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Influence of milling type on tef injera quality

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ABSTRACT

Injera is an Ethiopian flat bread that is mostly made from tef flour. Injera making on an industrial scale holds a significant economic and social interest but requires a thorough study of how the process variables affect the product quality. The aim of this work was to investigate the effects of mill type (hammer, disc, and blade) on injera sensory quality and starch digestibility. The application of software for the determination of injera quality descriptors and its comparison with visual human eye evaluation was also established. Injera made with disc mill flour had higher overall acceptability (6.6) than that obtained from hammer mill (4.2) and blade mill (4.1) flours. The injera made with blade mill flour obtained the lowest rapidly available glucose and rapidly digestible starch. The outcome of introducing software for the determinations of injera number of eyes was found effective; its difference with human eye determination was insignificant.

1. Introduction

Injera is leavened, flat round Ethiopian traditional bread made from cereals such as tef and sorghum (Pasqualone, 2018). Its surface has essentially evenly spaced gas holes that make up a honeycomb-like structure formed due to the production of gas during fermentation and baking. Injera has a shiny and smooth bottom surface. As stated by the work of Yetneberk, de Kock, Rooney, and Taylor (2004), good injera is expressed as soft and roll-able. A slight sourness is a characteristic taste of injera. Because injera is leavened bread made from natural gluten-free flour, it has great potential for commercial production internationally.

Injera prepared from the flour of tef [Eragrostistef (Zucc.) Trotter], a tiny, millet-like grain, is the most preferred (Yetneberk et al., 2004). Tef is an Ethiopian indigenous tropical cereal crop, and it has been cultivated for many years in the Ethiopian highlands (Viswanath, 2012). It is the main staple in the country and is mostly used to make *injera*. Tef represents 24% of the grain crop area in Ethiopia and 17.6% of the grain production (Central Statistical Authority, 2015).

The whole tef grain is ground to flour for making injera, local beverage porridges and soup and unleavened bread (Bultosa & Taylor, 2004). The sizes of the seed are very small, ranging from 0.6 to 1 mm diameter and 1–1.7 mm long with l000 seed weight averaging 0.3–0.4 g and 150 grains of tef have comparable weight with almost one seed of wheat (Dijkstra, Polman, van Wulfften-Palthe, Gamboa, & van Ekris, 2008). Tef grain products are nutritionally rich because they are eaten as whole grain with the significantly higher content of fiber, carbohydrate (USDA, 2007), iron, zinc and calcium than wheat, barley and sorghum (Abebe et al., 2007). Due to the absence of gluten and gluten-like proteins, tef has recently been popular globally particularly, as a "healthy food", making it right for celiac disease patients (Spaenij-Dekking, Kooy-Winkelaar, & Koning, 2005), and in addition, because of other dietary benefits such as the slow-release of carbohydrate constituents, it is useful for diabetic patients (Abebe & Ronda, 2014).

Depending on the mechanical forces and temperature during the grinding process, various milling or grinding methods have been introduced to produce different flours with different particle size and starch damage level (Kadan, Bryant, & Miller, 2008). In Ethiopia, mostly disk mill is used to grind tef grain in the homemade injera process. However, other types of mills have not been checked for their better quality of injera. The effect of milling technique on the sensory attributes of whole-wheat pan bread was studied by Kihlberg, Johansson, Kohler, and Risvik (2004). The result showed that technique of milling had a greater influence on bread sensory quality and on the slice area than did the baking technique and farming system. However, techniques of milling on sensory attributes of tef injera remain lacking.

The number, size, and distribution of holes (commonly called *eyes*) on the injera surface represent one of the most important quality attributes of injera (Yetneberk, Rooney, & Taylor, 2005). However, determinations of these injera quality descriptors are very difficult due to the nature of its uncountable eyes, which lead to subjective quality evaluation. Due to this, the injera standard, which was developed by

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the Ethiopian standard agency, lacks these quality attributes in measurable form. Currently, as injera industrialization is emerging, a systematic way of injera quality determination (injera number of eyes, eye size, and eye distributions) is mandatory for maintaining uniform quality.

Therefore, the objective of this research was to investigate the effects of three different mill types (Hammer, Disc, and blade) on injera sensorial quality and starch digestibility and to compare a software-based evaluation of injera quality descriptors with visual evaluation.

2. Materials and methods

2.1. Materials

Based on its popularity among Ethiopian tef farmers and users, the Qounchotef variety (DZ-Cr-387) was selected and obtained from the DebreZeit Agricultural Research Center of the Ethiopian Institute of Agricultural Research (EIAR). The tef sample was her metically stored in a cool and dry place using polyethylene bag. Before milling, the tef grain was cleaned by sifting.

2.2. Tef milling

Tef grain was milled using three types of mills to obtain the whole flour of the tef sample. The first one was the Hammermill (HM) (Perten 120, Finland) with a 0.8 mm sieve fitted inside as part of the mill, the second mill was the stone-diskmill (DM) (cottage tef grain-milling, Denmark) and the third mill was the blade mill (BM) (Nutri Bullet NB-101B, China). One kg of sample was milled by HM and DM for 7 min, and five kg of samples were milled by BM for 7 min at ambient temperature.

2.3. Injera preparation

The tef injera samples were prepared according to Parker, Umeta, and Faulks (1989) and Zegeye (1997). An amount of starter (*Ersho*) equal to 60 ml was initially added for each kg of flour. *Ersho* is a small amount of batter kept from previous dough to start first stage fermentation (Parker et al., 1989). The tef flour was mixed 2:3 (w/w) with potable water and kneaded by hand in a bowl until obtaining a homogenous mixture in the traditional way. The dough was allowed to spontaneously ferment for 60 h at room temperature (30 ± 5) °C in an injera baking household in Addis Ababa, Ethiopia. After this primary fermentation, 10% of the dough was mixed 1:3 (v/v) with boiling water and heated for 15 min with continuous stirring. The hot cooked dough (*absit*) was then mixed back into the fermenting dough, and sufficient potable water was added to make a batter. The batter was left covered for 2 h for secondary fermentation. Additional water was added to thin and form the right consistency of the batter. Finally, half a liter of batter was poured onto the hot clay griddle in a circular form. After 2–3 min of cooking using traditional electric injera baking equipment, the injera was removed and placed in a basket.

2.4. Flour characterization

2.4.1. Proximate analysis

Tef grain was milled using a stone-disc mill and flour proximate composition (Crude protein, fat, ash, fiber) was determined using AACC methods (AACC, 2000). Total carbohydrate was determined by difference to 100% (FAO/WHO, 2003).

2.4.2. Flour color

Flour color was evaluated according to the methods of Abebe, Collar, and Ronda (2015). The spectrophotometer was used for flour color measurements. CIE L^*a^*b coordinates were used to obtain the result by using the D65 standard illuminant and the 2°standard observer. The hue (h) and the chroma (C^*) were calculated from Eqs. (1) and (2) respectively.

$$h = \tan^{-1}\left(b^*/a^*\right) \quad (1)$$

$$C^* = ((a^*)^2 + (b^*)^2)^{1/2} \quad (2)$$

2.4.3. Particle size distribution

According to Sivaramakrishnan, Senge, and Chattopadhyay (2004), the particle size distribution was evaluated by passing the tef flour through an automatic standard sieve shaker (Retsch, Germany) that contains 5 sieves. Sieves with the sizes of 710, 500, 250, 125 and 90 μm were used. The percentage fraction of the sample retained on each sieve was measured by weighing.

2.4.4. Damaged starch evaluation

The damaged starch level of the tef flour samples was determined according to the AACC method (Association and of Cereal Chemists, 2012) using a Megazyme starch damage kit (Megazyme International Ireland Ltd., Co., Wicklow, Ireland). Absorbance was read at 510 nm in a microplate reader from BIOTEKEPOCH (Izasa, Barcelona, Spain). The damaged starch level of the tef flour was determined as a percentage of the flour weight on a dry basis.

2.4.5. Scanning electron microscopy (SEM)

Scanning Electron Microscope (SEM) model Quanta 200-F (FEI, Oregon, USA) equipped with an X-ray detector was used to examine the three tef flours. Samples were directly placed on stubs, and observations were done by accelerating voltage of 1.5 keV.

2.5. Injera quality analysis

2.5.1. Starch fractions analysis

The method by Englyst, Kingman, and Cummings (1992) was used to measure in vitro starch digestibility of tef injera with the modifications by Englyst, Hudson, Cole, and Cummings (1999); Englyst et al. (2000). The hydrolyzed glucose at 20 min (G20) and 120 min (G120) and the total glucose (TG) were measured by the glucose oxidase colorimetric method. The free sugar glucose (FGS) content was measured by a separate test according to the procedure proposed by Englyst et al. (2000). Rapidly digested starch (RDS) = 0.9 * (G20 − FGS), slowly digestible starch (SDS) = 0.9 * (G120 − G20), resistant starch (RS) = 0.9 * (TG − G120), for total starch, (TS) = 0.9 * (TG − FGS) and rapidly available glucose of the sample (RAG) = G20 were calculated. As used by Abebe et al. (2015), the starch digestibility rate index (SDRI) was computed from the percentage of RDS in TS in the flours.

2.5.2. Descriptive sensory analysis

The sensory evaluation was conducted by a panel trained according to Einstein (1991). The selected panelists were tested for their ability to detect basic tastes (Jellinek, 1985). The selected panel comprised 10 people, as recommended by Stone and Sidel (1985). They were females and males, who were students at Addis Ababa University. Nine *injera* quality descriptors were used for evaluation: color, taste, odor, texture (degree of softness), injera number of *eyes*, *eye* size, *eye* distribution (*eye* uniformity), and top and bottom surface (degree of being powdery and sticky); overall acceptability was also evaluated. A score sheet was prepared using the selected descriptors. Each one of the attribute was evaluated using a 10-point numerical scale (0–9) anchored on both sides with verbal descriptions (i.e., 0 = unpleasant, 9 = pleasant) to allow the panel to score the intensity on a framed common scale. Good sensory practices were followed according to Lawless and Heymann (1999). *Injera* samples were presented to the panelists on a tray at ambient temperature (≈25 °C) within 3–4 hr after baking. A glass of drinking water was used for rinsing between samples.