TEF [*Eragrostis tef*] GRAIN AND ITS CROP RESIDUE UTILISATION

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INTRODUCTION

Tef [*Eragrostis tef* (Zucc) Trotter] is an indigenous cereal in Ethiopia (Ketema 1997) with *ca.* 21% grain production annual coverage (CSA 1999). This paper highlights tef grain production systems, utilisation and implications on the environment. Some grain physico-chemical properties for 13 tef varieties released, grain nutrition merits, starch molecular features for five tef varieties, grain production constraints and future research needs are described.

Tef grain description: oval in shape and colours range from milk white to dark brown. The 1000 kernel weight (TKW) for 13 tef varieties ranged 0.24–0.29 g with mean 0.26g ± 0.01 (analysis in the author laboratory), which is in the range (0.19–0.42g) described by Assefa et al. (2001) for tef grain.

Pesticide applications on tef grain production system

Environmental degradations due to chemical pesticides usage on tef production system are generally less as compared to for the other common cereals (Ketema 1997 and Amogne et al., 2001).

Tef grain harvesting, threshing, cleaning and storage practices

Harvesting

Tef is harvested when the vegetative and reproductive parts turns to yellow straw colour and varies (45 to 160 days) with varieties (Tefera et al. 1995). The traditional harvesting is laborious (Figure 1b). The harvest is stacked as shown in Figure 1c.

Threshing and cleaning

Threshing is done mostly with an oxen feet trampling (Figure 1d). The traditional threshing and cleaning are laborious and lends itself to grain quantity loss. From threshing yard, incorporation of impurities is high particularly on the first threshing (Figure 2a). The chaffs and other broken tef plant parts separated (Figure 2b) are either allowed to decompose naturally as manure or sometimes burned off.

Tef grain storage

The traditional storages structures are: sacks, pots, tef straw reinforced mud made oval shaped called *Gumbii* and small hut like called *Gotaarra*. Tef grain has less storage pest problems compared to common cereal grains. For example in *Gumbii* can be stored for *ca*. 2–5 years safe.

Figure 1a. Tef field on the vegetative to ripening stage (DZ-01-196)

Figure 1c. Stacked tef panicles of top layer covered with tef straw

Figure 1b. Tef harvesting manually with sickle (adapted from Seyoum, 2007)

Figure 1d. Tef threshing by oxen trampling (adapted from Seyoum, 2007)

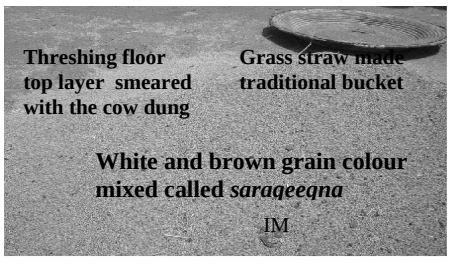

Figure 2a. Tef grain after cleaning by winnowing and wafting; IM = Impurities

Figure 2b. Chaff and other broken tef plants

Figure 2c. Stacked tef straw

TEF GRAIN COMPOSITION AND SOME CHARACTERISTICS

Proximate composition and amylose of 13 released tef varieties

The grain %: moisture, ash, protein (%N x 6.25), crude fat and crude fibre had ranged (mean) 9.30–11.22 (10.53), 1.99–3.16 (2.45), 8.7–11.1 (10.4) 2.0–3.0 (2.3), 2.6–3.8 (3.3), respectively. Tef flour starch amylose % had ranged 20.0–25.8%, mean = 23.0%. Amylose in maize and tef (DZ-Cr-37) starches analysed along were 28.4% and 27.7%, respectively.

Tef grain utilisation and nutrition

Tef grain is recognised for its better nutritional value than common cereal grains because is consumed as a whole grains mostly as *injera* (a fermented, spongy, sour, circular flatbread) (Ketema 1997) and is free from the type of gluten found in wheat (Dekking et al., 2005). Various studies (Yetneberk et al., 2004; Zegeye 1997) indicate that tef grain *injera* is superior among other cereal grains. Tef grain is also used in traditional unleavened bread, porridges, opaque beer and alcoholic distillates (Ketema 1997).

Tef starch and the pasting characteristics

Tef comprises of compound starch granules with many polygonal smooth surfaces forming granules of size similar to rice starch granules (2–6μm) (Bultosa et al., 2002). It had low viscosifying tendency, high shear tolerance and slower retrogradation than maize starch (Bultosa et al., 2002). In the 13 tef varieties released no *amylo*- or *waxy*- type starches were observed (Figure 3).

Starch molecular features

The amylopectin (AP) weight average molar mass ($\overline{M}_W$ x 10^7, g/mol) in five tef starches (10.1–16.6, mean = 13.9) was found lower than maize starch (19.6) with polydispersity index (PI) broader (tef = 1.9–3.3, mean = 2.4) than maize starch (2.5) (Bultosa et al., 2007). The amylose (AM) $\overline{M}_W$ x 10^6 (1.5–3.0, mean = 2.2) of most tef starches was apparently similar to maize starch (2.3) with narrower PI. The AM–iodine complex absorbed (611–679 nm, mean = 644 nm) somewhat toward longer wavelengths by 8–14 nm compared to maize starch (640 nm) AM–iodine complex. The blue value (1 mg amylose in 1 cm cuvette) was (tef = 2.3–2.8, mean = 2.5) slightly higher than for maize starch (2.2).

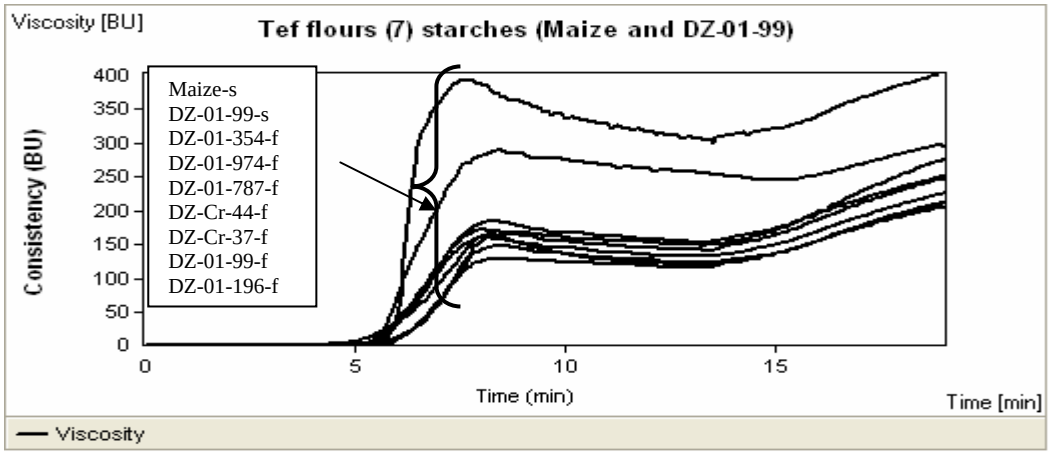

Figure 3a. Pasting curves of 7 tef flours (DZ-01-354, DZ-01-974, DZ-01-787, DZ-Cr-44, DZ-Cr-37, DZ-01-99 and DZ-01-196) and starches (maize and DZ-01-99)

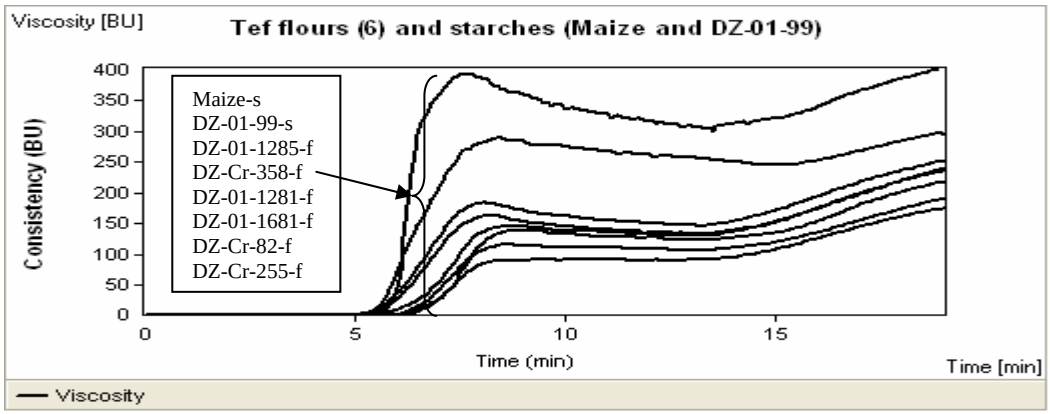

Figure 3b. Pasting curves of 6 tef flours (DZ-01-1285, DZ-Cr-358, DZ-01-1281, DZ-01-1681, DZ-Cr-82 and DZ-Cr-255) and starches (maize and DZ-01-99)

TEF BY-PRODUCTS AND UTILISATIONS

Straw as feed

On the dry matter (DM) basis tef straw was reported to comprise (%, n = 21): 92.4 DM, 1.7 ether extract (EE), 7.1 ash, 6.0 crude protein, 74.5 neutral detergent fibre (NDF), 42.4 acid detergent fibre and 7.7 lignin. The K, Na, Ca, P and Mg minerals (g/kg) level were 11.7, 0.3, 4.3, 1.6 and 1.9, respectively (Bediye and Fekadu, 2001; Bediye and Sileshi, 1989). Tef straw is most preferred than other cereal straw for cattle feeding, particularly during the dry season with somewhat deficient in nitrogen supply (Bediye and Fekadu, 2001).

Straw as a plastering aid

Tef straw mixed with mud is used as reinforcement for plastering of: wall in the traditional hut or modern iron sheet covered houses. It is also used as the plastering for traditional storage structures (*gumbii* and *gotaara*) and walls for the fire griddle.

CONCLUSIONS AND RECOMMENDATIONS

Tef is a reliable and low risk cereal crop in Ethiopia that grows on a wider ecology under moisture stress and waterlogged areas with few plant disease and grain storage pest problems. Tef grain nutrients are promising and are an alternative food for celiac patients. Tef straw is most preferred for animal feed and also used as a plastering aid for various traditional

structures. For farmers, it earns more value than any other cereals cultivated in Ethiopia. Tef is potentially not a low yielding crop. However, many of the production constraints have classified the crop as such. Global efforts are required to alleviate production constraints. Technologies for fast decomposition of tef straw, chaffs and other broken tef plant parts for manure production could be important. Address on tef grain chemistry and its utilisation (*injera* making quality) along with the genetic manipulation of the plant for characters like lodging resistance and seed size are important. Research on various ready to eat food products and innovative tef straw usages for material production are also important.

Acknowledgements
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