Comparison of Waxy and Non-Waxy Sorghum (*Sorghum bicolor*) with High Protein Digestibility Traits and Teff (*Eragrostis tef*) in Ethiopian *Injera* Making Performance

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Outline

1. Introduction
2. Materials and Methods
3. Results and Discussion
4. Conclusion
1. Introduction

**Injera** is pancake-like thin-flat bread from fermented *batter* of *cereals*  
✓ Staple food for majority of Ethiopians

✓ **Teff** is the best cereal for high quality *injera* to commercial & home uses

✓ **Sorghum** is *inferior* in *injera* making performance  
   ➢ Staling & fragile texture during storage  
     ◑ high amylose sorghum dry & become hard upon cooling

➢ Sorghum *injera* pushed to non-commercial use unlike **teff**
Injera:

- Upper side/“face” *(Ayin)*
- Underside/bottom *(Sebket)*
1. Introduction ... cont’d

Factors affecting the quality of sorghum injera

- Starch content & digestibility,
- Amount of amylose,
- Amylopectin starch lowers gelatinization temperatures
- Amount & types of phenolic compounds in sorghum
- Blending ratio with teff
1. Introduction … cont’d

✓ **Teff** is expensive than **sorghum** more than **twofold**
  - Teff attracted export market,
  - but the GO banned teff export to avoid domestic shortage

✓ **Sorghum** is good candidate for teff export substitution
  - Improving sorghum varieties & injera making performance are the strategies
    - Call for teaming up breeding and food technology researches
  - Are waxy & high **protein digestibility** (HPD) sorghum traits contribute to improved quality injera production?
1. Introduction … cont’d

- Relatively low nutritive value of sorghum is resistance of its seed storage proteins (kafirins) to protease digestion
  - enzyme resistant structure on the periphery of protein body
  - extended structures reduces digestion of protein & starch
  - Is processing technology improve quality of injera?
1. Introduction … cont’d

The overall **objective** is to:

- ✔ evaluate performance of Waxy & HPD sorghum lines for *injera* making
  - develop *injera* from waxy & HPD sorghum blended with teff

- investigate effect of fermentation & *injera* baking on tannin/phytate
- Determine partial substitution rate of teff with waxy and HPD sorghum traits for **commercial injera** production

- Describe the starch pasting and protein digestibility properties
- Assess the organoleptic acceptability of *injera* from sorghum lines with waxy and HPD traits
2. Materials and Methods

Proportion of sorghum with waxy & HPD traits to “Kuncho” teff flour

<table>
<thead>
<tr>
<th>Proportion of WLD, WHD, WLDh or NWLD with to teff flour</th>
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<tr>
<td>WLD:Teff</td>
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2. Materials and Methods ... cont’d

Phyto-chemical analysis - Phytic acids and tannins

Sensory evaluation – consumer-oriented sensory panel (9-point hedonic scale)

Starch pasting
   - Peak viscosity (degree of starch swelling during cooking)
   - Final viscosity (starch gel network integrity after cooling)

The Folin-ciocaltau reagent technique - Foling number (total phenol content)

Protein Digestibility - *in vitro* pepsin assay
   - Less reliable method compared to *in vivo*
2. Materials and Methods ... cont’d

Proximate composition – moisture, crude protein, fiber, fat, asdh, carbohydrate, energy conversion

Minerals - Fe, Zn and Ca

Microbiological and biochemical changes occurring during fermentation – bacteria, yeasts, pH, titratable acidity

The above were part of the research methods, but not shown here
3. Results and Discussions

3.1 Sensory/organoleptic acceptability of injera

- Sorghum with waxy & HPD traits showed good performance in injera production
- Waxy and HPD fermented faster (22 h) than normal sorghum
- Keeps injera quality for 3 days like that of teff

- Substation of teff up to 50% sorghum is applicable for commercial injera production
  - High economic benefits as export substitution and alternative resource utilization
Fresh baked injera
Injera stored in a pile
After 3 days storage at ambient temperature
Bread from 80% waxy & HPD sorghum substituted wheat flour
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3.2 … Tannin & phytate

Tannin & phytate reduced during injera dough/batter fermentation
✓ Teff has lower amount of tannin & phytate than sorghum
✓ Sorghum lines with waxy & HPD traits showed high reduction
  ➢ 184 mg/100 g in flour to 23 mg in injera

✓ bioavailability of minerals/protein
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<th>Sorghum to Teff Proportion</th>
<th>Flour</th>
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### Table 2b Reduction of phytate during fermentation and baking of sorghum injera

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<tr>
<td></td>
<td>Flour</td>
<td>Dough</td>
<td>Batter</td>
</tr>
<tr>
<td>KT 0: 100</td>
<td>168.61±0.00d</td>
<td>141.44±5.56f</td>
<td>140.01±3.36f</td>
</tr>
<tr>
<td>WHD 100:0</td>
<td>251.96±0.00a</td>
<td>178.90±1.60c</td>
<td>167.28±2.16de</td>
</tr>
<tr>
<td>WHh 100:0</td>
<td>268.18±0.56a</td>
<td>197.70±10.41b</td>
<td>156.23±2.93cd</td>
</tr>
<tr>
<td>WLD 100:0</td>
<td>194.12±0.56a</td>
<td>129.39±0.54d</td>
<td>126.01±3.28d</td>
</tr>
<tr>
<td>NWLD 100: 0</td>
<td>265.37±0.00a</td>
<td>189.96±2.62c</td>
<td>nd</td>
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<tr>
<td>WHD 50:50</td>
<td>205.54±1.11b</td>
<td>144.06±1.06f</td>
<td>140.20±4.33f</td>
</tr>
<tr>
<td>WHDh 50:50</td>
<td>207.62±8.64b</td>
<td>157.18±2.19cd</td>
<td>148.66±0.55d</td>
</tr>
<tr>
<td>WLD 50:50</td>
<td>191.74±2.81c</td>
<td>160.74±0.55b</td>
<td>145.83±2.10c</td>
</tr>
<tr>
<td>NWLD 50:50</td>
<td>219.11±5.98b</td>
<td>165.61±3.22de</td>
<td>nd</td>
</tr>
<tr>
<td>KT 0:100</td>
<td>167.23±1.96d</td>
<td>131.74±2.78g</td>
<td>nd</td>
</tr>
</tbody>
</table>
3.2 Results and Discussion ... cont’d

Peak viscosity - measurement of how readily starch swelling during cooking and resist shearing when heated in water.

Final viscosity - Retrogradation of starch paste on cooling.

Foling number - phenolic contents.

Protein digestibility – measures digestibility of protein using *in vitro* pepsin assay technique.
Peak viscosity

- Significantly increased after fermentation in waxy HD lines - 100% and 50% substitutions
- Waxy trait (WHD) improved sorghum starch swelling after fermentation equivalent to teff
- Decrease in injera, may indicate greater starch damage/gelatinization during fermentation & baking

**Figure 1** Peak viscosity (cP) of sorghum flour, dough, batter and injera compared to teff

*shows significant difference from the control (100% teff); values are least mean square and error bars are standard errors; ANOVA followed by Dunnett’s mean comparison
**Final viscosity**

Figure 2 Final viscosity (cP) of sorghum flour, dough, batter and *injera* compared to teff

*shows significant difference from the control (100% teff); values are least mean square and error bars are standard errors; ANOVA followed by Dunnett’s mean comparison

- Normal (NWLD) sorghum lines showed significantly in different way than teff
  - Starch gel network integrity after cooling
    - Important for *injera* texture
    - 50:50 WHD to teff best performance in a synergy
  - 50:50 WHD to teff best performance in a synergy
- Normal (NWLD) sorghum had lowest viscosity
  - Starch did not properly cooked to form a cohesive network
**Folin number**

- 24 hr fermented sorghum line showed higher *folin number* values than teff
- Slight decrease on fermentation & *injera*
- Increase was observed for 24 and 40 hr fermentation of teff

**Figure 3** Folin number of the fermented sorghum lines and teff

ANOVA and Tukey’s HSD; Values are least square means and error bars are standard errors; those with different letters of the same style are significantly different (*p*<0.05).
Protein digestibility

Figure 4 Protein digestibility of flour and *injera* produced from sorghum and teff

*values are significantly lower than the control (100% teff), values are least square means and error bars are standard errors.
4. Conclusion

The sorghum lines with waxy and HPD traits have potential for commercial *injera* production with consumer acceptance and 3 days keeping quality.

Fermentation and baking highly reduced the tannin and phytate that enhance bioavailability of sorghum based *injera*.

Waxy and HPD traits contributed to starch pasting, faster fermentation and delay *injera* stalling.

Substitution of teff up to 50% sorghum is applicable for commercial *injera* production.

- High economic benefits
Acknowledgement

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Thank you for your attention