The Study of Functional and Rheological Properties of Teff [Eragrostis Teff (Zucc.) Trotter] Grain Flour Varieties

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To cite this article:

Received: January 21, 2020; Accepted: February 25, 2020; Published: March 6, 2020

Abstract: This study was conducted to generate information on some functional and rheological properties of teff [Eragrostis teff (Zucc.) Trotter] grain flour varieties. Six teff varieties namely Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-438) varieties were considered and their selection was based on their recent year coverage area and the expected future expansion. Each variety was studied. The highest value of functional properties of teff flours which included water and oil absorption capacity, swelling power, dispersibility and water solubility index of the teff flour were 0.99 g/g, 1.42 ml/g, 11.99%, 74% and 19.61% for DZ-Cr-387, DZ-Cr-438, DZ-Cr-438, DZ-Cr-438 & DZ-Cr-457 and DZ-Cr-438 varieties respectively. The pasting properties of the teff flour such as pasting temperature, peak time, peak viscosity, final viscosity, breakdown viscosity, trough and set back viscosity values had ranged from 76 to 80.33°C, 5.13 to 6.17 min, 880 to 1650 cP, 1511 to 1721 cP, 340.33 to 800 cP, 540 to 880 and 370.33 to 971 cP. The farinograph values had ranged from 47.37 to 50.85%, 4.67 to 5.99 min, 3.62 to 4.24 min, 58.18 to 76.99 FU and 70.67 to 82.56 FU for water absorption, dough development time, dough stability time, mixing tolerance index and farinograph quality number respectively. There were significant (P<0.05) differences among the varieties except dough stability time.

Keywords: Teff Grains and Flour, Pasting Properties, Functional Properties, Physical Properties, Rheological Properties

1. Introduction

Teff is a unique durable crop grown over a wide range of environmental conditions in Ethiopia and has been utilized as food and supplements for majority of the human diet in Ethiopia [1]. Teff is an ancient tropical cereal that has its center of origin and diversity in the northern Ethiopian highlands, from where it is believed to have been domesticated. In Ethiopia; it is a major food grain, mainly used to make injera, a traditional fermented Ethiopian pancake. Teff grain size is known to be extremely small with mean length ranging from 0.61-1.17 mm and mean width ranging from 0.13-0.59 mm, which gives an average thousand kernel weight of 0.264 gram [1]. Teff grain anatomy studied by [2] indicates that the embryo, rich in protein and lipid, occupies a relatively large part of the grain. The aleurone layer is one cell thick and rich in protein lipid bodies. The testa is located within the pericarp and its thickness varies with the color of the grain. The testa of red teff is thicker than white teff and it is filled with pigmented material, suggested to be tannins or polyphenol compounds [3]. The teff grain proteins offer an excellent balance among the essential amino acids [4]. Teff is regarded as a “healthy food”, suitable for its employment in novel foods such as baby foods and gluten-free based goods [5]. The attention to teff has been recently increased because of its health benefits. Teff has an attractive nutritional profile having significant levels of minerals including calcium, iron, magnesium, phosphorus, potassium, and zinc. Also, teff is rich in vitamins, such as thiamin (B1), riboflavin (B2), vitamin A and K. Furthermore, teff is high in proteins including all 8 essential amino acids that is superior in lysine than wheat or barley along with its high carbohydrate sand fiber contents. Teff is beneficial for those who are lactose intolerant since it is gluten-free. Red teff grains are greatly recommended for the improvement of osteoporosis and bone healing conditions [6].

Currently, consumer’s preference towards baked goods with additional (functional and nutritional) value is increasing, forcing food industries to look for more natural nutrient-dense alternatives like grain teff flour for use by the people affected by celiac disease because it is a gluten free
cereal grain with high potential. The growing demand for products from teff grain flour due to its nutritional and health benefits is raising the interest of modern food industries and bulk flour milling, flour handling and processing operations of this cereal grain is inevitable. Therefore generation of some information concerning of engineering properties of teff grain and its flour, to investigate and provide concise information and data on selected physical, functional, thermal and rheological properties of teff grain and its flour is considered to be important [7].

2. Literature Review

2.1. Farinograph

Farinograph is used to measure the evolution of dough under specific kneading conditions after it was brought to standard consistency of 500 F. U. The principle of Farinograph operation is based on the resistance of dough to the kneader shaft. The resistant moment to the kneader shaft has increasing variation when mixing the components, hydrating of flour particles, dough formation and development, up to a maximum value, close to the value of dough normal consistency. Then, the variation of moment to the shaft, respectively dough consistency remain approximately constant, in the stability phase of the dough which can be maintained for longer or shorter time depending on the characteristics of flour. Graphic recording of the moment (dough consistency) during kneading with the farinograph device is called Farinograph [8]. The farinograph test is one of the most commonly used flour quality tests in the world. The results are used as parameters in formulation to estimate the amount of water required to make dough, to evaluate the effects of ingredients on mixing properties, to evaluate flour blending requirements, and to check flour uniformity. The results are also used to predict processing effects, including mixing requirements for dough development, tolerance to over mixing, and dough consistency during production. Farinograph results are also useful for predicting finished product texture characteristics. For example, strong dough mixing properties are related to firm product texture [9].

Water absorption is the amount of water required to center the farinograph curve on the 500 Brabender units (BU) line. This relates to the amount of water needed for a flour to be optimally processed into end products. Water absorption is expressed as a percentage [10].

Peak Time indicates dough development time; beginning at the moment water is added until the dough reaches maximum consistency. This gives an indication of optimum mixing time under standardized conditions. Peak time is expressed in minutes. Arrival Time is the time when the top of the curve touches the 500-BU line. This indicates the rate of flour hydration (the rate at which the water is taken up by the flour). Arrival time is expressed in minutes.

Departure Time is the time when the top of the curve leaves the 500-BU line. This indicates the time when the dough is beginning to break down and is an indication of dough consistency during processing. Departure time is expressed in minutes. Stability Time is the difference in time between arrival time and departure time. This indicates the time the dough maintains maximum consistency and is a good indication of dough strength. Stability time is expressed in minutes.

Mixing Tolerance Index is the difference in BU value at the top of the curve at peak time and the value at the top of the curve 5 minutes after the peak. This indicates the degree of softening during mixing. Mixing tolerance index is expressed in Brabender units (BU). Weak gluten flour has a lower water absorption and shorter stability time than strong gluten flour adapted from AACC, 2000.

Farinograph quality number is the point of the curve in which the curve has decreased by 30 FU after the maximum (based on the line of the diagram). Thus weak flour weakens early and quickly giving low quality number. Strong flour weakens late and slowly indicating a high quality number [11].

2.2. Pasting Properties

This property is very important to know the flour or starch characteristics of a cereal or starchy product. They are useful to predict the behavior of the flour in baking and brewing process [12]. Pasting properties of starch are the phenomena involving granular cooking, swelling, and total disruption of granules. It has been used to quantify cold-swellling of 'cooked' component, raw component that paste's during test and overall viscosity that indicates degree of starch dextrinization [13]. The pasting properties are important indices in predicting the pasting behavior during and after cooking. [14]. The pasting character predicts the processing qualities (cooking temperature and time, thickening ability, temperature, pressure, shear induce viscosity breakdowns, gelling and retrogradation tendencies over the storage durations) of starch based raw material food ingredients. The pasting character is fundamentally determined by the starch granule composition and its nature (ultra-structures) and is influenced by the non-starch flour components [1]. For example to determine these characteristics, it is necessary to use a Rapid Visco Analyzers, and the main characteristics are:

Pasting temperature. It indicates the minimum temperature required to cook starch [15].

Peak viscosity is the maximum viscosity attained by gelatinized starch during heating in water. It indicates the water binding capacity of the starch granule [16].

Breakdown viscosity is measurement of the vulnerability or susceptibility of the cooked starch to disintegration. The high breakdown in viscosity will reduce the ability of the starch sample to withstand heating and shear stress during cooking.

Trough viscosity is related to the ability of the starch paste to form a gel after cooling. Gelation occurs with junction zone formation mostly through hydrogen bonding, re-associating the hydrated and dispersed starch molecules, and can vary with the botanical sources of the starch, amyllose content and formation of amyllose-lipid complexes, amount
of water, other ingredients like proteins and temperature of cooling [17]. High-amylose (linear) starches re-associate more readily than high amylpectin branched starches.

Setback viscosity is a measure of recrystallization of gelatinized starch during cooling. High setback value gave lower retrogradation during cooling and the lower staling rate of the products made from the starch.

Final viscosity indicates the ability of the starch to form a viscous paste [18].

3. Materials and Methods

3.1. Experimental Site

These experiments were done at Wolkite University, College of Engineering and Technology in Food Process Engineering Laboratory.

3.2. Experimental Materials

The six-teff varieties of Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B) were obtained from Debre Zeit Agricultural Research Center of the Ethiopian Institute of Agricultural Research (EIAR). These teff varieties were released by the National teff Improvement Program of the Ethiopian Institute of Agricultural Research (EIAR). The six teff varieties were selected based on the color, popularity among the teff grain consumers and the teff grain farming community, high yield, and that some are released recently [19].

3.3. Statistical Analysis

Data was analyzed by the analysis of variance (ANOVA) procedures using statically analysis of software (SAS) for windows version 9.0. Least significant differences (LSD) are using for Fisher mean comparison tests. Significance is accepting at (P< 0.05)

4. Results and Discussions

Table 1. Teff Grain Varieties.

<table>
<thead>
<tr>
<th>No</th>
<th>Variety name</th>
<th>Common name</th>
<th>Seed color</th>
<th>Year of release</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DZ-Cr-387</td>
<td>Quncho</td>
<td>Very White</td>
<td>2017</td>
</tr>
<tr>
<td>2</td>
<td>DZ-Cr-442</td>
<td>Felagot</td>
<td>Red</td>
<td>2017</td>
</tr>
<tr>
<td>3</td>
<td>DZ-Cr-457</td>
<td>Tesfa</td>
<td>Pale White</td>
<td>2017</td>
</tr>
<tr>
<td>4</td>
<td>DZ-Cr-438</td>
<td>Kora</td>
<td>White</td>
<td>2014</td>
</tr>
<tr>
<td>5</td>
<td>DZ-Cr-425</td>
<td>Dukem</td>
<td>White</td>
<td>2016</td>
</tr>
<tr>
<td>6</td>
<td>DZ-Cr-43B</td>
<td>Dagme</td>
<td>White</td>
<td>2016</td>
</tr>
</tbody>
</table>

3.3. Statistical Analysis

Data was analyzed by the analysis of variance (ANOVA) procedures using statically analysis of software (SAS) for windows version 9.0. Least significant differences (LSD) are using for Fisher mean comparison tests. Significance is accepting at (P< 0.05)

4. Results and Discussions

Table 2. Functional Properties of Teff Flour.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>WAC (g/g)</th>
<th>OAC (ml/g)</th>
<th>SP (%)</th>
<th>DIS (%)</th>
<th>WSI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DZ-Cr-387</td>
<td>0.99±0.01</td>
<td>1.27±0.01</td>
<td>10.24±0.27</td>
<td>73.67±1.53</td>
<td>19.61±0.18</td>
</tr>
<tr>
<td>DZ-Cr-442</td>
<td>0.98±0.01</td>
<td>1.18±0.01</td>
<td>8.37±0.13</td>
<td>72.00±1.00</td>
<td>17.44±0.12</td>
</tr>
<tr>
<td>DZ-Cr-457</td>
<td>0.96±0.01</td>
<td>1.24±0.01</td>
<td>8.88±0.36</td>
<td>74.00±1.00</td>
<td>17.44±0.12</td>
</tr>
<tr>
<td>DZ-Cr-438</td>
<td>0.89±0.01</td>
<td>1.42±0.01</td>
<td>11.09±0.12</td>
<td>73.00±1.00</td>
<td>19.99±0.22</td>
</tr>
<tr>
<td>DZ-Cr-425</td>
<td>0.91±0.01</td>
<td>1.08±0.02</td>
<td>10.91±0.39</td>
<td>73.00±1.00</td>
<td>19.99±0.22</td>
</tr>
<tr>
<td>DZ-Cr-43B</td>
<td>0.93±0.01</td>
<td>1.32±0.01</td>
<td>9.21±0.22</td>
<td>72.00±1.00</td>
<td>17.96±0.66</td>
</tr>
<tr>
<td>LSD</td>
<td>0.02</td>
<td>0.02</td>
<td>0.47</td>
<td>1.97</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Note: WAC=Water absorption capacities, OAC=Oil absorption capacity, SP=Swelling power, DIS=Dispersability, WSI=Water Solubility index. Within a column, values with different superscript letters have significant (P<0.05) differences.

4.1. Swelling Power

The measured swelling power of the teff flour is presented in Table 2. The values were 10.24, 8.37, 8.88, 11.99, 10.91 and 9.21% for the varieties Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B), respectively. There were significant (P<0.05) differences among the varieties, with Kora (DZ-Cr-438) having the highest value (11.99%) whereas, Felagot (DZ-Cr-442) the lowest value (8.37%). These results were found to be within range between 7.7 and 12.5% which were reported by [20]. They indicated swelling power is a measure of hydration capacity of starch, because the determination is a weight measure of swollen starch granules and their occluded water. Food eating quality is often connected with retention of water in the swollen starch granules [10]. Swelling power and solubility of starch granules also play an important role in contributing to the pasting and rheological behavior in most starchy products. Moorthy [21] reported that the swelling power of flour granules is an indication of the extent of associative forces within the granule. Swelling power is also related to the water absorption index of the starch-based flour during heating [12]. Therefore, the higher the swelling power, the higher the associate forces. The variation in the swelling power indicates the degree of exposure of the internal
structure of the starch present in the flour to the action of water [13].

4.1.1. Water Absorption Capacity

The measured water absorption capacities of different teff flour are presented in Table 2. The values were 0.99, 0.98, 0.96, 0.89, 0.91 and 0.93 g/g for the varieties Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B), respectively. There were significant (P< 0.05) differences among the varieties. Quncho (DZ-Cr-387) having the highest values (0.99 g/g) of water absorption among the varieties studied because Proteins (consist of subunits structure and dissociates on heating as observed by Granito [22]. Dev and Quensil, (1988) reported that protein subunit have more water binding sites (increase in the number of hydrophilic groups) which are the primary sites of water binding of protein. Kora (DZ-Cr-438) showed the lowest value (0.89 g/g). These results were found in harmony with previous studies conducted by [23]. The high water absorption capacity has been attributed to loose structure of starch polymers while low water absorption capacity value indicates the compactness of molecular structure [24].

4.1.2. Oil absorption Capacity

The oil absorption capacity results of different teff flours are presented in Table 1. There were significant (P< 0.05) differences among the varieties with values of 1.27, 1.18, 1.24, 1.42, 1.08 and 1.32 ml/g for Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B) respectively. There were significant (P<0.05) differences among the varieties with values of 1.27, 1.18, 1.24, 1.42, 1.08 and 1.32 ml/g for Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B), respectively. These results were found to be within range between 1.00 and 1.55 ml/g reported by [25]. Oil present food products improves their mouth feel and flavor retention. The oil binding capacity of food protein depends upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity. The ability of the proteins of the flour to bind with oil makes it useful in foodsystem where optimum oil absorption is desired. This makes the powder to have potential functional uses in foods such as bakery products. The oil absorption capacity also makes the flour suitable in facilitating enhancement in flavor and mouth feel when used in food preparation. In addition fat increases the leavening power of the baking powder in the batter and improves the texture of the baked product.

4.1.3. Dispersibility

The property of Dispersibility determines the tendency of flour to move apart from water molecule and shows its hydrophobic interaction. [26] Reported that water absorption is influenced by processing methods affecting starch gelatinization and swelling power. The measured dispersibility of different teff flour are Presented in Table 1. The values were 73.67, 72.00, 74.00, 74.00, 73.00 and 72.00% for varieties Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B), respectively. There were no significant (P>0.05) differences among the varieties. Present values were fairly compatible with results of Ashogbon and Akintayo, (2012), who reported values of 70.33-99.44% dispersibility for pearl millet flour [27].

4.1.4. Water Solubility Index

Water solubility index is important parameter often used as an indicator of degradation of molecularcomponents. WSI measures the amount of soluble components released from theprotein and other molecules after extrusion. The water solubility index results of teff flours are presented in Table 1. The values were 19.61, 17.44, 18.69, 19.99, 19.51 and 17.96% for varieties Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B), respectively with significant (P<0.05) differences among the varieties. Kora (DZ-Cr-438) had the highest value of 19.99% whereas Felagot (DZ-Cr-442) the lowest value of (17.44%) water solubility index among the varieties. These results were found to be within the range between14.39 and20.33% which was reported by [28] for cassava flour. The low water solubility index offLOUR could be attributed to the possibility of amylase complex with especially lipids in flour starch preventing it from dissolving in solution. Other factors could be the high stability of flour starch amylpectin structure; hence, preventing it from possible degradation during heating [29].

<table>
<thead>
<tr>
<th>Varieties</th>
<th>PT (°C)</th>
<th>Pt. (min)</th>
<th>PV (cP)</th>
<th>FY (cP)</th>
<th>BD (cP)</th>
<th>TV (cP)</th>
<th>SB (cP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DZ-Cr-387</td>
<td>76.00±1.00</td>
<td>5.20±0.10</td>
<td>1640.33±2.00</td>
<td>1614±2.00</td>
<td>800±4.00</td>
<td>840±2.00</td>
<td>774±0.00</td>
</tr>
<tr>
<td>DZ-Cr-442</td>
<td>80.33±1.53</td>
<td>5.50±0.10</td>
<td>900.33±1.53</td>
<td>1568±2.00</td>
<td>340.33±2.51</td>
<td>602±2.00</td>
<td>967.33±1.53</td>
</tr>
<tr>
<td>DZ-Cr-457</td>
<td>79.00±1.00</td>
<td>5.17±0.03</td>
<td>1250±7.81</td>
<td>1721.67±1.52</td>
<td>541.00±1.00</td>
<td>880±1.00</td>
<td>370.33±3.30</td>
</tr>
<tr>
<td>DZ-Cr-438</td>
<td>70.00±1.00</td>
<td>5.13±0.06</td>
<td>880±1.00</td>
<td>1511.33±1.53</td>
<td>360.33±0.37</td>
<td>540.00±1.00</td>
<td>971.00±2.65</td>
</tr>
<tr>
<td>DZ-Cr-425</td>
<td>80.33±1.53</td>
<td>5.17±0.06</td>
<td>1650.33±1.53</td>
<td>1558.67±1.53</td>
<td>546.67±8.50</td>
<td>623.77±3.21</td>
<td>486.67±5.70</td>
</tr>
<tr>
<td>DZ-Cr-43B</td>
<td>80.00±1.00</td>
<td>6.17±0.03</td>
<td>1109±1.00</td>
<td>1681.00±1.00</td>
<td>458.00±6.93</td>
<td>650±1.00</td>
<td>925.67±3.70</td>
</tr>
</tbody>
</table>

Table 3. Pasting Properties of Flour.

4.2. Pasting Temperatures

The measured pasting temperatures of the teff flours dough are presented in Table 3. There were significant (P<0.05) differences. Varieties, Felagot, Tesfa, Dukem and Dagme exhibited pasting temperatures of 80.33, 79.00, 80.33 and 80.00°C, respectively with no significant differences among them. Their values is found to be statistically higher than the
between 64.1°C and 90.8°C for five parameters to define a particular sample quality [1 2]. Final pasting temperature of different flour varies due to various sizes of the teff starch granules. Larger teff flour granules are associated with lower pasting temperature and high swelling properties [30]. In this observation, Dukem (DZ-Cr-425) and Felagot (DZ-Cr-442) flour had smaller granules size than the other varieties, thus may have contributed to the higher pasting temperature. Higher pasting temperature also indicates a greater structural rigidity of the flour [31]. The Pasting temperature found in this work is somehow similar to the reported RVA pasting temperatures between 64.1°C and 90.8°C for five teff flour starches [32].

4.2.1. Peak Time
The peak time results of teff flour are presented in Table 2. The time at which peak viscosity occurred in minutes is termed peak time [33]. The values were 5.20, 5.50, 5.17, 5.13, 5.17 and 6.17 min for varieties Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B), respectively. There were significant (P<0.05) differences among the varieties. Dagne (DZ-Cr-43B) having the highest value (6.17 min) followed by the 5.50 min of variety Felagot. The rest of the varieties had peak time values of 5.13 to 5.20 min with no significant (P=0.05) differences among them. These results showed slightly longer time thanthe RVA Pasting time reported (6.00-3.43 min) for teff flour by [32]. Short peak time observed in the flour may be due to reduced starch content. However, short peak time is indicative of its ability to cook fast.

4.2.2. Peak Viscosity
The peak viscosity results of teff flour values had ranged from 880 to 1650.33cp. Dukem (DZ-Cr-425) having the highestvalue (1650.33cp) whereas Kora (DZ-Cr-438) the lowest value (880cP). There were significant (P < 0.05) differences among the varieties. The peak viscosity is indicative of the strength of pastes, which are formed from gelatinization during processing in food applications. It also reflects the extent of granule swelling [34] and provides an indication of the viscous load likely to be encountered during mixing. The higher the peak viscosity the more is the swelling index, while low paste viscosity is indicative of higher solubility as a result of starch degradation or dextrinization [35]. The PV indicates the thickening ability and water holding capacity of the pasted flour and reflects the eating quality of the food products to be made as reported by [36]. The final viscosity results of the teff flours are presented in Table 3. The values had ranged from 1511.33 to 1721.67 cP Tesfa (DZ-Cr-457) having the highest value (1721.67cP) and Kora (DZ-Cr-438) the lowest value (1511.33 cP). There were significant (P<0.05) differences among the final viscosities due to the varieties. Final viscosities are important in determining ability of the flour sample to form a gel during processing and it is the most commonly used parameters to define a particular sample quality [12]. Final viscosity shows the ability of the material to form a viscous paste and it is mainly determined by the retrogradation of soluble amylose in the process of cooling.

4.2.3. Breakdown Viscosity
The measured breakdown viscosity of the teff flours are presented in Table 2. The values had ranged from 340.33 to 800 cP. There were significant (P<0.05) differences among the varieties. Quncho (DZ-Cr-387) had the highest value (800cP) while Felagot (DZ-Cr-442) had the lowest value (340.33 cP). Quncho (DZ-Cr-387) breakdown viscosity larger than that of the other varieties. This means that these teff varieties showed the highest disintegration degree of the swollen systems and alignment of amylase and other linear components in the direction of shear while the lowest value of breakdown viscosity in Felagot (DZ-Cr-442). Breakdown viscosity reflects the stability of the paste during processing. The higher the breakdown in viscosity, the lower the ability of the starch in the flour samples to withstand heating and shear stress during [33]. It was also reported by [37] that high breakdown value indicates relative weakness of the swollen starch granules against hot shearing while low breakdown values indicate that the starch in question possesses cross-linking properties. The breakdown viscosity measures the differences between peak viscosity and trough viscosity achieved during the high temperature (80.33°C for 5.17 min) holding duration and shows the relative differences of shear thinning and degree of disintegration of the swollen systems. Teff flour starch pasting are shear tolerant and thus had a potential for use in foods processed under high shear conditions.

The results of trough viscosity values are displayed in Table 3. The values had ranged from 540 to 880cP. Tesfa (DZ-Cr-457) had the highest value (880cP) and Kora (DZ-Cr-438) the lowest value (450cP). There were significant (P<0.05) differences among the varieties.

4.2.4. Setback Viscosity
The measured setback viscosity of the teff flours values are presented in Table 2. The values had ranged from 370.33 to 971cP. Kora (DZ-Cr-438) had the highest value (971cP) whereas Tesfa (DZ-Cr-457) had lowest value (370.33cP). There were significant (P<0.05) differences among the varieties. The SB predicts the degree of gelatin in the gradual retrogradation tendencies on cooling and storage of the teff flour starch pasted system. Teff starch was known to have less thickening ability, shear tolerance and slow setback than commercial normal maize starch reported by [1] on the RVA pasting and similar is also seen in the Bra bender amyl graph pasting. Teff starches were also known to have slow retrogradation tendencies on the refrigeration and freeze storages and freeze-thaw cycle treatments than the maize starches [38]. The remarkably lower SV of the teff flours with respect to wheat and rice flours is related to amylase retrogradation and confirm that teff flours retrograde extent than other cereals. Such lower retrogradation tendency in the teff flours could make them to be advantageous in formulation of different food products [1].

Farinograph Test
4.3. Water Absorption

Water absorption is the point chosen by the baking industry which represents a target water-to-flour ratio in bread dough. It is important to determine taste and texture of flour and dough performance during proofing and baking. The measured water absorption capacity of the different teff flours dough is presented in Table 3. The values were 47.37, 50.11, 48.14, 48.14, 50.15 and 50.85% for varieties Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B), respectively. There were significant (P<0.05) differences among water absorption capacity of the varieties. Dagme (DZ-Cr-43B) had the highest value (50.85%) and Quncho (DZ-Cr-387) having the lowest value (47.36%) [39].

4.3.2. Dough Stability

Dough stability time is the time from the first addition of water to the time the dough reaches the point of greatest torque. The measured of dough development time teff flours are presented in Table 3. There were significant (P<0.05) differences among the varieties on the dough development time of the teff flour dough. The longest time (5.99 min) was recorded for Dukem (DZ-Cr-425) whereas Quncho (DZ-Cr-387) having the shortest dough development time. The longest DDT for this flour could be due to the lowest fraction of teff flour dough in which resulted in the lowest gluten content which absorbs the water. Dough development time increases with the increase in the proteolytical degradation of protein [40]. This is also may be due to decrease in their gluten contents and weakening of protein network due to proteolytical activity of composite flour. These results were found to be the range between 4.5 and 6.5 min who reported by [41].

4.3.3. Mixing Tolerance Index

Mixing tolerance index is used by bakers to determine the amount that dough was softening over a period of mixing. The mixing tolerance index results of the flours are shown in Table 3. The values were 68.69, 74.58, 76.99, 59.12, 58.82 and 58.18 FU for varieties Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B), respectively. There were significant (P<0.05) differences among the varieties. Tesfa (DZ-Cr-457) having the largest value (76.99 FU) whereas Dagme (DZ-Cr-43B) the shortest value (58.18 FU) of the varieties. These results were found to be the range between 44.23 and 80.21 FU reported by [42] teff flour blend with wheat flour dough.

4.3.4. Farinograph Quality Number

Farinograph quality number is the point of the curve in which the curve has decreased by 30 FU after the maximum (based on the line of the diagram). Thus weak flour weakens early and quickly giving low quality number. Strong flour weakens late and slowly indicating a high quality number. The farinograph quality number results of the teff flours dough are presented in Table 3. The values were 77.94, 77.47, 76.07, 70.67, 82.56 and 80.32 FU for varieties Quncho (DZ-Cr-387), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B) respectively. There were significant (P<0.05) differences among the varieties. Dukem (DZ-Cr-425) having the highest value (82.56 FU) whereas Kora (DZ-Cr-438) the lowest value (70.67FU). These results were found to be within the range between 40 and 115 FU reported by [43] for blend both teff flour and soft wheat flour dough.

5. Conclusions

Teff is one of the major and indigenous cereal crops in Ethiopia. It is a unique durable crop grown over a wide range of environmental conditions in Ethiopia and has been utilized as food and supplements for majority of the human diet in Ethiopia. This study was conducted to generate information on some engineering properties of teff (Eragrostis teff (Zucc.) Trotter) grain and its flour. Six teff varieties namely Quncho (DZ-Cr-387), Felagot (DZ-Cr-442), Tesfa (DZ-Cr-457), Kora (DZ-Cr-438), Dukem (DZ-Cr-425) and Dagme (DZ-Cr-43B).
The results were reported as an average value of triplicate analysis of (mean ± SD) and were analyzed by Fisher’s Least Significance Difference (LSD) method and at statistical significance of P<0.05. The functional and rheological properties of the flours and dough expected of the teff grains. The color data showed that the varieties vary in the color of their flours which could be reflected on the processed products. The whiteness values as well as the a* and b* show that the white starch color is strongly diluted by the color of the non-white pigments found on the cover of the grains. This is also supported by the high fiber contents of the flours recorded in the study. All in all valuable information have been obtained about the teff grains that are of high importance in industrial processing of the grain to various products.

References


