# Sensory Evaluation of a Teff and Dairy-Enriched Flatbread and Sustainable Development Goals of the United Nations

Amir Golmohamadi[1]*, Michael Rossi[1], Hossein Vojoudi[1]

[1]. Department of Nutrition, West Chester University of Pennsylvania, West Chester, PA 19383

## Abstract

Teff has a potential to contribute to Sustainable Development Goals (SDG) of the United Nations, particularly goals number SDG1 (no poverty), SDG2 (zero hunger) and SDG3 (good health and well-being). Adding fermented-dairy products such as yogurt may have a counter-effect on the activity phytates in teff-enriched bread products. The objective of this current pilot sensory evaluation study was to evaluate whether a teff and dairy-enriched flatbread (yogurt or milk) would receive a higher acceptance among students, faculty, and staff of the College of Health Sciences at West Chester University of Pennsylvania. Texture, taste, moisture, color, and aftertaste were evaluated using a 9-point hedonic scale for a regular (0T), a Teff and Milk (TMF) enriched (15% teff dry basis), and a Teff and Yogurt (TYF) enriched flatbread samples. An 18-component questionnaire (included demographics) was administered. Fifty-nine percent of respondents were female, 41% were male, 82.5% were white, and 82% were between the ages of 18-30 years. Ninety-seven percent of them were familiar and enjoyed flatbread. There was no significant ($p<0.05$) difference between the scores for texture, taste, color, and aftertaste of all three bread samples. However, the moisture of the TMF bread was liked most ($p<0.05$). Overall, 44% of participants preferred the TMF bread followed by the TYF bread (35%) and 0T (21%). Further investigation using objective tests will help with the optimization process of the TMF and TYF.

**Keywords:** Sustainable Development Goals, Teff, Flatbread, Phytates, Sensory Evaluation

[1] . Corresponding author: Amir Golmohamadi, PhD. Associate Professor, agolmohamadi@wcupa.edu

# 1. INTRODUCTION

Teff is currently cultivated commercially in Ethiopia, is a staple crop for this country, and is a well-known therapeutic grain in other parts of the Middle East and North African countries. The grain (Eragrostis tef) is beginning to expand globally due to both its nutritional qualities, and because of its environmental rigidity (Bultosa, Wrigley, Corke, Seetharaman, & Faubion, 2016). Teff is also gaining wide-spread popularity due to its gluten-free nature which particularly would interest consumers who have celiac disease or choose to follow an elective gluten-free diet (Gebremariam, Zarnkow, & Becker, 2014). Teff is a tiny kernel that contains 73% starch, 11% protein, and 3% fat. These numbers for the whole wheat grain are 71%, 12%, and 2%, respectively. Per 100 grams, Teff contains 154 mg calcium (wheat: 39.5 mg), 16 mg Iron (wheat: 3.5 mg), 181mg magnesium (wheat: 103 mg), 336 kcal energy (wheat: 450 kcals) (Beloshapka, Buff, Fahey, & Swanson, 2016; Gebremariam et al., 2014). In comparison, the protein content of the Teff grain (11%) is comparable to other more common cereals; for example, barley consists of 11% protein, wheat 12%, and rye 8%. However, the essential amino acid lysine is relatively higher in teff. It also contains more essential fatty acids, fiber, and phytochemicals, than many other grains (Baye, 2014). Additionally, teff starch granules are in a special form that makes it an excellent whole grain flour (Gebremariam et al., 2014). In essence, because teff is a gluten-free grain, has more essential fatty and amino acids, is drought resistant, and is considered “supergrain” would make it a good option for food-product development and plant-based recipe innovations (Golmohamadi, Yazdi, & Kita, 2020).

Food product and recipe development have been conducted in different parts of the world, particularly in Europe and North America; for instance, in “Dr. Praegers Super Greens Teff Hemp Veggie Burger” and “Lovegrass Ethiopia Wholegrain Teff Waffle & Pancake Mix” (Golmohamadi et al., 2020). The potential use of teff as a valuable source of calcium and iron in some food products has also been reported previously. Alaunyte and Ieva (2013) used “iron-rich teff bread” as a method to increase dietary iron intake. Regarding dietary calcium, teff can potentially be a good source of this mineral, however, the bioavailability of calcium might be negatively affected by the level of phytates in the grain. Therefore, to have unbiased results, phytates (or phytic acids) are commonly found in the bran of most grains should be factored into research designs. Phytates bind to major minerals like calcium, iron, zinc, and magnesium, by forming chelates with the minerals in the small intestine, rendering them relatively un-absorbable. Because we can observe iron deficiencies and high prevalence of bone diseases such as osteoporosis and rickets (Uday & Högler, 2017) in Ethiopia, it can be concluded that by itself, teff would not be a significant source of calcium and iron, contradicting previous studies making this claim (Gebremariam et al., 2014).

Teff has a potential to contribute to Sustainable Development Goals (SDG) of the United Nations, particularly goals number SDG1 (no poverty), SDG2 (zero hunger) and SDG3 (good health and well-being) (Coleman, Abaye, Barbeau, & Thomason, 2013; Golmohamadi et al.,

2020). Additionally, it seems that fermented and lactic acid-based products (found in yogurts), have a counter-effect on the activity phytates (Evivie, Huo, Igene, & Bian, 2017; Rollán, Gerez, & LeBlanc, 2019); therefore, potentially can increase the absorption of calcium and iron in teff-enriched food products, contributing to SDGs in the Middle East and North African regions. One of the most common staple foods in MENA is flatbread (Mekonen, Ambelu, & Spanoghe, 2019; Yetneberk, Rooney, & Taylor, 2005), and the opportunity for it to be used as a vehicle to supplement dietary calcium and iron to its consumers, including women and children, is apparent. Therefore, the objective of this pilot research study is to evaluate the acceptability of a Teff, Yoghurt, and Milk enriched flatbread among the students, faculty, and staff at West Chester University's College of Health Sciences.

## 2. Materials and methods

Teff-enriched flatbreads recipe was a modified version of a pita bread recipe (Brown, Walter, & Beathard, 2015). All the ingredients were purchased from a local grocery store in West Chester, PA. Bread preparation was conducted in the Department of Nutrition's Foods lab at West Chester University of Pennsylvania. Dry ingredients included half a package of dry active yeast (3.5 g), sugar (6.25 g), salt (1.5 g), bread flour (240 g), and ivory teff (135 g). Wet ingredients included Greek yogurt (30 g), lukewarm 1% milk (42ºC, 60 ml), and ghee (7 g). Ivory teff was mixed with milk and heated in a skillet until teff gelatinized. Other dry ingredients were mixed with gelatinized teff and activated yeast to create the dough. Two mixtures were then created, one using Greek yogurt and the other using the rest of the milk. The flatbread samples included a teff and milk (TMF) enriched flatbread (15% teff dry basis), a teff and Greek yogurt (TYF) enriched flatbread (15% teff, dry basis) and a control, which was a regular flatbread (0T). After mixing, each dough was placed in a separate clean bowl, covered with plastic wrap, and left to rise for 2 hours at room temperature. Once risen, each ball of dough was divided in half and was rolled out continuously onto a lightly floured surface with a rolling pin for about three minutes until all air-pockets were removed. The dough was left undisturbed for 5 minutes, and then rolled out for a second time into the shape of a flatbread. The final thickness of the dough was 0.5 cm. Finally, the flatbreads were baked in a residential oven (General Electric, Louisville, KY) at 260 ºC for 5-10 minutes, or until the crust was golden brown.

### 2.1. Institutional Review Board (IRB) approval

This study was approved by the West Chester University of Pennsylvania Institutional Review Board on 04/12/2016.

### 2.2. Participants and Sensory Evaluation

Participants were convenience sampling of the College of Health Sciences' students, faculty, and staff at West Chester University. The tasters were instructed to adequately chew the samples to get an appropriate evaluation. A 9-point hedonic scale sensory evaluation along with a

demographic questionnaire was administered to evaluate the flatbread samples. Participants evaluated the samples' texture, taste, moisture, aftertaste, and overall acceptance. Flatbread samples (1.25 $cm^2$) were unknown to the participants and presented on identical paper plates coded with 3-digit numbers (double-blinded).

### 2.3. Data Analysis

Descriptive statistics (median, mode, range, and frequency) was used to report the results of demographics, eating habits, and sensory evaluation data. A nonparametric data analysis (independent samples: Kruskal–Wallis) was used to analyze the differences among samples. The significance level was set at $p < 0.05$.

## 3. Results and discussion

### 3.1. Demographics

Since this was a pilot study, none of the participants were from the MENA region; therefore, it is needless to say that they have varied eating behaviors and perceive tastes differently. Demographic data (table 1) showed that of those surveyed (n=34), 82% were white, 59% were female, 41% were male, 41% were between the ages of 18 - 22 years, and 41% were between the ages of 23 - 30 years. Of all participants (mostly undergraduate students), 97% reported that they were familiar with and liked flatbread prior to participating in the study. Most of the participants made less than $52,000 a year, while a third of them made $74,000 or higher. Over half of the respondents were single, and none of the women were pregnant during the data-collection. Forty-two percent of the respondents' age was between 18 and 22 years old, which fell within the range of women in the MENA region who became pregnant (CIA, 2018).

Table 1. Summary of the selected demographics information of the participants.

| **Age group (years)** | **Frequency (%)** |
|---|---|
| 18-22 | 41% |
| 23-30 | 41% |
| More than 30 | 18% |
| **Employment** | |
| Part time ≥ 29 hours | 53% |
| Full time ≤ 30 hours | 21% |
| Other (Seasonal Unemployed etc.) | 26% |
| **Education** | |
| Undergraduate Students | 76% |
| Graduate (Masters) | 15% |
| Graduate (Doctoral) | 9% |
| **Household Income** | |
| Less than $35,000/year | 29% |
| $42,000-$51,999/year | 21% |
| $52,000-$58,999/year | 3% |
| $59,000-$73,999/year | 12% |
| Over $74,000/year | 35% |
| **Marital Status** | |
| Single | 56% |
| Married | 41% |

3.2. Sensory Evaluation

Table 2 summarizes the frequency of the main sensory attributes that were collected in this study. There was no significant ($p<0.05$) difference between the scores for texture, taste, color, and aftertaste of all three bread samples. However, the moisture of the TMF bread was liked most ($p<0.05$) by the participants (median: 7). All three of the samples received at least one maximum score in any of the five sensory attributes, implying that, at least a percentage of the participants

liked the three breads equally. The range of acceptance of all three samples was large, but did not deviate significantly; all three samples experienced an equal distribution of sensory attributes. This information can be supported by the means of each sensory attributes falling between the range of 6-7 (data not shown). The highest standard deviation was observed for the texture and moisture of the control. When asked to rate their favorite sample overall, 44% of the participants preferred the TMF bread, followed by the TYF bread (35%) and 0T (21%) (Figure 1).

Table 2. Results of the frequency analyses of the five sensory attributes of flatbread samples regular/control or enriched).

| | | Taste | After-taste | Texture | Moisture | Color |
|---|---|---|---|---|---|---|
| **Control (0T)** | Mode | 7.0 | 7.0 | 4.0 | 4.0 | 8.0 |
| | Minimum | 3.0 | 2.0 | 2.0 | 1.0 | 5.0 |
| | Maximum | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| | Range | 6.0 | 7.0 | 7.0 | 8.0 | 4.0 |
| | Median | 7.0 | 7.0 | 6.5 | 5.0 | 7.0 |
| **Teff and Milk** | Mode | 8.0 | 8.0 | 8.0 | 7.0 | 8.0 |
| | Minimum | 4.0 | 1.0 | 3.0 | 3.0 | 5.0 |
| | Maximum | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| | Range | 5.0 | 8.0 | 6.0 | 6.0 | 4.0 |
| | Median | 7.0 | 6.5 | 7.0 | 7.0 | 7.0 |
| **Teff and Yogurt** | Mode | 7.0 | 7.0 | 6.0 | 6.0 | 8.0 |
| | Minimum | 3.0 | 2.0 | 2.0 | 3.0 | 4.0 |
| | Maximum | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| | Range | 6.0 | 7.0 | 7.0 | 6.0 | 5.0 |
| | Median | 7.0 | 7.0 | 7.0 | 6.0 | 7.0 |

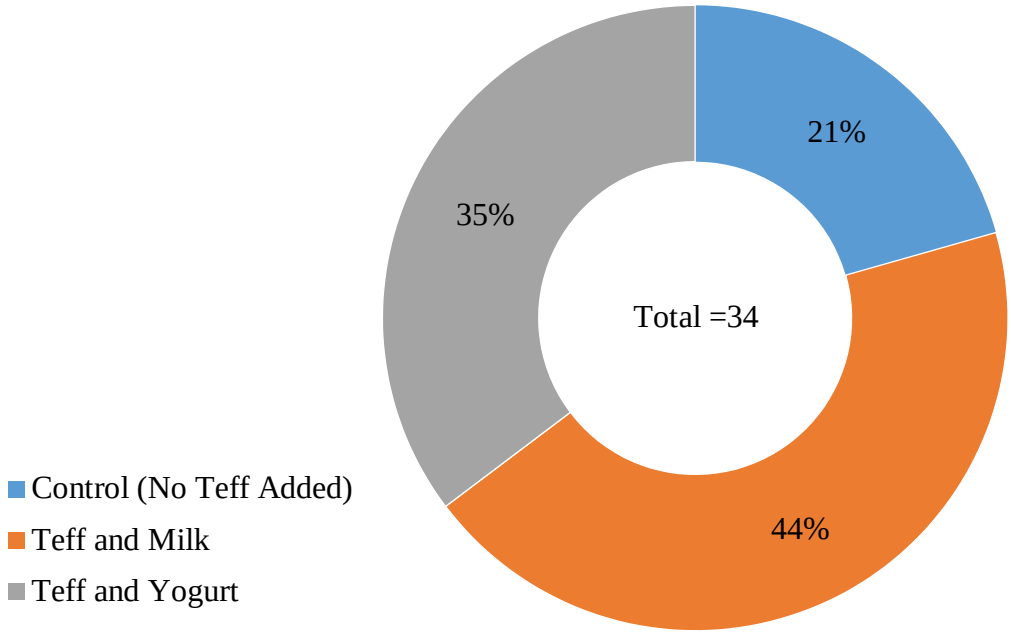


Figure 1. Majority of participants preferred TMF (Teff and Milk) over TYF (Teff and Yogurt) and 0T (No Teff Added).

## 4. Conclusion

Teff can reduce the rate of poverty in MENA regions by creating opportunities for small businesses and individuals to cultivate and grow this "super-grain". The potential for its use in these areas could ultimately help the local economy by means of food product development and exportation. The grain may also be utilized to fortify current staple food products to increase the total calcium and iron intake of the people in MENA. However, the bioavailability of these minerals due to the presence of phytates requires further investigation to prove its viability. In this pilot study, we observed that when using milk and yogurt, the overall acceptance of a teff-enriched flatbread was increased. Further investigation on the effect of gluten development in teff-enriched bread using Farinographs and Extensographs is needed for product-optimization. During this optimization process, collaborations with dietitians and food scientists will enhance the contributions of the product to meet the Sustainable Development Goals of the United Nations.

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