Physicochemical and Cooking Characteristics of Tunisian Chickpea Varieties

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ABSTRACT

Seed weight, size and volume, hydration and swelling capacities and cooking time of six Tunisian Kabuli chickpea varieties were evaluated and compared to one Desi accession. Physicochemical characteristics (water solubility and water absorption indices, bulk density and hunter color) of flours were determined for all of them. The Tunisian chickpea varieties showed higher seed weight, size and volume than the Desi type. This tendency was also observed for swelling and hydration capacities and cooking time. Cooking time was positively correlated with hydration capacity ($R^2=0.67$), and was positively correlated to seed size ($R^2=0.77$). Concerning the physicochemical characteristics of chickpea flours, significant variability between Tunisian chickpea varieties was observed. Compared to Desi type ‘JG62’, they presented lighter flours with low bulk density ranging between 0.6 and 0.67 g/ml and high water solubility index varying between 25.2 and 30.8%.

Keywords: seed, flour, legume, quality
Abbreviations: ADF, acid detergent fiber; INRAT, National Institute of Agricultural Research of Tunisia; NDF, neutral detergent fiber; WAI, water absorption index; WSI, water solubility index

INTRODUCTION

Chickpea (Cicer arietinum L.) is the second most important pulse crop in the world, considered as a major food legume crop in many countries (FAO 2008) and an important source of protein ranging from 20 to as much as 40 g/100 g dry matter (Saxena et al. 1987). It contains high levels of carbohydrates (57-60 g/100 g), vitamins and minerals (1950-1695 mg/100 g dry matter) and is relatively free from antinutritional factors (Muzquiz et al. 2007; Wood et al. 2007, Wang et al. 2010). Furthermore, chickpea’s oil is enriched with polyunsaturated fatty acids accounting for about 6.58-9.12 g/100 g dry matter (Abdul Wajid et al. 2003; Lou et al. 2010). Many reports have proposed this grain legume as part of the dietary treatment due to the fact that the chickpea extract decreases the level of triglycerides, cholesterol (Perry 1980; Wu et al. 2001) and could be used in the prevention of obesity and on the treatment of non-insulin-dependent diabetes (Gu et al. 2008).

Based on seed colors and shapes, chickpeas are grouped into two types: Desi (Indian origin) and Kabuli (Mediterranean and Middle East origin) (Kaur et al. 2005). Desi type is characterized by small, angular dark-colored seed whereas Kabuli type is large smooth coaled, beige seeds (Gil et al. 1996). Some reports already indicated variation in physical qualities as well as in the chemical composition of this grain legume. These variations might be due either to intrinsic factors (mainly genetic) or extrinsic factors such as storage, soil types, agronomic practices, climatic factors and technological treatments (Amir et al. 2007). Kharrat et al. (1990) reported high variations of protein and fiber (Acid Detergent Fiber and Neutral Detergent Fiber) contents between Desi and Kabuli chickpea types. These variations were much more important between both types for ADF and NDF. In fact they found that Kabuli genotypes varied for ADF from 3.9 to 7.7% and for NDF from 6.0 to 12.7% whereas Desi genotypes ranged between 10.4 and 17.5 for ADF and between 13.6 and 20.7% for NDF. However the range of variations is almost similar for protein between Kabuli and Desi genotypes, which vary from 20.6 to 27.3% and 19.9 to 26.8%, respectively.

In recent years, due to their high protein content, much more interest was given to the incorporation of grain legumes into flour to improve their composition for various food formulations (Walsh 1997; Sterner et al. 1999; Birkina et al. 2004). Nevertheless, the benefits of these proteins are usually dependent on their physical and chemical characteristics and also on their interactions with other food components. These characteristics influence the preparation process and the quality attributes of food (Kaur and Singh 2005).

The consumption of chickpea in the world is around 6 Kg/person/year, however in Tunisia it is only about 3 Kg/person/year with a total production of 9400 T/year during the period 2004-2008 (Anonymous 2009) and where only Kabuli varieties are grown. In Tunisia, researches conducted in field crops laboratory of INRAT are mainly focused on selection of high-yielding and tolerant varieties to Ascochyta blight and Fusarium wilt. These researches permitted to release of six Kabuli chickpea varieties based mainly on disease resistance and yield performance. However, the physicochemical properties of these varieties are not sufficiently studied.

The objectives of this work were to determine the physicochemical properties of seed and flour of six Tunisian Kabuli chickpea varieties. The cooking characteristics were also evaluated. The obtained results were correlated and compared to those of a Desi type genotype.

MATERIALS AND METHODS

Material

Seven chickpea varieties obtained from Field Crops Laboratory of the National Institute of Agricultural Research of Tunisia were...
used in this study. Six of them are Tunisian Kabuli type: ‘Béja 1’, ‘Béja 2’, ‘Neyer’, ‘Kasseb’, ‘Bouchra’, ‘Chetoui’ and the seventh is ‘JG62’, a Desi type. Seeds of different chickpea varieties were ground by using Cyclotec (Foss, France) to obtain flour.

**Proximate composition**

Moisture, fat, NDF and protein contents (N×6.25) of chickpea varieties were determined by employing standard methods of analysis (AOAC 1984).

**Physical characteristics of chickpea seeds and cooking time**

**Seed weight (g/seed):** 100 seeds were weighted. The test is done on three samples (Williams et al. 1988).

**Seed volume (ml):** volume of 100 seeds was measured by absolute displacement using distilled water (Attia et al. 1994).

**Seed size distribution (mm):** a rack of sieves with round holes of 9, 8, 7 and 6 mm diameter was used. Amount of 100 g of chickpea seeds were transferred to top (9 mm) sieve and shacked mechanically for 3 min. The seeds of each sieve were weighted and the seeds size distribution was calculated from the amount of seeds of each sieve (Williams et al. 1988).

**Hydration capacity (g/seed):** 100 chickpea seeds were weighted and placed in a beaker. 150 ml of distilled water were added and the samples were held for 16 h at room temperature. After removing the surplus water and non swelling seeds, the sample was weighted. The hydration capacity per seed is the weight of water absorbed by the seeds (Williams et al. 1988). This is given by the following formula:

\[
\text{Hydration capacity} = \frac{(Y - X - (X/100 \times N_2))}{(N_1 - N_2)}
\]

where \(Y\) = weight of seeds after soaking, \(X\) = weight of seeds before soaking, \(N_1\) = original number of seeds, \(N_2\) = number of non-hydrated seeds.

**Swelling capacity (ml/seed):** is a volumetric measurement based on the difference in volume between dry and soaked seeds. 100 seeds were placed in a 150 ml graduated cylinder and leaved for 16 h at room temperature. The non hydrated seeds were removed and the remaining seeds were replaced in a 250-ml graduated cylinder with 100 ml water. Volume of hydrated seeds is then recorded. Swelling capacity is calculated using the following formula (Williams et al. 1988):

\[
\text{Swelling capacity/seed} = \frac{(Y_1 - Y_2) - (X_2 - X_1) - ((X_2 - X_1) \times N_1)/N_2}{N_1 - N_2}
\]

where \(Y_1\) = volume of water + hydrated seeds, \(Y_2\) = volume of water added to hydrated seeds, \(X_1\) = volume of water + dry seeds, \(X_2\) = volume of water added to dry seeds, \(N_1\) = original number of seeds, \(N_2\) = number of non-hydrated seeds.

**Cooking time (min):** determined using Williams et al. (1988) method after boiling 100 seeds of each chickpea variety in beaker containing 800 ml of distilled water.

**Physicochemical characteristics of chickpea flours**

**Water Solubility Index (WSI) and Water Absorption Index (WAI):** WSI and WAI were evaluated using the method of Kaur and Singh et al. (2005). Samples (1 g/sample) were dispersed in 12 ml of distilled water using a glass rod and cooked at 90°C for 15 min in water bath. After cooling at room temperature, sample was centrifuged at 3000 × \(g\) for 10 min. The supernatant was decanted for determination of its solid content into a tarred evaporating dish and the sediment was weighted. The weight of dry solid was recovered by evaporating the supernatant overnight at 110°C. WSI and WAI were calculated by the following formulas:

\[
\text{WSI} = \frac{\text{Weight of dissolved solids in supernatant} \times 100}{\text{Weight of dry solids}}
\]

\[
\text{WAI} = \frac{\text{Weight of sediment}}{\text{Weight of dry solids}}
\]

**Bulk density (\(\rho_b\)):** The flour samples were placed in a known volume stainless cylinder. The bottom of cylinder was gently tapped on a laboratory bench 10 times until there was no further diminution of the sample level. Bulk density was obtained dividing the sample mass by the cylinder volume (g/ml) (Kaur and Singh 2005).

**Hunter color characteristics:** Color measurements of chickpea flour samples were done with a Minolta colorimeter Model (Minolta Ltd, Japan). \(L, a, b\) color values were recorded and compared with a white standard possessing the following values:

\[
L_0 = 97.63; a_0 = 0.78; b_0 = -2.85.
\]

The ‘L’ value indicates the lightness, 0 to 100 representing dark to light, the ‘a’ value gives the degree of the red-green color, with a higher positive value indicating more red. The ‘b’ value indicates the degree of the yellow-blue color, with a higher positive value indicating more yellow.

**Statistical analysis**

The data reported in all the tables are the averages of triplicates observation. The data were subjected to statistical analysis using Statistica software version 5 (USA) using one-way analysis of variance (ANOVA) followed by Duncan’s multiple range test comparison among mean. Significance was defined at \(P \leq 0.05\).

**RESULTS AND DISCUSSION**

**Proximate composition**

Proximate composition of the seven chickpea varieties are presented in Table 1. Protein contents ranged between 25.2% for both ‘Béja 2’ and the Desi line ‘JG62’ and 28.65% for ‘Kasseb’. These high protein contents confirm the interest of using chickpea seeds to obtain protein products with added value (Clemente et al. 2005). Moisture and natural detergent fiber (NDF) of flours from different Tunisian chickpea varieties ranged from 9.95 to 10.70% and 15.98 to 28.28%, respectively. Compared to ‘Desi’, the Tunisian Kabuli chickpea varieties presented low NDF values. This is in agreement with results reported by Kharrat et al. (1990) showing highest values of NDF for Desi as compared to Kabuli chickpea genotypes. The crude fat values of the Tunisian chickpea varieties have almost similar levels than Desi variety. They vary from 3.94 to 4.9%.

**Physical characteristics of chickpea seeds and cooking time**

Physical characteristics of Tunisian chickpea varieties varied significantly (Table 2). The seed weight fluctuated from 26.5 to 34.7 g/100 seeds. Highest value was observed for ‘Béja 2’ and the lowest for ‘Chetoui’. The ‘Desi’ type JG62 had the lowest seed weight 13.8 g/100 seeds. Kaur et al. (2005) reported similar results. This variation might be due to intrinsic factors, mainly genetic (Amir et al. 2007) and appears to be correlated to seed size. Indeed, the Tunisian chickpea varieties presented higher seed size ranging from 6.29 mm to 7.66 mm, with lowest value for ‘Chetoui’ and highest one for ‘Béja 1’. Seed size was positively correlated with seed weight (\(R^2 = 0.95, P < 0.05\)) and could be correlated to the enzymes activity in sugar metabolism for chickpea cotyledon’s development (Turner et al. 2009).

Seed volume showed also significant differences between varieties. It varied from 17.5 ml to 26.5 ml for Tuni-
Physicochemical and cooking characteristics of Tunisian chickpea varieties. Sfayhi and Kharrat

Table 1 Proximate composition of flours from different chickpea varieties.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Ash (g/100 g)</th>
<th>Moisture (%)</th>
<th>Crude fat (%)</th>
<th>Protein (%)</th>
<th>NDF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nayer</td>
<td>3.12 ± 0.02c</td>
<td>10.28 ± 0.04ab</td>
<td>4.81 ± 0.07a</td>
<td>26.26 ± 0.07e</td>
<td>21.07 ± 2.46bcd</td>
</tr>
<tr>
<td>Kessab</td>
<td>3.22 ± 0.02a</td>
<td>10.37 ± 0.04a</td>
<td>3.94 ± 0.21bc</td>
<td>28.65 ± 0.07a</td>
<td>25.40 ± 6.07bc</td>
</tr>
<tr>
<td>Bouchra</td>
<td>3.15 ± 0.07b</td>
<td>10.70 ± 0.47a</td>
<td>4.27 ± 0.09b</td>
<td>27.75 ± 0.21b</td>
<td>15.98 ± 4.16d</td>
</tr>
<tr>
<td>Chetoui</td>
<td>3.14 ± 0.01bc</td>
<td>10.27 ± 0.05ab</td>
<td>4.6 ± 0.27a</td>
<td>27.32 ± 0.007c</td>
<td>28.28 ± 5.82b</td>
</tr>
<tr>
<td>Béja 1</td>
<td>3.21 ± 0.01a</td>
<td>10.33 ± 0.29ab</td>
<td>4.9 ± 0.16a</td>
<td>26.65 ± 0.21d</td>
<td>19.12 ± 2.04ed</td>
</tr>
<tr>
<td>Béja 2</td>
<td>3.12 ± 0.02c</td>
<td>9.95 ± 0.023b</td>
<td>4.24 ± 0.14bc</td>
<td>25.20 ± 0.2f</td>
<td>19.12 ± 2.05bc</td>
</tr>
</tbody>
</table>

Table 2 Physicochemical and cooking characteristics of different chickpea varieties.

<table>
<thead>
<tr>
<th>Seed weight (g/100 g)</th>
<th>Seed size (mm)</th>
<th>Seed volume (ml)</th>
<th>Hydration capacity (g/seed)</th>
<th>Swelling capacity (ml/seed)</th>
<th>Cooking time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chetoui</td>
<td>26.5 ± 0.52c</td>
<td>6.29 ± 0.005e</td>
<td>17.5 ± 0.5d</td>
<td>0.29 ± 0.01cd</td>
<td>110.2 ± 2.64a</td>
</tr>
<tr>
<td>Kasseb</td>
<td>32.5 ± 0.52ab</td>
<td>7.03 ± 0.05c</td>
<td>23.5 ± 0.5c</td>
<td>0.28 ± 0.01d</td>
<td>92.66 ± 1.52c</td>
</tr>
<tr>
<td>Bouchra</td>
<td>34.3 ± 1.26a</td>
<td>6.92 ± 0.07d</td>
<td>24.83 ± 0.7b</td>
<td>0.28 ± 0.025c</td>
<td>96.66 ± 1.15b</td>
</tr>
<tr>
<td>Béja 1</td>
<td>34.1 ± 1.57a</td>
<td>7.66 ± 0.025a</td>
<td>26.5 ± 0.5a</td>
<td>0.36 ± 0.026b</td>
<td>111.66 ± 2.08a</td>
</tr>
<tr>
<td>Béja 2</td>
<td>31.66 ± 1.53b</td>
<td>7.07 ± 0.089c</td>
<td>24.16 ± 0.28bc</td>
<td>0.4 ± 0.005a</td>
<td>113.66 ± 1.52a</td>
</tr>
<tr>
<td>Neyer</td>
<td>34.46 ± 1.11a</td>
<td>7.47 ± 0.060b</td>
<td>26.5 ± 0.5a</td>
<td>0.35 ± 0.005b</td>
<td>95.33 ± 0.57bc</td>
</tr>
<tr>
<td>Desi (JG62)</td>
<td>33.83 ± 0.35d</td>
<td>5.21 ± 0.06f</td>
<td>11.16 ± 0.28c</td>
<td>0.14 ± 0.005e</td>
<td>76.33 ± 2.08d</td>
</tr>
</tbody>
</table>

Fig. 1 Relationship between hydration capacity and seed size of chickpea varieties.

Table 2 presents Hunter color values of flour for the different chickpea varieties. The Hunter a value of ‘Chetoui’, ‘Kasseb’ and ‘Bouchra’ varieties are higher than ‘Béja 1’, with an average of 103.6 min. The highest value was for ‘Béja 2’ and the lowest for ‘Kasseb’ variety. The ‘Desi’ genotype needed only 76.3 min for cooking. The difference in cooking time could be attributed to the difference in the hydration capacity. The later influences the water penetration in order to reach the intermost portions of seeds (Kaur et al. 2005). The cooking time for ‘Chetoui’ had the highest one. The differences could be mainly due to the carbohydrate and fat contents (Kaur et al. 2005). These authors found a positive correlation between seed volume and these both components.

For Tunisian varieties, swelling and hydration capacities ranged between 0.35-0.44 ml/seed and 0.28-0.4g/seed, respectively (Table 2). ‘Béja 2’ had the highest values (0.44 ml/seed; 0.4g/seed) whereas ‘Chetoui’ had the lowest value for swelling capacity and ‘Kasseb’ had the lowest value for hydration capacity. As compared to ‘JG62’, these values were higher and could be due to the size of the seeds and its composition. Positive correlation was observed between seed size and hydration capacity (Fig. 1). Muller (1967) had shown that the water absorption capacity depends on cell wall structure, composition of seed and compactness of the cell in the seeds. The cooking time is an important aspect of cooking quality. It is a heritable characteristic that differ widely among genotypes (Kaur et al. 2005). The cooking time for Tunisian chickpea varieties varied from 92.7 to 113.7 min, with an average of 103.6 min. The highest value was for ‘Béja 2’ and the lowest for ‘Kasseb’ variety. The ‘Desi’ genotype needed only 76.3 min for cooking. The difference in cooking time could be attributed to the difference in the hydration capacity. The later influences the water penetration in order to reach the intermost portions of seeds (Kaur et al. 2005). Fig. 2 shows a positive correlation between hydration capacity and cooking time. Ibarz et al. (2004) studied the kinetic model for water absorption and cooking time in chickpea, as well as the effect of soaked sample in the cooking time. They showed that the cooking time decreases as the soaking time increases. Moreover, they found a correlation between cooking time and initial water content in chickpea. In our study, the varieties studied had almost same initial humidity around 10% (Table 1).

Physicochemical properties of chickpea flours

Table 3 presents Hunter color values of flour for the different chickpea varieties. The Hunter a value of ‘Chetoui’, ‘Kasseb’ and ‘Bouchra’ varieties are higher than ‘Béja 1’,
suggests that Tunisian chickpea flours were light yellow in color. Comparing to 'Desi' variety, all these values were higher. The value indicates that it is the darkest reddish in color. The values of bulk density of different flours issued from Tunisian chickpea varieties varied significantly (Table 4) and ranged between 0.6 and 0.67 g/ml. The highest value was for 'Béja 1' flour and the lowest one for 'Bouchra'. However the 'Desi' type had the highest bulk density (0.71 g/ml). This result suggests that 'Desi' chickpea flour is denser than the Tunisian chickpea flours. Significant differences were also observed for water solubility index (WSI) in flours from different Tunisian chickpea varieties. The WSI is related to the presence of soluble molecules, which had sometimes been related to dextrinization according to Colonna et al. (1983). Milan-Carrillo et al. (2000) showed the decrease in WSI with extrusion of the chickpea flour. They suggested that this behavior is caused by a higher bulk density and lower particle size index of extruded chickpea flour. In our work, the flour issued from Tunisian chickpea varieties presented higher values of WSI (25.24-30.80%) comparing to 'Desi' variety (21.67%). These results are in agree of those of Kaur and Singh (2005), who showed significant differences between Kabuli and Desi types in WSI. Concerning WAI, no significant differences were observed among all the samples.

CONCLUSION

Significant differences were observed in physicochemical, cooking characteristics of different Tunisian chickpea varieties. Seeds with high size have higher hydration capacity and longer cooking time. Among all the tested chickpea varieties, the Tunisian variety 'Béja 2' has the highest value in seed size, weight, hydration capacity and cooking time. Concerning physicochemical flours characteristics, the Tunisian chickpea flours present lighter flours with low bulk density and high water solubility index comparing to 'Desi' variety (JG62).

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