Received: 24 October 2022 | Revised: 28 December 2022 | Accepted: 1 January 2023

DOI: 10.1002/cche.10642

NOTE

CEREALS & GRAINS ASSOCIATION

Small-scale microwave cooking-based procedure for evaluation of injera-making quality of sorghum genotypes

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Funding information
United States Agency for International Development, Grant/Award Number: AID-OAA-A-13-00047

Abstract

Background and Objectives: Evaluation of the injera-making quality of sorghum and teff genotypes is problematic because of the large quantity of grain required to make injera using the conventional full-scale method. This study evaluated a small-scale microwave cooking-based injera making procedure. Eight lines expressing waxy and high protein digestibility traits and three normal-type sorghums were used. Freshly prepared and stored injeras were evaluated using instrumental texture analysis.

Findings: The stress and strain data of fresh and stored injeras from the microwave procedure significantly ($p < .01$) correlated with those from the full-scale method: Stress: fresh injera ($r = 0.725$), 2-days stored ($r = 0.741$), 4-days stored ($r = 0.852$); Strain: fresh injera ($r = 1.000$), 2-days stored ($r = 1.000$), 4-days stored ($r = 0.999$).

Conclusions: The small-scale microwave procedure uses much less grain and correlates with the full-scale method.

Significance and Novelty: The small-scale microwave procedure should enable screening of considerably larger numbers of genotypes for injera-making quality.

KEYWORDS
amylopectin, injera, protein digestibility sorghum, texture analysis

1 | INTRODUCTION

Injera is the most important staple food for Ethiopians. It is a very large thin circular leavened flatbread with honeycomb eyes/holes on the top surface produced by the escape of carbon dioxide during fermentation and baking (Yetneberk et al., 2005). Injera can be prepared from teff, maize, barley, sorghum, rice, and finger millet. Teff injera is consumed throughout Ethiopia by over 66% of the population and by some 89% in urban communities (Alem & Söderbom, 2012).

Teff is the preferred cereal for injera making as the injera is more flexible and has a longer shelf life than when made with other cereals (Yetneberk et al., 2005). However, teff grain/flour is more expensive than other cereals (Tadele & Hibistu, 2021) due to its low yield and its tiny grain size, which makes mechanized harvesting challenging (Lobamo, 2020).

Sorghum is commonly grown in Ethiopia and is relatively inexpensive as it is well-adapted to the harsh climate and gives good yield (Habte et al., 2020). However, the poor texture and keeping quality of sorghum injera are limiting factors (Yetneberk et al., 2005).

Screening cereal genotypes for injera making requires a large quantity of grain/flour (200 g per injera), which is

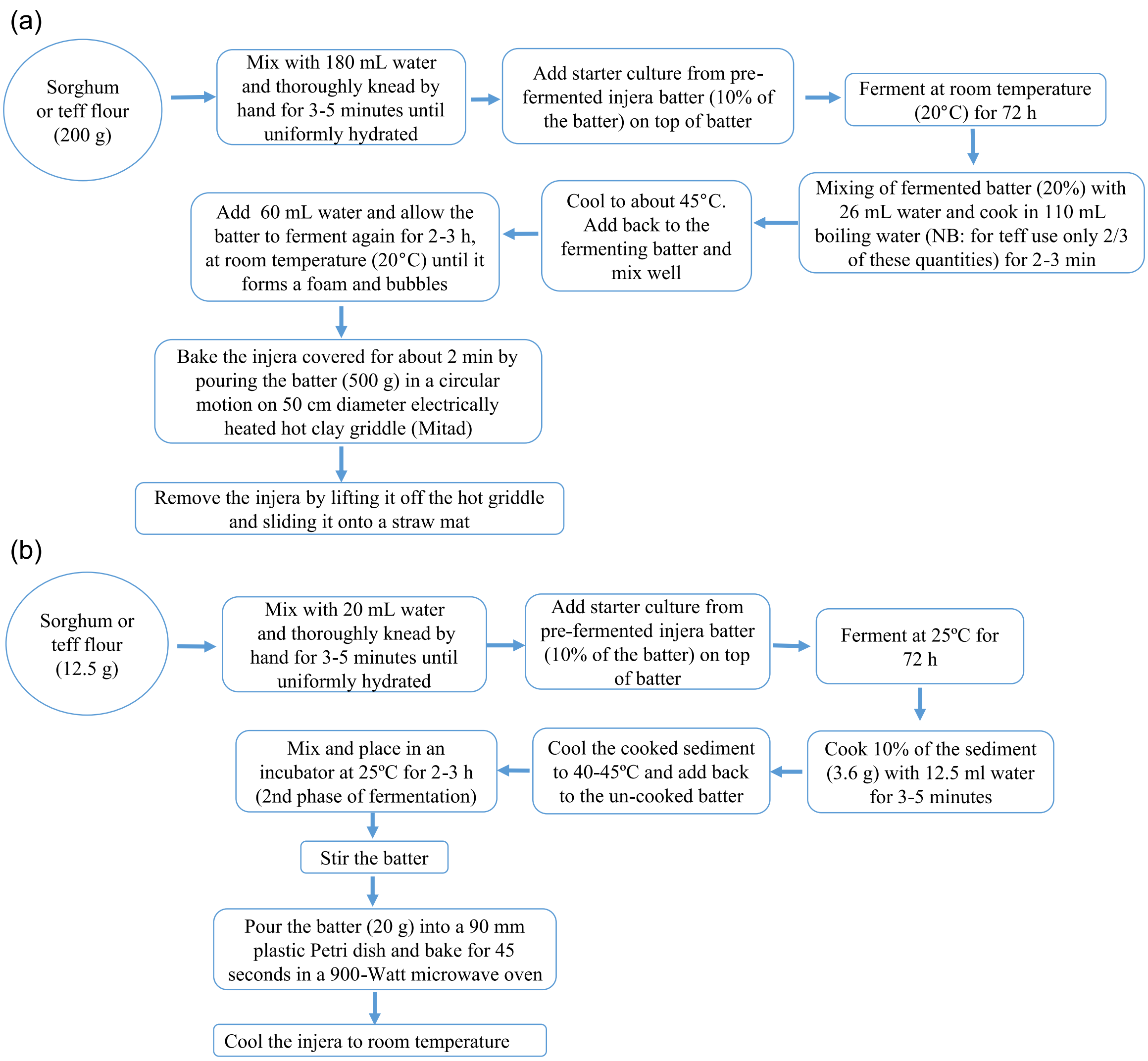

FIGURE 1 Injera making process flowcharts (quantities required to produce 1 injera: the making of tef injera [the control] and sorghum injera). (a) Conventional (full-scale) method. (b) Microwave (small-scale) procedure. [Color figure can be viewed at wileyonlinelibrary.com]

not cost-effective and efficient for breeders, who produce large numbers of lines. The objective of this study was therefore to evaluate a small-scale microwave cooking-based procedure for assessing the injera making quality of cereal genotypes in terms of instrumental texture using sorghum genotypes demonstrating various levels of the waxy and protein digestibility traits. These sorghum genotypes have been shown to differ in their injera-making quality (Mezgebe et al., 2020).

2 | MATERIALS AND METHODS

2.1 | Materials

White teff and 11 sorghum types (8 novel sorghums variously expressing waxy and/or high protein digestibility (HD) traits plus 3 normal types) were evaluated. The sorghums comprised 3 waxy-normal protein digestibility (WND), 1 heterowaxy-normal protein digestibility (hWND), 2 waxy-HD (WHD), 1 non-waxy–HD (NWHD), 1 non-waxy–normal digestibility (NWND) type (Mezgebe et al., 2018), a white non-tannin sorghum (wNTS), a red non-tannin sorghum (RNTS), a red tannin sorghum (RTS), and white teff flour (from Bloemfontein Teff Growers). The teff flour was used to prepare a control injera.

2.2 | Milling

The whole sorghum grain types were tempered to 16% moisture then milled using a twin break roller-type mill (Maximill) at an 84%–86% extraction rate. This meal was remilled using a laboratory hammer mill fitted with a 500 μm mesh opening size screen.

FIGURE 2 Comparison of conventional and microwave injera making processes. (a) Conventional (full scale). A. Fermented injera batter, B. Pouring the batter onto the hot baking griddle (Metad) from periphery to center), C. Baking the injera covered with the lid (Kidan), D. Baked injera. (b) Microwave method (small scale). A. Fermented injera batter, B. Pouring the batter into a 9 cm petri dish, C. Baking the injera in microwave oven without lid, D. Microwave cooked injera. [Color figure can be viewed at wileyonlinelibrary.com]

2.3 | Preparation of injera by the conventional (full-scale) method

Injera was prepared as described by Yetneberk et al. (2005), modified to 200 g flour scale to produce 1 injera, according to the process flowchart (Figure 1a). This produced conventional sized injeras (diameter: 500 mm) (Figures 2a and 3a).

2.4 | Preparation of small-scale injera (microwave procedure)

Small-scale injera was prepared in principle according to (Anyango et al., 2011), modified to 12.5 g flour to produce 1 small size injera (diameter: 90 mm), as described in the process flowchart (Figure 1b) by adjusting the volumes in proportion and omitting the

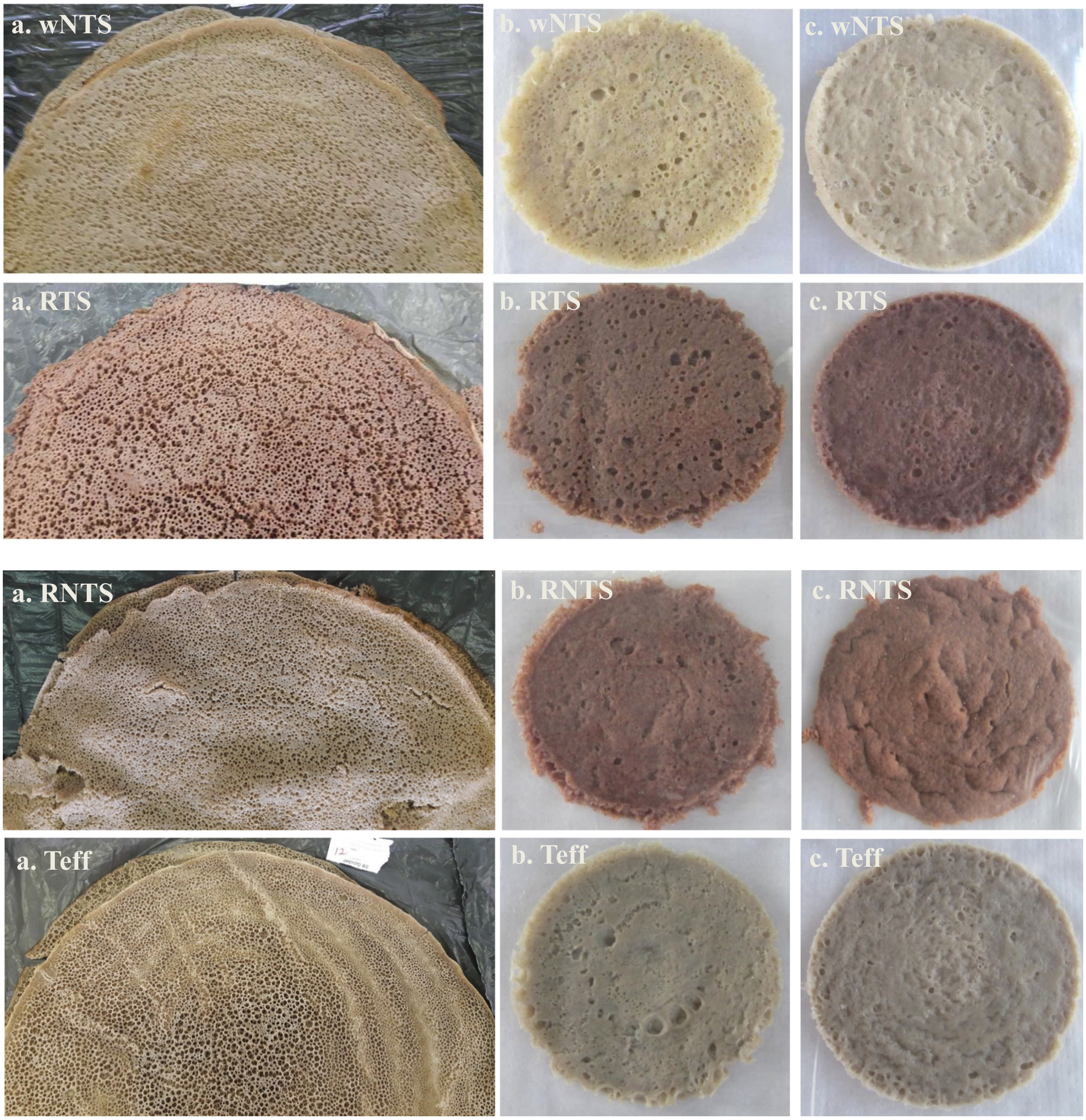

FIGURE 3 Comparison of full-scale and small-scale injera (made in different ways) from different sorghum genotypes and teffa. a. Conventional (full scale injera making), b. Microwave (small-scale procedure) with bakers' yeast and sugar in second fermentation, c. Small-scale injera prepared by back-slopping fermentation (omitting addition of bakers' yeast and sugar). RNTS, red non-tannin sorghum; RTS, red tannin sorghum; wNTS, white non-tannin sorghum. [Color figure can be viewed at wileyonlinelibrary.com]

inclusion of baker's yeast and sugar in the second fermentation (Figure 2b). These components resulted in eyes (gas cells) of variable size and distribution in the injeras (Figure 3b). Omitting baker's yeast and sugar resulted in no or few eyes and a more uniform texture and improved textural evaluation of injeras made from the sorghum genotypes (Figure 3c).

2.5 | Analyses

2.5.1 | Batter pH and titratable acidity (TA)

pH and TA were measured at 0, 24, 48, and 72 h of fermentation. TA (%) was determined according to Wakil and Kazeem (2012).

2.5.2 | Texture analysis

Injera stress and strain over storage were determined using a 3-point bending rig with an aluminum bar (5 mm wide and 90 mm long) mounted on a SHIMADZU EZ-L texture analyzer, as described by Mezgebe et al. (2020).

2.5.3 | Statistical analysis

Fermented flour pH and TA data were analyzed by one way ANOVA using Statistica v.8 (StatSoft). Correlation analysis of the instrumental texture data was performed using XLSTAT v.2016.03 (Addinsoft).

3 | RESULTS AND DISCUSSION

3.1 | Injera batter pH and TA

The pH of all the sorghum genotypes and teff batters decreased during sourdough fermentation (Supporting Information: Table S1). The pH at 48 and 72 h of all the sorghums and teff batters were similar ($p \geq .05$), with exception of RTS which was higher, presumably due to tannins inhibiting microbial growth. The pH of the sorghum genotype batters after 72 h fermentation was within the range reported for different injera batters (pH 3.65–4.02) by Attuquayefio (2014). TA of all the sorghums and teff batters increased during fermentation.

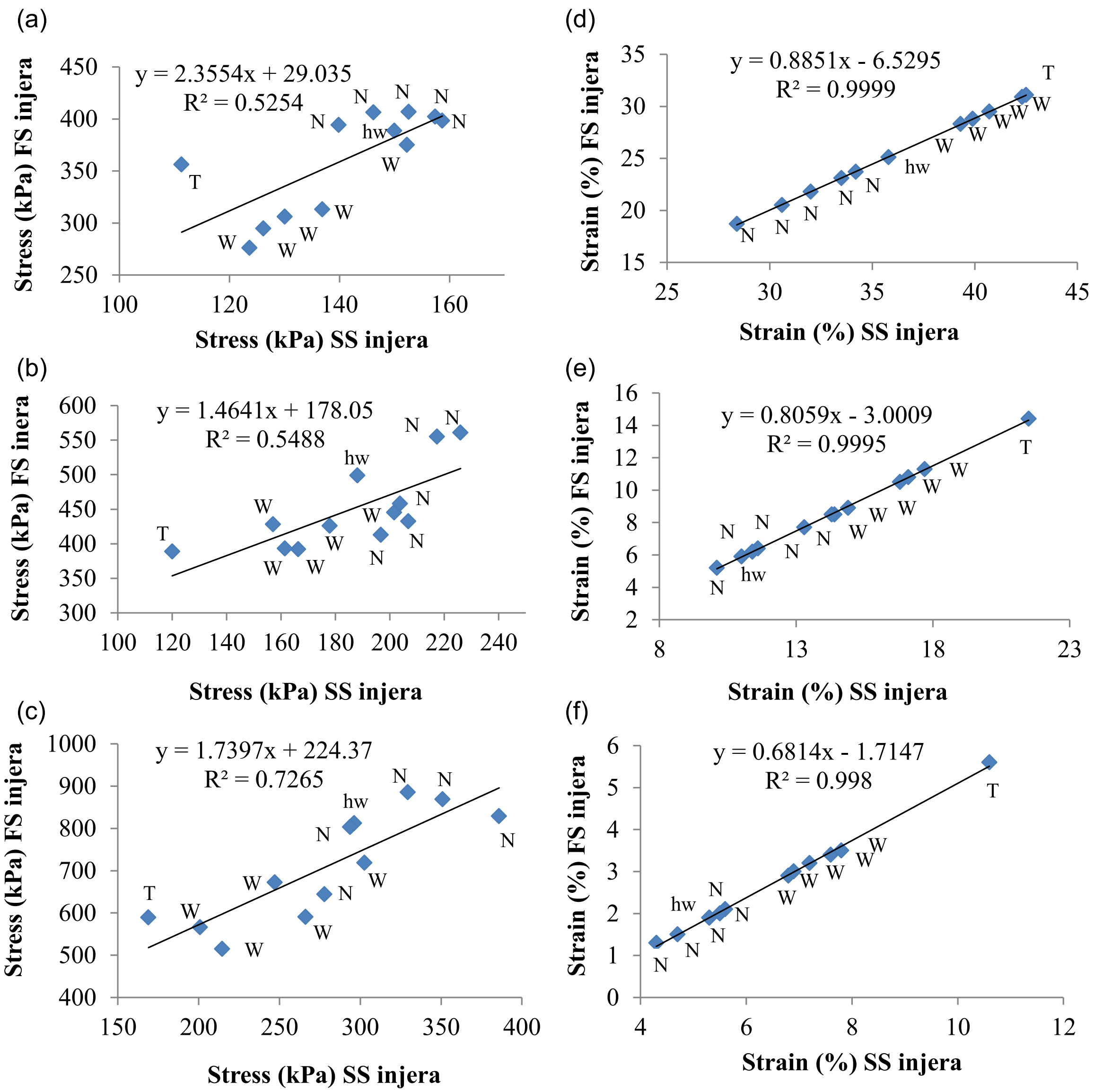

FIGURE 4 Correlation of the stress of fresh (a), 2 days (b), and 4 days (c) stored sorghum injera and their strain (d–f) at maximum elastic extensibility prepared using the full-scale (FS) and small-scale (SS) (microwave) methods. T (teff injera), W (waxy sorghum injera), hw (heterowaxy sorghum injera), N (non-waxy/normal sorghum injera). [Color figure can be viewed at wileyonlinelibrary.com]

All sorghum batters had lower TA compared to teff but higher than RTS after 72 h fermentation. The higher TA of the teff injera batter can be attributed to its high buffering capacity (Wolter et al., 2014). The higher TA of RTS was also presumably due to tannin inhibition of microbial growth. Importantly, however, neither pH nor TA were affected by the waxy and HD traits (Supporting Information: Table S2), due to the fact that there was no significant correlation between these (Supporting Information: Table S3). The methods used to determine starch amylose and in vitro protein digestibility are provided in Mezgebe et al. (2018, 2020).

3.2 | Injera instrumental texture analysis

Injera texture was measured to determine whether the texture of injeras made by the small-scale (microwave procedure) correlated with that of injeras made using the conventional (full-scale) method. Fresh injera of waxy sorghums had lower ($p < .05$) stress compared to teff (Figure 4a). The injera of these sorghums also had lower ($p < .05$) stress compared to injera of non-waxy, normal and heterowaxy sorghum types. Stored waxy sorghum injeras showed similar trend in stress profile as of the full-scale injeras (Figure 4b,c). The stress values for small-scale injeras were relatively higher than that of full-scale injeras. Notwithstanding this, the lower stress of fresh and stored of the softer injeras from the waxy sorghums (Mezgebe et al., 2020) was still evident with the small-scale microwave procedure.

The fresh waxy sorghum injeras had similar ($p \geq .05$) strain to teff injera (Figure 4d). These waxy sorghum injeras also had higher ($p < .05$) strain compared to non-waxy, normal, and heterowaxy sorghums injeras. When stored, waxy sorghum injeras had lower ($p < .05$) strain compared to teff injera and higher ($p < .05$) strain compared to the non-waxy and normal sorghum and heterowaxy types (Figure 4e,f). Strain values of injeras from the microwave procedure were lower than those from the full-scale method. However, both injera-making methods gave higher strain and more extensible fresh and stored injeras from waxy sorghums.

The correlation plots of the stress and strain data (Figure 4), showed that injera from the small-scale microwave procedure followed similar trends to those of the full-scale method. The correlations of stress were significant at $p < .01$ for fresh ($r = 0.725$) and 2 days stored injera ($r = 0.741$) (Figure 4a,b, respectively), and at $p < .001$ for 4 days stored injera ($r = 0.852$) (Figure 4c). Furthermore, the correlations of strain were significant at $p < .01$ for fresh ($r = 1.000$), 2 days stored ($r = 1.000$), and 4 days stored ($r = 0.999$) injera (Figure 4d-f, respectively). This indicates that the microwave procedure could be used for screening sorghum injera-making, where a large number of genotypes with a small sample size have to be evaluated.

4 | CONCLUSIONS

The stress and strain data of stored sorghum injera made by the small-scale (microwave) procedure are significantly correlated ($p < .01$) with those from injera made by the conventional (full-scale) method. The amount of grain/flour required to make 1 conventional injera is 200 g, while in the small-scale microwave process, it is just 12.5 g. Thus, the small-scale process has considerable potential to be used in breeding programs for screening the injera making quality of sorghum genotypes, and probably those of other cereals.

ACKNOWLEDGMENTS

This study is made possible by the support of the American People provided to the Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet (SMIL) through the United States Agency for International Development (USAID) under Cooperative Agreement no. AID-OAA-A-13-00047. The contents are the sole responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Mezgebe, A. G., de Kock, H. L., & Taylor, J. R. N. (2023). Small-scale microwave cooking-based procedure for evaluation of injera-making quality of sorghum genotypes. *Cereal Chemistry*, 100, 567–573. https://doi.org/10.1002/cche.10642