Baking: Injera – the Multi-Eyed Flat Bread

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Definitions (in Amharic)

1. Injera: a thin, spongy, elastic flat bread with pores on one side that is used to lay wot on top and scoop sauces.
2. Irsho: a small amount of a previous batter saved and used as a starter for fermentation.
3. Wot: vegetable or meat sauces typically eaten with injera.
4. Absit: a portion of batter taken out after the first fermentation to be boiled and returned in the batter. The role of this partially gelatinized starch is to correct the viscosity of batter, which influences the formation of eyes.

Injera is a staple of East African food culture and is consumed by Ethiopians, Eritreans, and Somalis often more than twice a day around the world. Laid flat on a big plate, this unique chewy and spongy bread is often the base for meat and vegetable wot. While the variations in recipe and culture make injera distinct, for many it is literally and metaphorically the center of table and diet. Injera is eaten with the hands and often serves as a pliable utensil and serving plate. In appearance, injera is light gray, tan, or brown with distinctive open bubbles or “eyes” a few millimeters in diameter. Injera’s distinctive sour taste is the result of the fermentation (for several days) of the flour obtained by milling the seeds of *Eragrostis tef*, also known as teff, an annual grass. Multiple factors are required for acceptable injera, including the quality of the eyes, the pliability and ability to be rolled without tearing, a spongy texture, soft but not adhesive or sticky surfaces, and a distinctive sour taste. The materials at hand determine how easily acceptable injera is achieved by home bakers. For example, for Ethiopians, ideally injera is made entirely from teff flour. However, a home baker may use a mixture of teff and other flours such as barley, sorghum, and all-purpose wheat flour. Injera may even be prepared using just yeast and only all-purpose wheat flour. This chapter reflects an Ethiopian perspective but respects the diversity of how injera is prepared in other parts of the world.

Injera is a hardy plant originating in Ethiopia and Eritrea but is now cultivated across Africa, the United States, and the European Union. The tiny grain comes in varieties of white, brown/red, or mixed with seeds just a millimeter in size (Hagos et al., 2012). In addition to producing grain, teff straw is also used as feed for livestock, making it a valued agricultural product. An increase in demand has raised teff’s popularity in the United States. It is now produced in Idaho and Oregon, two states that share a geography and climate with Ethiopia. However, teff availability around the world and the impact of climate change will increase demand for acceptable substitutes. A variety of flours from grains such as barley, sorghum, and wheat can be fermented in the same way to yield the spongy flavorful flat bread. The global surge in popularity of teff is due to two reasons. First, for immigrants from Ethiopia, Eritrea, and Somalia, injera has a symbolic significance in culture and remains a continuous central staple of dishes. Second, because teff lacks gluten and contains all eight essential amino acids, it is gaining popularity as a nutritious gluten-free cereal (Gebremariam et al., 2014). Presently, food science research is focused on the commercialization and production of injera. However, it is still made in homes around the world using ingredients available to bakers (usually women). Figure 7.1 illustrates teff and starch granules on several length scales.

The general approach to preparing injera is to knead flour and water together to create a dough, and then let the dough ferment for a period of time (typically ranging from one to three days). Traditionally, fermentation in the batter is initiated by using a small amount of batter, called irsho, from a previous batch, much like a starter for sourdough bread. Most commonly, the starter culture for injera is a symbiotic combination of lactic acid bacteria and yeast whose co-metabolism provides a mechanism for the breakdown of carbohydrates (Chavan and Chavan, 2010). After this initial fermentation, a small portion (10–20%) of the batter is taken out to be boiled for several minutes. After boiling, this batter of gelatinized starch (called absit) is added back to the batter and allowed to ferment for a few hours or up to a day as a second fermentation. The first fermentation process creates acidity and gas in the batter. The second fermentation process initiates additional CO₂ production as both gelatinized swollen starch granules from the absit and ungelatinized starch granules from the original batter are fermented (Parker et al., 1989).

Injera is baked as a flat bread on a large hot plate under a well-sealed lid to retain steam. During the baking process, the starch is gelatinized, and bubbles from the fermentation process evolve into pores and ultimately form “eyes”. Because the bread is only cooked on one side, eyes only form on one side of the bread. Depending on the choice of flour and the fermentation method, the batter preparation time can be reduced to 24 hours. For
instance, injera can be made from all-purpose wheat and/or rice flour by fermenting it for a few hours using yeast, and absit is not needed to acquire the distinctive eye formation.

Regardless of flour, recipe, or method, a simple way to quickly judge injera quality and the baker’s skill is to assess the quality of the eyes: uniform eye size and density are an easy proxy for a baker’s skill. This is more than simply aesthetics. Properly made injera will have a uniform distribution of eyes to hold stews and sauces.

Several factors influence the distribution, size, and area fraction of the eyes. A batter poured unevenly on the griddle, poor fermentation and low CO$_2$ levels, or too high viscosity would result in uneven eye formation and density. As a dispersed system of gas within batter, the rheology of the injera batter as it is baked and gelatinized determines eye properties. The work of Attuquayefio (2014) has explored how fermentation and batter viscosity influence eye formation and elasticity of the bread. A comprehensive study by Assefa et al. (2018) found that kneading conditions and
absit preparation were important factors in the molecular profile of flavanoids as well as sensory perception of injera. Specifically, the ratio of batter to water during absit preparation was found to influence the number of eyes. Because teff is gluten-free, the absit is believed to increase the viscosity of the batter and increase the gas retention (Zannini et al., 2012). Reduced to physics, the formation of eyes becomes a complex problem in the fluid dynamics of bubbles passing through a dense batter as it solidifies.

Several metrics have been used to quantitatively assess the quality of eyes in injera. Some examples include the number, size, density, and area fraction. Figure 7.2 illustrates the eyes from several perspectives. The importance of injera as a utensil implies that additional quantitative analysis may be appropriate. The volume and network structure of the pores through the flat bread may also impact the sensory experience. Specifically, the volume of material that may be easily absorbed and held

![Figure 7.2](image-url)
in the eyes and the weight the injera can take on before tearing or yielding are both of interest. These considerations are only partly accessible by previous surface quantification tools. This network structure of the pores can be seen in Figure 2c. Understandably, the pores, network structure, and eyes have received attention as viewed from above. However, CO₂ bubbles also nucleate near the baking surface and likely rupture against the baking surface before evolving and flowing up through the batter (Figure 2d). This may provide an additional perspective on bubble and pore formation. Finally, because eyes are such an important and distinctive feature of injera, several strategies are utilized when preparing injera under improvised conditions. These include the addition of a small amount of baking powder to increase the CO₂ available just before baking or the use of self-rising flour.

Conclusions
This chapter conveys the importance of injera to people of East African descent around the world. The ways injera is served and eaten demonstrate its versatility. It is served on a plate big enough for a whole family to share eating. Its nutritional value and physical uses to lay wot on top and scoop sauces with make it an important part of most meals. Although it originated in East Africa, we highlight that injera can be made in households around the world using materials at hand. Eyes on surface, elasticity, and sour taste have been studied and determined to be its most distinct properties.

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REFERENCES