorghum and overall grain hardness in sorghum is often reported to be well correlated to the percent vitreosity of the kernel (Hallgren and Murty 1983). The outer appearance of sorghum can vary widely from white or yellow to red. Endosperm color in sorghum can be yellow to white and can influence the outer appearance of the grain in germplasm with a thin pericarp. Tannins, or proanthocyani-dins, are polyphenolic compounds found in the sorghum lines with a pigmented testa.

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The presence of the pigmented testa and thus tannins, is under genetic control and only sorghums with the Bl/B2 genes have a pigmented testa (Waniska, 2000). It is a common myth that all sorghum lines contain tannin and often non-tannin phenolic compounds are presented as tannins. Another common myth is that the presence of tannins is linked to kernel color in sorghum; sorghum lines with a pigmented testa can have any pericarp color, including white (Waniska, 2000). One important characteristic feature of sorghum is that its protein digestibility decreases upon cooking, apparently through the formation of more protein cross-links during the cooking process (Duodu *et al*., 2003).

Sorghum is commonly consumed by the poorer section of the population in many countries and it forms a major source of proteins and calories in the diet of large segments of the population of Africa (Belton and Taylor, 2004). It is the most important cereal crop in Sudan. In many parts of Sudan, where sorghum is a major food grain, people depend on whole sorghum meals, as the main meal. In many African countries, sorghum is milled into flour before fermentation and cooking. Fermentation is an ancient method of food processing aimed at prolonging shelf-life and improving palatability of foods. It may also improve digestibility and nutritional value of food and feed. Preservation of foods by fermentation is mostly due to the lactic acid bacteria, often in combination with yeasts (Fadlallah *et al*., 2010).

Celiac disease is a life-long intolerance to gluten proteins. A decade ago, celiac disease was considered an uncommon disorder in the world, with prevalence rates of 1 in 1000 or lower (Feighery, 1999). However, recent population studies have reported a much higher prevalence and it is now estimated that celiac disease may affect one in 100 of the population, including both adults and children (Mendoza and McGough, 2005). In addition, there are geographic differences, and in Finland, for instance, the prevalence of celiac disease in adult Finns achieved 1.99% in 2000–2001 (Lohi *et al*., 2007). People suffering from celiac disease react with inflammation of the small intestine, leading to malabsorption of several important nutrients including iron, folate, calcium and fat soluble vitamins (Feighery 1999 and Murray 1999). Clinical and epidemiological studies have showed celiac disease to be a risk factor for cancer (Silano *et al*., 2007), osteoporosis, thyroid disease (Sategna-Guidetti *et al*., 2000), female infertility (Stazi and Mantovani, 2000), neurological and psychiatric disorders (Ludvigsson *et al*., 2007). Therefore a strict gluten-free diet – without cereals containing gluten proteins (wheat, barley, rye, triticale, dinkel and kamut) is essential (Gallagher *et al*., 2004). Such a diet improves the health-related quality of life in terms of less symptoms of the disease and normalised microvilli, which is of utmost importance for optimal gastrointestinal functions (Johnston *et al*., 2004). The definition of gluten-free food varies in different countries. In the US a gluten-free diet includes mostly rice and maize that are naturally gluten-free. In Scandinavia and the UK, a gluten-free diet may include wheat starch that has been rendered gluten-free (Peraaho *et al*., 2003 and Thompson 2001).

Recently, there has been increased interest in sorghum as a gluten-free cereal to substitute the gluten-rich cereals in the diet of people suffering from celiac disease (Elkhalifa *et al*., 2005). The functional properties of sorghum proteins can be used to define how flour proteins can be used to supplement or replace more toxic protein sources (e.g. wheat). In developing countries, particularly sub-Saharan Africa, infant complementary foods are grossly inadequate, complementary foods were formulated. Sorghum plays a significant role in the food security of the rural populations all over the world (Adebayo-Oyetoro *et al*., 2013). There is a small, but significant, proportion of the population who cannot tolerate wheat gluten, which has been linked to a specific disorder of intestinal absorption, known as celiac disease (Gallagher, 2009). The prescribed treatment is strict adherence to a gluten-free diet (O'Neill, 2010) and therefore, sorghum would be an ideal dietary choice. Therefore, attempts have been made to totally or partly substitute sorghum in starch pizza dough preparing.

Consequently, supplementing the wheat flour, partially substituted, or completely replaced by sorghum flour, nutritive value of vegetarian or celiac disease diets can be improved in terms of proteins and minerals. Keeping this in view, the present investigation was undertaken to evaluate the nutritional composition of value added traditional and specified bakery products (pizza) incorporated sorghum (Sikandra and Boora 2009).

Materials and Methods

Materials:

Sorghum flour and other ingredients were purchased from the local market at Makkah city, Kingdom of Saudi Arabia.

Methods:

Preparation of pizza:

Ingrediants:

The materials used to produce the control pizza dough included:300g sorghum flour**,** 15g skimmed milk, 25g butter, 1g salt, 5g malt, 1g sugar, appreciate amount of water and 10g cheese for decoration only.

The used method was the straight-dough system (Pacheco de Delahaye *et al*., 2005), in such method all the formula ingredients are mixed into a developed that is allowed 100 min to ferment. During the fermentation, the dough was punched (gas knocked out) one or more times as necessary. After fermentation, another 55 min, it was divided into loaf-sized pieces and rounded and placed into a container, Packing and Storage at –18° C until analyzed and baked then sensory estimated.

Other five treatments, to estimate its impact on tested properties, were done, i. e., 0.5 and 1% gum were added to the formula. Fermented pizza where 1% instant yeasts was used. 0.5 and 1% gum were added to the fermented pizza.

Chemical analysis:

Moisture, ash, protein, fiber and fat were determined by the methods of AOAC (2005) and the carbohydrate contents were calculated by difference. Caloric values were calculated according to the following equation as recommended by FAO/WHO (1974).

Caloric value in Kcal/100 g on dry weight basis = 4(protein% + carbohydrates%) + 9 (fat%)

Mineral (potassium, calcium, iron, magnesium, sodium and zinc) contents were determined by Perkin Elemr 3300 atomic absorption spectrophotometer as applied by ASTM (1997). Phytic acid was determined by the method of Wheeler and Ferrel (1971) while Tannins was determined by Price *et al*., (1978).

Sensory evaluation:

The tested sorghum pizza samples were elaborated using the defrosted pizza dough. The sensorial attributes evaluated were overall acceptability, odor, color, flavor and texture (represented by hardness, and chewing action). The sensorial evaluation was done by twenty well trained members of Food technology assistant professor, College of Medical Applied Science, Umm Al-Qura University, Ministry of Higher Education, Kingdom of Saudi Arabia. Each of the samples was numbered using the random three-digit numbering system. Panellists were asked to indicate their preference on a 10-point Hedonic scale with degree of liking: 1 = dislike extremely, 10= like extremely as recommended by Jayasena *et al*., (2008) and Pacheco de Delahaye *et al*., (2005).

Statistical analysis:

Mean values of all determinations and their standard deviation were recorded. Analyses of variance (ANOVA) were achieved to calculate the significant differences toward the different means at 0.05 level by using SAS (1987) software.

Results And Discussion

Pizza is becoming very convenient food product and becoming very popular in Egypt especially among children. Such product could be a big problem to human if they were suffering from celiac disease. Therefore, there is an ever growing demand for produce free gluten pizza to effectively maintain their health. Consequently, at first, utilization of specified flour other than wheat, such as sorghum, in preparing suitable therapeutic product is a good idea. The present investigation were undertaken to prepare a favorite pizza from sorghum and to evaluate quality of such product. Such idea was originated from the report of Pontieri *et al*., (2010) who stated that sorghum is often recommended as a safe food for celiac patients those people with a negative autoimmune response to wheat gluten and similar proteins in rye and barely.

Sorghum, also, has been used for thousands of years in human food products. As such, a diverse selection of traditional food products are available including fermented and un-fermented flat breads and porridges, rice-like products, taco shells, and tortillas (Serna-Saldivar and Rooney, 1995; Rooney and Serna- Saldivar, 2003). With few exceptions such as the tortilla, these products are not typical of Western diets. Since such products are typically made without any wheat, they are safe for people with celiac disease, and could, therefore, fill a specialty market for the celiac community. The use of sorghum in wheat/sorghum composite breads has been studied by many scientists (Munck, 1995), not so much as a food for people with celiac disease, for which they would not be suitable, but more as research into breads that could reduce the expensive importation of wheat into parts of Africa (Satin, 1988). As mentioned above, much of the work on sorghum bread production has stemmed from a need to reduce wheat imports into Africa, where sorghum is not a staple crop and therefore suggested to be a viable alternative to wheat. In addition to composite breads, several researchers have reported on the production of gluten-free bread from sorghum and much of this work is reviewed by Taylor and Dewar

(2001). Consequently, Table (1) illustrated the importance of sorghum as a good source for the nutrient constituents to prepare valuable nutrition bakery products. It was found that sorghum contained detectable amounts of carbohydrates, protein and fat which led to a higher energy value (392.54 Kcal/100 g on dry basis). Such results were agreed with that found by Agunbiade and Ojezele (2010) and Rooney and Serna-Saldivar, (2003) who stated that sorghum promises to be a "living factory" and as prevailing shortage of livestock product and low income earning have compelled large population in developing nations to resort to plants as the chief source of proteins.

The same Table showed also that the minor components (fiber and ash) were, also, higher in the sorghum flour suggesting the involvement of sorghum flour in bakery products enable to prepare highly nutritious products. Such findings confirmed the observation of Elleuch *et al*., (2010), Pontieri *et al*., (2010) and Chanapamokkhot and Thongngam (2007) who reported that sorghum is higher in protein, ash and fiber compared to other cereals used for human consumption.

The data presented in Table (1) showed also that minerals present in sorghum are mainly potassium, calcium, iron and zinc concurrent with that found by Pontieri *et al*., (2010).

In general, it is clear that (like all cereal grains) the major component of sorghum is proteins. Whereas, Rooney and Serna-Saldivar, (2003) reported that as with all cereal grains, starch is the major component of sorghum, where it contains about 50-75% starch of the sorghum grain, on a weight basis.

Table 1: Chemical Composition and mineral contents of sorghum grains

Component	%	Mineral	Amounts***
Moisture	10.45 ±0.06	Potassium	290.0 ±5.25
Ash*	2.82 ±0.02	Calcium	13.74 ±0.86
Protein*	11.52 ±0.07	Iron	5.82 ±0.11
Carbohydrate*	75.05 ±1.22	Magnesium	2.14 ±0.04
Fiber*	5.11 ±0.11	Sodium	0.09 ±0.01
Fat*	5.50 ±0.84	Zinc	4.11 ±0.06
Calorie values**	392.54 ±6.22		

* As % on dry weight basis.
** Kcal Per 100 g on dry weight basis.
*** As mg/100g on dry weight basis
Carbohydrate contents were determined by difference.
Each mean value is followed by ± standard deviation.

In a preface, Vavreinová *et al*., (2003) stated that gluten-free products (foodstuffs) are fundamental for population group suffering from celiac disease. The main sign of celiac disease (celiac sprue, gluten-sensitive enteropathia) is intolerance to gluten, resulting in failure of small intestine mucous membrane. The dermatic form of this disease is Duhring herpetiform dermatitis and some patients do not tolerate gluten without failure of small intestine.

The present research schemed to utilize of the fermentation process (by addition specified amount of yeasts) to enhance the pizza dough characteristics and involved of the gum (either individually utilize 0.5 and 0.1% or with a combination with the fermentation. Such process is a trial to develop the dough elasticity. Previously, it was found that the addition of xanthan gum was reported to produce sorghum bread with acceptable quality, but the right technique for its addition was important to get good results (Satin, 1988). Soaking the xanthan gum in water before adding it to the dough resulted in improved bread quality relative to dry addition. Therefore, a comparison study was done among the tested pizza samples in Table (2) with respect to their chemical composition and caloric value. It shows that all the tested pizza seemed to be possessed the same amounts of protein, fat and carbohydrate content which represented the higher amount of such components in the sorghum grains. It could be also noticed that the caloric values of all the tested pizza showed no significant variation. Such results confirmed that all the tested treatments revealed no impacts on the chemical composition of the resulted pizza. Both of fiber and ash seemed to be higher in the fermented pizza formula containing gum (specially in 1% samples). Such results could be demonstrated by the next points.

In addition to xanthan gum other tested processing (such as fermentation process) have been used by Hart *et al*., (1970) and other scientists pre-gelatinized (Olatunji *et al*., 1992; Hugo *et al*., 1997) to improve sorghum bread quality. Suhendro *et al*., (2000) produced sorghum bakery product from decorticated sorghum flour, water, and salt by preheating, extrusion, and drying. Heterowaxy sorghum produced noodles of inferior quality relative to normal sorghum. The noodles were sticky, soft, and had a high dry matter loss during cooking. Increased amylopectin and reduced amylose content in the heterowaxy sorghum limited retrogradation.

The authors further reported that the timing of amylose dispersion (solubilization), formation of noodles, and amylose retrogradation was critical as suggested by effects of the preheating and drying methods.

Flour particle size was also critical, with finer flour producing better quality noodles. Good-quality noodles resulted when processing conditions were optimized and when the noodles were cooked properly (Suhendro *et al*., 2000).

Table 2: Chemical Composition of pizza

Pizza of	Moisture	Ash*	Protein*	Carbohydrate*	Fiber*	Fat*	Calorie values**
Sorghum	25.11^{d} ±0.12	3.22^{d} ±0.03	13.45^{a} ±0.04	64.45^{a} ±1.00	6.32^{e} ±0.20	12.56^{a} ±1.00	424.64^{a} ±4.82
0.5% gum	26.72^{cd} ±0.16	3.72^{b} ±0.02	13.55^{a} ±0.06	63.63^{bc} ±0.88	6.55^{c} ±0.07	12.55^{a} ±0.62	421.67^{a} ±6.00
1%gum	27.34^{bc} ±0.04	4.11^{a} ±0.04	13.60^{a} ±0.02	62.99^{ab} ±1.20	6.82^{a} ±0.04	12.48^{a} ±0.34	419.00^{a} ±3.22
Fermented	28.16^{ab} ±0.24	3.27^{cd} ±0.06	13.32^{a} ±0.01	64.27^{a} ±1.11	6.42^{de} ±0.08	12.72^{a} ±0.48	424.66^{a} ±6.2
Fermented and 0.5%gum	28.30^{ab} ±0.22	3.80^{b} ±0.01	13.46^{a} ±0.02	63.47^{a} ±0.86	6.57^{bc} ±0.12	12.70^{a} ±0.72	421.94^{a} ±4.88
Fermented and1.0%gum	28.66^{a} ±0.06	4.14^{a} ±0.03	13.55^{a} ±0.04	62.59^{b} ±1.22	6.90^{a} ±0.08	12.82^{a} ±0.48	419.74^{a} ±2.36

* As % on dry weight basis.
** Kcal Per 100 g on dry weight basis.
Carbohydrate contents were determined by difference.
Each mean value is followed by ± standard deviation.
Each mean value, within the same column, followed by the same letter is not significant at 0.05 level.

Data presented in Table (3) showed that the highest amounts of calcium, iron and zinc were found in the samples containing gum and addition the fermentation process to the gum addition led to decrease their contents in the corresponding pizza. On contrary, the highest amounts of potassium, magnesium and sodium were detected in the sorghum pizza. Such trends are inagreement with that found by Abdelseed *et al*., (2011).

Table 3: Mineral content* in grain sorghum and pizza

Pizza of	Potassium	Calcium	Iron	Magnesium	Sodium	Zinc
Sorghum	282^{a} ±4.72	12.55^{c} ±1.62	5.11^{b} ±0.23	2.00^{a} ±0.07	0.11^{a} ±0.04	3.64^{c} ±0.01
0.5% gum	264^{bc} ±8.34	13.00^{b} ±2.11	5.42^{a} ±0.16	1.82^{b} ±0.01	0.14^{a} ±0.01	3.72^{c} ±0.04
1%gum	268^{bc} ±7.11	13.52^{a} ±1.88	5.00^{c} ±0.30	1.86^{b} ±0.03	0.16^{a} ±0.02	3.76^{bc} ±0.06
Fermented	275^{ab} ±5.92	12.82^{bc} ±2.40	4.75^{d} ±0.24	1.52^{d} ±0.02	0.12^{a} ±0.01	4.00^{a} ±0.04
Fermented and 0.5% gum	270^{abc} ±7.24	12.90^{b} ±1.22	4.80^{d} ±0.11	1.56^{d} ±0.06	0.11^{a} ±0.04	4.06^{a} ±0.01
Fermented and1.0% gum	265^{bc} ±8.12	12.70^{bc} ±1.82	4.73^{d} ±0.26	1.62^{cd} ±0.08	0.11^{a} ±0.02	4.00^{a} ±0.05

* As mg/100g on dry weight basis
Each mean value is followed by ± standard deviation.
Each mean value, within the same column, followed by the same letter is not significant at 0.05 level.

The antinutritive (tannin and phytic) content in sorghum flour and the tested pizza is found in Table (4). It showed that the highest tannin and phytic contents were in the sorghum flour. It was also found that all the tested pizza preparing methods (fermentation, gum addition or combination of them) had no effect on the phytic acid content on contrary with that found by Abdelseed et al., (2011). On the other hand, either fermentation, gum addition or combination of them revealed a dramatic decrement, with a highly significant variation, in the tannin content (Table 4). The highest decrement was noticed in the fermented pizza containing gum followed by the fermented only and that containing gum only, respectively. It confirmed that either fermentation or gum addition lowered the tannin content in the preparing pizza and the combination of the two treatment led to a synergist impact agreed with Abdelseed *et al*., (2011).

Table 4: Anti-Nutritive (Tannin and Phytic) content* in sorghum and pizza

Item	Tannin	Phytic
Sorghum flour	2.50^{a} ±0.11	1.49^{a} ±0.05
Pizza of		
Sorghum	1.89^{b} ±0.06	1.44^{a} ±0.02
0.5% gum	1.44^{cde} ±0.08	1.24^{a} ±0.01
1%gum	1.32^{de} ±0.11	1.20^{a} ±0.08
Fermented	1.50^{bc} ±0.08	1.11^{a} ±0.02
Fermented and 0.5%gum	1.24^{e} ±0.12	0.98^{a} ±0.04
Fermented and1.0%gum	1.11^{e} ±0.22	0.92^{a} ±0.01

* As % on dry weight basis.
Each mean value is followed by ± standard deviation.
Each mean value, within the same column, followed by the same letter is not significant at 0.05 level.

The sensory evaluation was carried out in order to get consumer response for overall acceptability of the pizza incorporated gum addition and fermentation processes compared to the traditional sorghum preparation method. The pizza samples were thawed before baked and tested as described earlier.

Data presented in Table (5) showed that the prepared pizza (ordinary one) without the tested treatments (fermentation or gum addition) showed the lowest panelist records toward the tested attributes (except color). On contrary, either fermentation or gum addition preparation showed a significant varied improvement in the tested attributes. It could also noticed that combination of fermentation process and 0.5% gum addition possessed the highest values of the panelist records with respect to overall acceptability, color and texture pizza attributes. The explanation of such results are of interest for some researches to gain the highly acceptability pizza and could be summarized in the next remarks.

High amylose have been identified in sorghum and the sorghum starch granule sizes are about 5 to 30 µm in diameter (Johnson, 2000). The properties of such starches widely vary , and may prove the usefulness in some instances in the production of gluten-free foods, though more researches are needed in this area. In addition, sorghum starch has also been reported to have a higher swelling at 90°C as well as higher peak and cold viscosities (Abd Allah *et al*., 1987).

Table 5: Sensory evaluation of pizza attributes manufactured from sorghum

Pizza of	Overall acceptability	Odor	Color	Flavor	Texture
Sorghum	7.0^{e} ±0.3	8.0^{b} ±0.54	8.0^{a} ±0.42	7.0^{e} ±0.32	7.0^{e} ±0.122
0.5% gum	9.0^{b} ±0.22	8.5^{a} ±0.60	8.0^{a} ±0.33	8.6^{a} ±0.52	9.0^{b} ±0.38
1%gum	8.7^{c} ±0.44	8.5^{a} ±0.62	7.3^{b} ±0.42	7.5^{c} ±0.12	8.0^{d} ±0.22
Fermented	8.2^{d} ±0.34	7.0^{c} ±0.36	7.0^{c} ±0.16	8.0^{b} ±0.22	8.0^{d} ±0.32
Fermented and0.5%gum	9.2^{a} ±0.38	8.0^{b} ±0.16	8.0^{a} ±0.28	8.0^{b} ±0.36	9.3^{a} ±0.11
Fermented and1.0%gum	7.0^{e} ±0.51	8.4^{a} ±0.28	7.0^{c} ±0.22	7.2^{d} ±0.31	8.5^{c} ±0.22

Each mean value is followed by ± standard deviation.
Each mean value, within the same column, followed by the same letter is not significant at 0.05 level.

Conclusion and future prospectives:

From the obtained results in th current study, it can be concluded that functional properties of the produced pizza influenced to a great extent by sorghum grain. As previously mentioned, studies have shown that fermentation improved the nutritive value of sorghum flour, it seems to be possible to design some new foods based on fermented sorghum for people suffering from celiac disease and also to use fermented sorghum flour as a functional agent in fabricated foods such as weaning foods and baked goods. Supplementing the sorghum flour with gum, can be improved in terms of the nutritive value and sensory evaluation of vegetarian and celiac diets.

There is, however, no information on the functional properties of sorghum flour. This information is essential for determining potential uses of this product in food formulations and will add value to this important African crop. The aim of this study should be to determine the functional properties of flour obtained from sorghum grains.

However, the concentrations of folate in gluten-free products are much lower than those in their gluten-containing counterparts (Thompson, 2000), which can lead to reduced folate intake in celiac patients. Recently, it was demonstrated that the celiac patients consuming gluten-free products have a daily folate intake of 186µ g for women and 172µg for men (Hallert *et al*., 2002), which is much lower than recommended daily intake of 400µg for women in fertile age and 300µ g for adults (Becker *et al*., 2004). These figures of daily folate intake among celiac patients are in the lower range of the folate intake of the populations in European countries yet not having introduced mandatory folic acid fortification, i.e. 168–320µg/day for women and 197–326µg/day for men (De Bree *et al*., 1997). The increase of folate content of gluten-free products therefore seems to be necessary. However, up to now no countries have performed mandatory folic acid fortification of gluten-free products, whereas mandatory fortification of white flour has been introduced in several countries, such as US (1998), Canada (1998) and Chile (2000). Furthermore, there are limited data in food data bases regarding gluten-free products which makes the decision making difficult.

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