Utilization of millet flour in production of gluten free biscuits and cake

Fatma A. Nada, Asma A. El-Gindy and M. R. G. Youssif


ABSTRACT

This study aimed to produce healthy free gluten biscuits and cake from rice flour (RF) and germinated millet flour (GMF). 100% rice flour was the control sample and substituted by 25, 50, 75 and 100% germinated millet flour. The physical, chemical and sensory characteristics of biscuits and cake were evaluated. The results indicated that the substitution by GMF increased protein, fat, Ca, Fe, Zn, phenolic and flavonoid contents in the produced biscuits and cake and decreased their antinutritional factors. The results also showed that the substitution by GMF significantly increased specific volume of cake than control sample. Results showed that the sensory characteristics of biscuits and cake samples containing 50% GMF were the most acceptable samples than other samples. The results cleared that the substitution by GMF decreased staling rate of cake samples than control sample.

Key words: Celiac disease, millet, rice, anti-nutrients, germination, biscuits, cake.

Introduction

Celiac Disease is a chronic enteropathy produced by gluten intolerance, more precisely to certain proteins called prolamine, which causes atrophy of intestinal villi, malabsorption and clinical symptoms that can appear in both childhood and adulthood (Osella et al., 2014).

The toxic fractions adopt different names, depending on the cereal: gliadin in wheat, avidin in oat, secalin in rye and hordein in barley. Prolamins of wheat, barley and rye are characterised by high proline content. These proteins, the main constituents of gluten, contain toxic sequences that can trigger celiac disease (Tsatsaragkou et al., 2012).

Cereal grains are the most important source of the world’s food and have a significant role in the human diet throughout the world. As one of the most important drought-resistant crops, millet is widely grown in the semiarid tropics of Africa and Asia and constitutes a major source of carbohydrates and proteins for people living in these areas. In addition, because of their important contribution to national food security and potential health benefits, millet grain is now receiving increasing interest from food scientists, technologists, and nutritionists (Saleh et al., 2013).

Millet is one of the most important drought-resistant crops and the 6th cereal crop in terms of world agriculture production. Also, millet has resistance to pests and diseases, short growing season, and productivity under drought conditions, compared to major cereals (Devi et al., 2011).

Germination or malting of cereal grains may result in some biochemical modifications and produce malt with improved nutritional quality that can be used in various traditional recipes. It has been found that germination of proso millet grains increased the free amino acids and total sugars and decreased the dry weight and starch content. Increases in lysine, tryptophan, and nonprotein nitrogen were also noticed (Parameswaran and Sadasivam, 1994).

Germination also appreciably improved the in vitro protein (14% to 26%) and starch (86% to 112%) digestibility in pearl millet, and the improvement by germination was significantly higher than by blanching (Archana and Kawatra, 2001). It has also been found that the in vitro extractability and bioaccessibility of minerals such as calcium, iron, and zinc were increased in finger millet and pearl millet by germination; however, the antinutritional factors such as phytic acid were decreased (Krishnan et al., 2012).

Due to this, the refined finger millet malt flour has scope for utilization in infant foods (Malleshi and Gokavi, 1999), weaning foods (Malleshi and Desikachar, 1982), and enteral foods (Malleshi, 2002;
The millet malt flour has also been utilized in milk-based beverages, confectionary, and cakes (Desai et al., 2010). Millets are also rich source of phytochemicals and micronutrients (Mal et al., 2010; Singh et al., 2012). Millets are small-seeded subsistence cereal crops belonging to the family Poaceae. Millets play an important role in the economies of many developing countries. In Africa, East-Asia and Indian subcontinent millets serve as staple diet for large population of underprivileged groups (Chandrasekara et al., 2012). The nutritive value of millets is comparable to other staple cereals like wheat and rice. They are particularly low in phytic acid and rich in dietary fiber, iron, calcium and B vitamins (Klopfenstein and Hosene, 1995).

Besides nutrients, millet grains have an abundance of phytochemicals, particularly phenolic compounds (Shahidi and Chandrasekara, 2013). Several potential health benefits reported for millets such as preventing cancer and cardiovascular diseases, lowering blood pressure have been attributed to these phenolics Saleh et al. (2013). Chandrasekara and Shahidi (2011) reported a wide range of phenolic compound concentrations and antioxidant capacities insoluble as well as bound fractions of millets. In addition to antioxidant properties, polyphenols of millets, particularly finger millet, possess other health benefits such as antimicrobial, anti-inflammatory, antiviral, anticancer, antiplatelet aggregation and inhibitory activities on cataract formation (Viswanath et al., 2009).

This investigation was carried out to evaluate the nutritional quality and potential health benefits of germinated millet grains and studying its application in production of some bakery products for celiac disease patients.

**Materials and Methods**

**Materials:**

1. Egyptian pearl millet (shendawil) (*Panicum miliani*) were obtained from Field Crops Dep., Agr. Res. Center, Giza, Egypt.
2. Rice flour, palm oil, salt, white sugar and vanilla used in cakes and biscuits formulation, baking powder, full fresh egg and bono gel used in cakes formulation and fresh egg yolk, sodium bicarbonate used in biscuits formulation. All of them were obtained from the local market.

**Preparation of Raw Materials:**

**Germination:**

The whole grains of millet were immersed in water over night. The grains were spread on trays lined with cloth and kept wet by frequent spraying of water for 72 hrs. The germinated millet (GM) grains were dried and ground to pass sieving 80 meshes described by Eltayeb et al., (2007).

**Biscuits and cake preparation**

**Biscuits preparation**

The biscuits prepared according to the methods described by Oyewole et al., (1996) with some modification. A biscuits recipe containing 100% rice flour, 30% sugar, 20% margarine, 1% sodium chloride, 0.5% sodium bicarbonate, 1% ammonium bicarbonate, 0.39% baking powder and 16 ml water. A biscuits rice was used as control and Free gluten biscuits samples were prepared by replacing rice flour by different levels (25%, 50%, 75% and 100%) of GMF. Butter and sugar were mixed in Kenwood mixer at a medium speed until a light and fluffy cream was formed, fresh egg yolk was added and continue the mixing. Water containing sodium bicarbonate, ammonium bicarbonate and sodium chloride was added to the above cream and mixed for 5 min. at 125 rpm to obtain a homogeneous cream. Finally, blends level flour of rice and GM sieved twice and baking powder was added and mixed for 3 min. at 60 rpm. Dough was prepared by different levels of RF and GMF at the formula, then rolled on a flat rolling board. Circular biscuits were cut, placed on greased baking trays.
and baked in an electric oven (Kumatel, Turkey) at 160°C for 15 min. The biscuits were cooled for 30 min. and stored in air tight tins for 24 hr. before further analysis.

Cake preparation

Cake prepared according to the method described by Turabi et al., (2010) with some modification. A cake batter recipe containing 100% rice flour, 100% sugar, 25% shortening, 100% whole fresh egg, 3% salt, 5% baking powder and 1% Improver gel cake (all percentages are given on a flour weight basis) was used in the experiments. The amount of water added to the batter was 30% of the overall formulation. A cake rice was used as control and Free gluten cake samples were prepared by replacing rice flour by different levels (25%, 50%, 75% and 100%) of GMF. During preparation of the cake, firstly, dry ingredients were mixed thoroughly. In a separate cup, sugar and whole fresh egg were mixed, and then melted shortening was added and mixed for 1 min at medium speed by using a mixer kitchen machine (National, Japan). Emulsifier was added to the melted shortening. Then, dry ingredient mix and water were added simultaneously to this mixture and mixed first for 2 min at medium speed, then for 1 min at high speed and finally for 2 min at medium speed. Cake samples were baked in an electric oven (Kumatel, Turkey) at 175°C for 30 min.

Methods

Chemical analysis

Proximate analysis including moisture, protein, fat, ash and crude fiber were carried out according to the methods of A.O.A.C. (2000). Carbohydrates content was calculated by difference. Calcium (Ca), Iron (Fe) and Zinc (Zn), were digested according to the method of A.O.A.C. (2000) using the dry ashing method. The Perkin Elmer 3300 (USA) atomic absorption spectrophotometer was used for minerals determination.

Antinutritional factors

Antinutritional factors such as phytic acid was determined according to the method of Wheeler and Ferrel (1971) and tannins were determined according to the method of Khokhar and Chauhan (1986).

Determination of total phenolic content and total flavonoid

Total phenols were estimated by the Folin-Ciocalteu method of Elfalleh et al., (2009) and the amount of total flavonoids was measured spectrophotometrically according to the method of Elfalleh et al., (2011).

Radical scavenging activity

The antioxidant activity of native and processed little millet extracts were also measured by the DPPH radical scavenging method according to the method of De Ancos et al., (2000).

Texture profile analysis: Texture profile was determined using CT3 Texture Analyzer according to the method of Dahle and Sambucci (1987).

Physical properties

1) Biscuits

Physical characteristics of produced biscuits (weight, gm; width, mm; thickness, mm; spread ratio, width / thickness) were determined according to A.A.C.C., (2002).
2) Cake

The height (cm), volume (cm$^3$), weight (g) and specific volume (cm$^3$/g) of cakes were measured according to Sai-Manohar and Haridas (1997).

Organoleptic Evaluation of Products:

1) Biscuits

Biscuit samples were organoleptically evaluated by ten panelists for its sensory characteristics: appearance, color, odor, texture, taste and overall acceptability as the method described by Larmond, (1977). The maximum score of each attribute was (10) degrees.

2) Cake

Cake samples were assessed for their sensory attributes after baking by ten member’s preference taste panels from the staff in Food Tech. Res., Institute Agric. Res. Center, Giza, Egypt. They were asked to score the internal characteristics of cake samples i.e. cell uniformity (30), grain (20), texture (30), crumb color (10), flavor (10) and overall acceptability (100) using the respect sheet according to A.A.C.C, (2000).

Statistical analysis

Data were expressed as the means ± SD. Statistical analysis was carried out using one – way analyses of variance, ANOVA (Rao, and Blane, 1985).

Results and Discussion

Chemical analysis of raw materials

The percentage proximate composition of rice, millet and germinated millet on dry matter basis are presented in Table (1). It was found that native millet and germinated millet were higher in protein, fat and ash than rice flour. The highest crude protein values of germinated millet sample was due to accumulation of proteins and production of some additional amino acids in the samples as a result of germination. The increment in protein content of the germinated grains may be due to quantitative reduction in antinutritional factors (tannin, and phytic acid) as well as other constituents of the grains such as starch (Hassan et al., 2006).

Table 1: Chemical analysis and minerals content of native (rice, millet) flour. (On dry weight basis).

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Rice flour</th>
<th>Native millet flour</th>
<th>Germinated millet flour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein %</td>
<td>7.71</td>
<td>9.90</td>
<td>10.76</td>
</tr>
<tr>
<td>Fat %</td>
<td>0.67</td>
<td>2.10</td>
<td>2.30</td>
</tr>
<tr>
<td>Ash %</td>
<td>0.37</td>
<td>1.25</td>
<td>1.06</td>
</tr>
<tr>
<td>Fiber %</td>
<td>0.75</td>
<td>2.30</td>
<td>1.92</td>
</tr>
<tr>
<td>Total carbohydrates %</td>
<td>90.50</td>
<td>84.45</td>
<td>83.96</td>
</tr>
<tr>
<td>Minerals content mg/100g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>35.19</td>
<td>45.95</td>
<td>55.34</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.91</td>
<td>3.48</td>
<td>5.09</td>
</tr>
<tr>
<td>Antinutritional factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phytic acid mg/g</td>
<td>4.71</td>
<td>11.72</td>
<td>9.76</td>
</tr>
<tr>
<td>Tannin mg/g</td>
<td>not detected</td>
<td>6.61</td>
<td>4.58</td>
</tr>
<tr>
<td>Antioxidant and Antioxidant activities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total phenolics as gallic acid mg/g</td>
<td>0.28</td>
<td>1.06</td>
<td>3.612</td>
</tr>
<tr>
<td>Total flavonoids as quercetin mg/g</td>
<td>0.34</td>
<td>1.90</td>
<td>2.737</td>
</tr>
<tr>
<td>*FRSA%</td>
<td>9.52</td>
<td>35.50</td>
<td>37.567</td>
</tr>
</tbody>
</table>

*FRSA% : Free radical scavenging activity.

Adebiyi et al., (2016) mentioned that the crude fat content of the millet flours ranged between 1.7 – 2.3 %. Fiber values of germinated millet sample was higher than rice flour while the ash contents of GM were relatively lower to the native samples (Table 1 ). The observed reduced ash contents in the
fermented and germinate samples may be due to the leaching of soluble inorganic salts during the fermentation and malting processes, similar decreases were reported in literature for fermented and germinated millet varieties (Laxmi et al., 2015).

From the results in Table (1) it could be noticed that Fe, Ca, Zn contents were markedly higher in millet and germinated millet than rice. The germination of millet improved the mineral content and its availability (Grewal and Jood 2006). Increasing of minerals content (Ca, Fe, Zn) and availability during germination may be due to increasing of phytase activity, which resulted in decrease content of phytate, phytate content in rice and sorghum ranged 1.2 - 3.7 and 5.9 - 11.8 mg/g respectively (Arora et al., 2011). The results of some of the antinutrients (phytic acid and tannin) of millet and germinated millet are presented in Table (1). These results showed that germinated millet contain less antinutrients than millet flour. These results confirmed those reported by Hassan et al., (2006).

Results in Table (1) showed that rice contains smaller amount of total phenol and flavones compared with millet and germinated millet. Shen et al., (2009) reported that phenolic acids are mostly present in the bran fractions of rice, while refined rice contains smaller amounts of phenolic acids. Activated glucosidases mediated release of aglycones from glucosides and/or biosynthesis of phenolic compounds during germination may have contributed to the increased levels of phenolic compounds in germinated millets (Pradeep and Srerama, 2015). Results in Table (1) showed that the highest FRSA% was found in germinated millet. A high correlation that observed between total phenols and antioxidant activity may be contributed to the highest phenolic compounds content (Dykes and Rooney, 2007).

### Chemical analysis of biscuits and cake

Results in Table 2 showed that the relatively high fat content of the biscuits samples was due to fat added during dough preparation and agreed with other authors (Adetunji et al., 2016).

**Table 2:** Chemical analysis and minerals content of gluten-free biscuits and cake. (On dry weight basis).

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Control 100 % RF</th>
<th>RF+GM 50%+50%</th>
<th>Control 100 % RF</th>
<th>RF+GM 50%+50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture%</td>
<td>3.50</td>
<td>4.41</td>
<td>20.21</td>
<td>21.07</td>
</tr>
<tr>
<td>Protein%</td>
<td>8.02</td>
<td>11.29</td>
<td>8.48</td>
<td>11.38</td>
</tr>
<tr>
<td>Fat%</td>
<td>12.53</td>
<td>14.60</td>
<td>8.64</td>
<td>10.56</td>
</tr>
<tr>
<td>Ash%</td>
<td>1.05</td>
<td>2.05</td>
<td>1.18</td>
<td>2.16</td>
</tr>
<tr>
<td>Total carbohydrates%</td>
<td>78.40</td>
<td>72.06</td>
<td>81.70</td>
<td>75.89</td>
</tr>
<tr>
<td>Calcium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>1.24</td>
<td>3.16</td>
<td>1.45</td>
<td>2.22</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.71</td>
<td>2.14</td>
<td>0.54</td>
<td>1.49</td>
</tr>
<tr>
<td>Antioxidant and Antioxidant activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total phenolics as gallic acid mg/g</td>
<td>1.23</td>
<td>2.36</td>
<td>1.18</td>
<td>2.91</td>
</tr>
<tr>
<td>Total flavonoids as quercetin mg/g</td>
<td>0.81</td>
<td>0.95</td>
<td>0.72</td>
<td>0.97</td>
</tr>
<tr>
<td>*FRSA%</td>
<td>18.94</td>
<td>35.47</td>
<td>26.74</td>
<td>31.20</td>
</tr>
</tbody>
</table>

*FRSA%: Free radical scavenging activity.

As observed in Table (2) the protein, fat, and ash contents of biscuits and cake samples contained germinated millet were higher than control. Results in Table (2) showed that the addition of GMF which had a high content of minerals, caused calcium, zinc and iron content to be double in biscuits and cakes. This is also due to the GMF high content of calcium, zinc, and iron. These results confirmed those reported by Grewal and Jood (2006). Also GM biscuits and GM cake samples recorded higher values for the total phenolic sample (TF) and total flavonoid (TV) compared with rice control. These increased values were probably due to the release of bound phenolics from cell walls of millet grains during the baking process, which subsequently caused an increased extractability of phenolic compounds (Taylor and Duodu, 2015).

FRSA % was high in GM biscuits and cake samples compared to control, corresponding to higher TF and TV contents.
Physical properties

Biscuits

Results of Physical properties the of biscuit samples prepared from rice flour and germinated millet flour are presented in Fig (1), the results show that there were no significantly differences between samples contained 25 ,50% germinated millet and control for weight and width. The results also indicated that samples containing 25 , 50 and 75 % GMF were also not significantly different from control sample for spread ratio. Concerning to thickness of biscuit samples, control sample was not significantly different with sample contained 25% germinated millet flour.

![Fig 1](image)

**Fig 1:** Physical properties of biscuits contained different levels of rice flour and germinated millet flour.

Cake

Table (3) indicated that specific volume values of cake contained 50, 75 and 100% of germinated millet flour were found to be significantly different from control. Jaganathan, (2016) found that although rice is noted for preparing gluten free products, quality problems such as low gas retention, poor texture, color and crumb structure have been associated with the products.

**Table 3:** Physical properties of cake contained different levels of rice flour and germinated millet flour.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>100% (RF)</th>
<th>25% (GMF)</th>
<th>50% (GMF)</th>
<th>75% (GMF)</th>
<th>100% (GMF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g)</td>
<td>33.10±0.869 a</td>
<td>30.40±2.971 b</td>
<td>30.08±0.656 b</td>
<td>29.23±1.076 b</td>
<td>32.21±0.757 a</td>
</tr>
<tr>
<td>Volume(cm³)</td>
<td>53.50±1.826 b</td>
<td>54.90±3.843 b</td>
<td>56.50±5.797 b</td>
<td>56.10±3.725 b</td>
<td>60.90±3.81 a</td>
</tr>
<tr>
<td>Specific volume(cm³/g)</td>
<td>1.62</td>
<td>1.81</td>
<td>1.88</td>
<td>1.92</td>
<td>1.89</td>
</tr>
</tbody>
</table>

Means in the same column with different letter are significantly different (P ≤ 0.05).
Sensory characteristics

Biscuits

From the obtained data in Table 4 it could be observed that there were significant differences between that samples contained 25% and 50% germinated millet biscuits and control sample for appearance ,taste, odor , and overall acceptability. Moreover, the results presented in Table 4 showed also that texture characteristic of treatments containing 25, 50 GMF were found to be significantly different from control. However, all the treatments were found to be not significantly different in between and having high scores compared to control sample. During germination the hydrolysis of non-starch was increased polysaccharide and this lead to improve texture (Hugo et al., 2003).

Table 4: Sensory characteristics of gluten- free biscuits contained different levels of rice flour and germinated millet flour.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Appearance 10</th>
<th>Color 10</th>
<th>Taste 10</th>
<th>Odor 10</th>
<th>Texture 10</th>
<th>overall acceptability 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% (RF)</td>
<td>9.52±0.02a</td>
<td>9.48±0.21a</td>
<td>9.78±0.05a</td>
<td>9.60±0.08a</td>
<td>8.83±0.40b</td>
<td>47.42±0.36a</td>
</tr>
<tr>
<td>25% (GMF)</td>
<td>9.50±0.19a</td>
<td>9.46±0.21a</td>
<td>9.75±0.50a</td>
<td>9.62±0.18a</td>
<td>9.58±0.28a</td>
<td>47.91±0.44a</td>
</tr>
<tr>
<td>50% (GMF)</td>
<td>9.46±0.04a</td>
<td>9.45±0.44a</td>
<td>9.79±0.47a</td>
<td>9.61±0.13a</td>
<td>9.42±0.29a</td>
<td>47.74±0.18a</td>
</tr>
<tr>
<td>75% (GMF)</td>
<td>8.38±0.16c</td>
<td>9.18±0.05a</td>
<td>8.90±0.21b</td>
<td>9.40±0.41b</td>
<td>9.16±0.29ab</td>
<td>45.02±0.37b</td>
</tr>
<tr>
<td>100% (GMF)</td>
<td>8.11±0.61c</td>
<td>8.16±0.11b</td>
<td>8.03±0.41c</td>
<td>9.30±0.38b</td>
<td>9.33±0.33ab</td>
<td>42.93±1.25c</td>
</tr>
</tbody>
</table>

Means in the same column with different letter are significantly different (P ≤ 0.05).

Cake

Result in Table 5 showed the sensory evaluation of cake samples. The results indicated that all samples were acceptable, but samples which contain 50% RF and 50% GMF having the highest score for all the evaluated sensory characteristics and was highly significantly different compared to other treatments. However, the same treatment were previously found to be having nutritionally attributes (Table 2).

Table 5: Sensory characteristics of gluten- free cake contained different levels of rice flour and germinated millet flour.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Cell uniformity (30)</th>
<th>Crumb color (10)</th>
<th>Texture (30)</th>
<th>grain (20)</th>
<th>Flavor (10)</th>
<th>Overall acceptability (100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% (RF)</td>
<td>28.00±0.5b</td>
<td>7.5±0.5773ab</td>
<td>28±0.8168a</td>
<td>18±0.810a</td>
<td>9.25±0.5a</td>
<td>90.75±0.8166b</td>
</tr>
<tr>
<td>25% (GMF)</td>
<td>27.75±0.52c</td>
<td>7±0.816b</td>
<td>27.5±0.577a</td>
<td>18±0.816a</td>
<td>9±0.816a</td>
<td>89.25±0.2601b</td>
</tr>
<tr>
<td>50% (GMF)</td>
<td>28.5±0.580a</td>
<td>8.25±0.500a</td>
<td>29±0.816a</td>
<td>19±0.820a</td>
<td>9.75±0.510a</td>
<td>94.5±1.732b</td>
</tr>
<tr>
<td>75% (GMF)</td>
<td>26±0.816a</td>
<td>4.5±0.577a</td>
<td>26.75±0.50a</td>
<td>15.25±0.816a</td>
<td>5±0.82b</td>
<td>77.5±2.217c</td>
</tr>
<tr>
<td>100% (GMF)</td>
<td>24.5±0.577a</td>
<td>2.75±0.5b</td>
<td>20.5±0.577a</td>
<td>11.75±0.50e</td>
<td>4±0.817e</td>
<td>63.5±1.0d</td>
</tr>
</tbody>
</table>

Means in the same column with different letter are significantly different (P ≤ 0.05).

Texture profile analysis of germinated millet cake

The effect of germinated millet on hardness value of the gluten-free cake samples during storage time (3 days) are given in Fig 2(a). Results in Fig. 2 (a) showed that rate of hardness decreased with increasing of germinated millet addition compared to rice control during all storage time. Meanwhile all cake samples increased in hardness during storage time.

As shown in Fig. 2(b) it was observed that springiness values were decreased with increasing of added germinated millet. Regarding springiness change during storage of free gluten bread, a decrease was observed during ageing (Phattanakulkaewmorie et al., 2011).

Both, chewiness and gumminess are parameters dependent on firmness (hardness) These parameters decreased with increasing of germinated millet addition compared to rice control during all storage time Fig. 2 (c, d). Gomez et al., (2007) reported that the trend to crumbliness with ageing may be related to the loss of intermolecular attraction among ingredients.

The behavior of cohesiveness during storage as shown in Fig. 2 (e) it could be noticed that, a general decrease in cohesiveness was observed. A similar result was also obtained in other baked goods (Esteller et al., 2004).
Fig 2: The effect of Germinated millet on hardness (a), Springiness (b), Chewiness (c), Gumminess (d) and Cohesiveness (e) of the gluten-free cake samples.
Conclusion

From this study it could be concluded that germinated millet flour (GMF) contain many health-promoting components such as phytochemical, fiber, minerals (calcium, zinc and iron) and phenolics compounds and lowered antinutritional factors. The nutritionally superior sample which contain 50% (RF) and 50% (GMF) caused rising in nutrition value and sensory characteristics for biscuits and cakes, it could be recommended that incorporation the (GMF) in bakery products could be applied to improve the characteristics of the produced products and utilization such products as food for a large and growing population especially for celiac disease patients.

References


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