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Article

Fermentation dynamics of Ethiopian traditional beer (*tella*) as influenced by substitution of gesho (*Rhamnus prinoides*) with *Moringa stenopetala* as innovation for nutrition

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Abstract: This study was designed to improve Ethiopian traditional beer – *tella* with the substitution of *gesho* by moringa leaves to enhance micronutrients. Substation of *gesho* by moringa from 50 – 100% against the biochemical dynamics, nutritional and sensorial profiles of *tella* was assessed. Incorporation of moringa suppressed the activities of yeast and favored that of lactic acid bacteria, which shifted the property of the product from mild alcoholic nature to low alcoholic and mild acidic nature, revealing the probiotic potential of *tella*. Moringa leaves at 100% substitution for *gesho* resulted in to the least yeast count compared to the other formulations. The storage of *tella* samples over periods of 10 days also strengthened the probiotic nature of *tella* by drastically reducing the yeast cell counts (from 5 logs to <1). This corresponded to the slow increase in the acidity (0.63 to 0.99%), indicating comparatively higher activities of lactic acid bacteria. The best nutritional contents (dietary minerals) and sensorial acceptance of the product was attained at the 50% substitution of *gesho* by moringa. The implication of the present study is that ethnic foods and beverages can be innovated to meet the nutritional needs of the community

Keywords: Ethnic beer, *borde*, *shamita*, *keribo*, *korefe*, indigenous drinks, fermented beverages, probiotics, *Farsoo*, moringa

1. Introduction

Tella is an Ethiopian traditional fermented beer-like beverage made from varieties of cereals and a herb locally called *gesho* (*Rhamnus prinoides*). *Tella* resembles commercial beer in that it is made of malted barley and other grains, with the addition of gesho as a traditional beer [1]. *Tella* is a predominant traditional alcoholic drink consumed in almost every region of Ethiopia, but more popular in the central and northern parts of the country [2]. A variant of tella known as *karibo*, which is made without the addition of the herb gesho and brief fermentation, is also common among the Muslim families in Ethiopia [3]. *Tella* is still widely consumed on special occasions like holidays and wedding ceremonies in the urban areas. It is part of staple foods of the rural families during the busy farming seasons as a refreshing and energy drinks among the rural communities. Tella is known by different names among the Ethnic groups in Ethiopia, which includes ጠላ (*tella*) in Amharic, *Farsoo* in Afaan Oromoo and *Siwa* in Tigrigna. There are also variations in the ingredients and processes of tella making among the different ethnic cultures in Ethiopia [4]. Ingredients and processing methods used by the Amhara mothers in the north-western Ethiopia is more common and considered for the current work. With the popularization of industrial beer and soft drinks, consumption of *tella* and other traditional beverages is declining. Moreover, a stigmatized view towards *tella* consumption is developing among the urban youth.

Tella is a low alcoholic beverage with a maximum alcoholic level of ~4.0% g/100 mL [5], which makes nutritionally important in the rural community. *Tella* also makes up a

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livelihood of significant number of poor women in a petty trade setting [5]. It is therefore, important to investigate the processes, properties and ingredients of such traditional products to improve it and scale to a mechanized commercial processing level. Fermented indigenous foods and beverages are also being subjects of extensive research for popularizations due to potential roles of involved microbes for probiotics in search for functional foods. There are recent reports of some positive outcomes of the Ethiopian traditionally fermented foods and beverages [6,7].

There is therefore, an obvious need to improve the nutritional properties of the traditional beverages in line with their likely of commercialization in the local and international markets. Looking of more nutritious and cheaper ingredients that can serve multiple purposes is of great importance. In line with this, the current research was designed to substitute *gesho* (*R. prinoides*) with *Moringa stenopetala*, which is reported to have higher concentrations and diversity of micronutrients among herbs used as foods [8–10], which is sometimes called the "miraculous African tree" [8]. Leave powder of *M. stenopetala* was used to substitute 50 – 100% of the traditionally used herb – *gesho (R. prinoides)* with both the *kitta* (barley made into a thick flat bread) and *Enkuro* (roasted barley flour made into a cake of water and flour) based preparations. Comparisons of microbial activities and physicochemical characteristics at different phases fermentation were made to a control *tella*. Comparisons of selected micronutrient – dietary minerals at the end of fermentation were carried out.

2. Materials and Methods

2.1. Ingredients

The basic raw materials for *tella* preparation raw grain barley (*Hordeum vulgare*), barley malt; leaves and steams of *gesho (R. prinoides)* were obtained and prepared in Motta town of Gojjam, Amhara Region, Ethiopia with the help of experienced local women in traditional *tella* brewing. Moringa *(M. stenopetala)* leaf powder was purchased from local supermarket in Hawassa city, Ethiopia. The ingredients were packaged in polyethylene bags and stored under cold and dry condition until used in further preparation steps.

2.2. Preparation of Ingredients

Barley grain was cleaned and roasted to dark color for modification of the endosperm and flavor and color development. The roasted barley grain was then milled into flour (locally known as *derekot*) and packaged into polyethylene bags and stored at room temperature until required for the next processing steps. Barley malt was cleaned and milled and preserved the same way the *derekot* was stored. The leaves and thin branches of *gesho* were pounded of a desirable particle size (not too fine), using a wooden traditional mortar and pestle. The powders were also packaged in polyethylene bags and stored at dry and dark place until required for the next step of *tella* making. The moringa leaf powder was also stored under the same conditions with *gesho*.

2.3. Adjunct Preparation Methods for Tella

Tella was made using two commonly used traditional methods: *kitta* and *emkuro* based preparations. The roasted barley flour was mixed with adequate water to make sticky dough in the *kitta* preparations, that was baked into thick flat bread on a hot metallic griddle [11]. *Kitta* was kept to cool and broken into pieces. *Kitta* pieces were dried and preserved for use in the *difdif* stage of *tella* fermentation. For the *enkuro* based preparations, the roasted barley powder was mixed with limited amount of water (compared to that of *kitta*) and kneaded into bolus cakes, that was cooked on a hot metallic griddle. *Enkuro* was then cooled, dried, packaged in polyethylene bag and transported to the laboratory for use in the *difdif* stage of *tella* fermentation.

2.4. Tella Processing Phases

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Tella processing employs three basic fermentation stages: namely *tejet*, *tenses* and *difedef* [1,12]. Three types of *tejet* were made by mixing 100 g of malt and 125 g of (i) gesho leaf powders (ii) moringa leaf powders (iii) 50:50 *gesho* – moringa mixtures and left to ferment for 96 hrs. being covered with a piece of clean cloth. The *tejet* preparations were *devided* into two and converted to tenses by adding 225 g of either *kitta* or *enkuro* adjuncts (section 2.3). The *tenses* preparations were also left covered to ferment for another 96 hrs. The fermented *tenses* was transformed into the final stage of *tella* fermentation, the *difdif* by adding 900 g of the remaining adjuncts (*kitta* and *enkuro*) and diluted to *tella* with 5 liters of water. The final *tella* mixture was also left covered for another 96 hrs. of fermentation. The solution strained with clean muslin cloth to remove suspended impurities and biochemically and sensorially characterized.

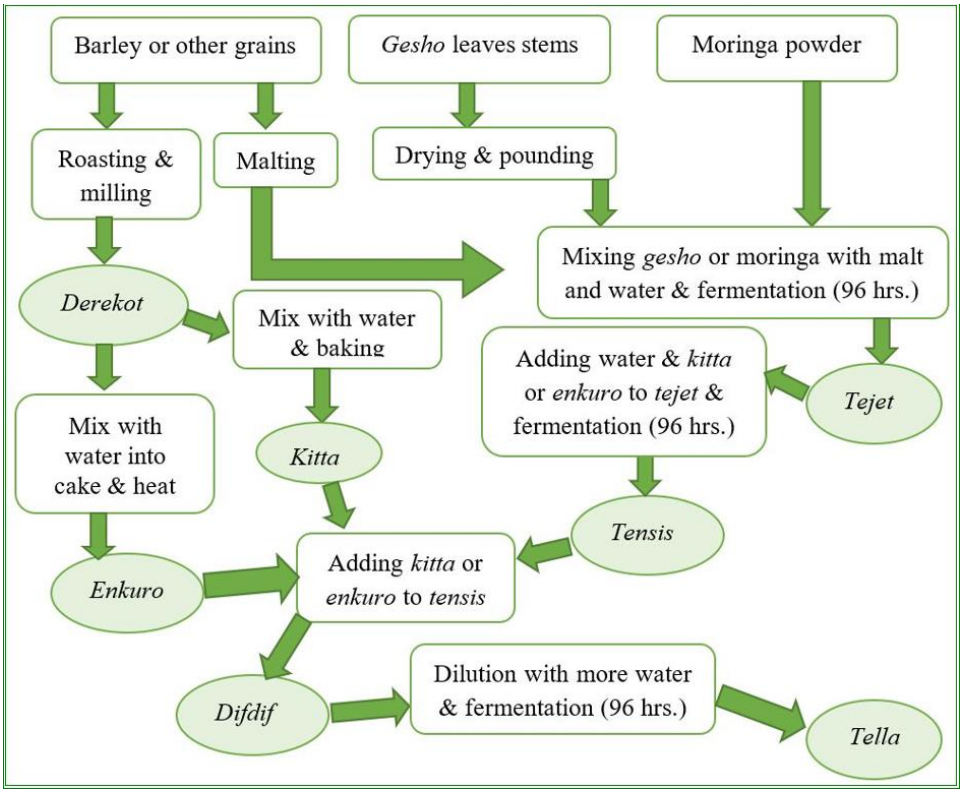

Figure 1. Flow diagram for *tella* making depicting the major ingredients and operations

2.5. Determination of Biochemical Dynamics during Tella Fermentation

2.5.1. Yeast Counts

Ten g of samples at *tejet*, *tenses* and *tella* stages were weighed into a stomacher bag (Lab-Blender 400, Seward Medical, London, England) with 90 mL sterile 0.1% peptone water (Merck) and homogenized for 30 s. The homogenized samples were prepared into dilutions with peptone water and 0.1 mL of each sample were spread-plated in triplicates on pre-dried plates of yeast extracts glucose chloramphenicol (YGC) agar and incubated at 28°C for 5 days [13].

2.5.2. Total Aerobic Mesophilic Counts (TAMC)

Samples (10 g) of *tejet*, *tenses* and *tella* were transferred into a stomacher with 90 mL sterile 0.1% peptone water and homogenized for 30s. The homogenate was separately (0.1 mL) spread-plated in triplicates on pre-dried plate count agar (PCA) and incubated at30°C for 48 hrs. The total aerobic mesophilic count (TAMC) were enumerated and averages microbial loads were reported as log10 colony forming units (CFU) per mL of samples [14].

2.5.3. Lactic Acid Bacteria (LAB)

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Similar dilution and homogenization protocols to those used for TAMC was employed. LAB from the different preparation and formulations were inoculated on Man, Rogosa and Sharpe (MRS) agar plates and anaerobically incubated at 30°C for 72 hrs. The LAB CFU were counted and reported in similar form for TAMC (section 2.5.3.).

2.5.3. Enterobacteriaceae

2.6. Determination of Physicochemical Properties of Tella

2.6.1. Determination of pH

The pH of fermented *tella* using a digital pH meter. About 10 g of the different samples were weighed in duplicates in 250 mL beaker and mixed with 20 mL of distilled water. The mixes were stirred for 10 min and the measurements were taken after calibrating the meter with buffers of known pH (4.0 and 7.0). The rode of the pH meters was thoroughly washed using distilled water in between samples.

2.6.2. Alcohol Content

The specific gravity of the samples from different preparation and formulations were measured using a hydrometer. The alcohol percent by volume (ABV (%)) was estimated by a standard conversion factors based on Association of Official Agricultural Chemists (AOAC and American Society of Brewing Chemists (ASBC) [15,16].

2.6.3. Titratable Acidity

Titratable acidity (also called total acidity) measures the total acid concentration in a food. This quantity is determined by exhaustive titration of intrinsic acids with a standard base. Titratable acidity (TA) was determined by titrating 10 g of samples with 0.1 N NaOH using three drops of phenolphthalein as indicator. Titratable acidity of *tella* samples was expressed as a percentage of lactic acid [13], given by:

$$TA\ (\%) = volume\ of\ NaOH\ \times 0.0 \quad (1)$$

2.6.4. Color

The color of each *tella* sample was determined using a spectrophotometer (Jenway model 7315, Bibby Scientific, Stone, UK), set at 430 nm. The spectrophotometer was set up in concentration mode to directly calculate the European Brewery Convention (EBC) value directly.

2.6.5. Turbidity

Turbidity of each sample was determined by Haze meter based on the percentage of light deflected from the incoming light direction based on the European Brewery Convention (EBC) and ASBC methodologies. Unfiltered beer sample was poured into a test bottle and a calibrated turbidity meter was used to monitor the turbidity (WGZ-4000, Xinrui, China) [17].

2.7. Tella Nutrient Analysis

Dietary mineral contents of *tella* were analyzed see if addition of moringa improved the dietary minerals. The digestates were refluxed for 90 minutes until clear solution was obtained. Dietary minerals including iron, calcium, magnesium, potassium, sodium, and zinc were analyzed using flame atomic absorption spectrophotometer. Samples (10 mL) were digested in 2 mL of nitric acid and 2 mL of hydrogen peroxide. Estimation of the minerals were made using the spectrophotometer at specific wavelengths for each element.

2.8. Sensory Acceptability of Tella

A consumer sensory test was used to assess the difference between sensory acceptability of *tella* from different formulations (*gesho* versus moringa) under different adjunct preparation methods. Sensory attributes considered included color, aroma, taste and overall acceptability. Adults (n = 46) who normally consume *tella*, were recruited and

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oriented to score the level of liking or disliking the products based on the 5-point hedonic scale, where 5 = like extremely, 4 = like slightly, 3 = neither like nor dislike, 2 = dislike slightly and 1 = dislike extremely. The panelists have been instructed to cleanse their palates before and between samples. *Tella* samples were coded with random three-digit numbers and presented to panelists at random orders.

2.8. Experimental Design and Data Analysis

The experiment was designed into a 2x3x3 factorial arrangement for the biochemical properties, where 2 levels of adjunct preparation (*kitta* versus *enkuro*), 3 levels of formulations (100% *gesho*, 50% and 100% moringa substitutions) and 3 stages of fermentation (*tejet*, *tenses* and *difdif*) were compared. Similarly, a 2x3 factorial with 2 levels of preparations and 3 formulations for the dietary minerals and with an additional 3 levels of storage days (1, 5 and 10) were compared using analysis of variance (ANOVA) followed by Tukey's honestly significant (HSD) mean separation techniques. Data were presented in graphs (main effects) and Tables (interaction) in the form of least square means with standard errors.

3. Results

3.1. Biochemical Dynamics by Fermentation Stages

3.1.1. Microbial and Biochemical Dynamics

The microbial loads (LAB, TAMC, yeast) and chemical status (pH. TA) are by the formulations and fermentation stages (Figure 1, Table 1). The adjunct preparation method (*kitta* versus *enkuro*, Figure 1 [A]) did not seem to influence majority of the biochemical parameters except the for the titratable acidity (TA, %). The *kitta* preparation method resulted in higher acid production, which might be due to the differences in the degrees of heating and starch modification. The substitution of *gesho* by moringa favored lactic acid bacteria but limited to growth of yeast (Figure 1 [B]), which paralleled the increasing trends of lactic acid concentrations. The highest yeast growth on the other hand corresponded to the 50:50 *gesho*-moringa blends and there were no clear trends in the total aerobic mesophilic count (TAMC).

The increasing number of log10 CFU of the LAB together with the substitution levels of moringa (0 to 100%) was also accompanied with an increasing of lactic acid concentrations. This is evident that the alcohol production suppressed by the addition of moringa leaf powder in stead of the traditionally used *gesho*. This also implies that substitution of *gesho* with moringa has better probiotic potential and nutritional relevance. The ranges of the biochemical parameters assessed in the present study for *tella* are in agreement with those previously reported for *tella* [5] and *keribo* [3].

There was no *Enterobacteriaceae* detected in the tella samples, that indicates low chance of the product being contaminated by poor hygienic practices. The reason might be the high acidity and alcohol levels that create unfavorable conditions for the growth of pathogens. However, it is always recommended that the maximum possible hygienic and sanitary practices are exercised during processing and handling of indigenous foods and beverages to safeguard the safety of the public.

Significantly different microbial loads and chemical phenomena were observed at the different stages of *tella* fermentation (Figure 1 [C], Table 1). The highest LAB and yeast counts were observed at the *tenses* stage likely due to the addition of the adjunct regardless of its type (*kitta* or *enkuro*). However, the pH continued to drop as the three stages of fermentation (*tejet* through *difdif*), which also twinned the continuously accumulating lactic. The declining counts of bacteria (particularly the TAMC) and yeas in the *difdif* phase of fermentation attributed to the depletion of nutrients and acidifying environment. This presents a probiotic application opportunity as *tella* is consumed without heating after fermentation.

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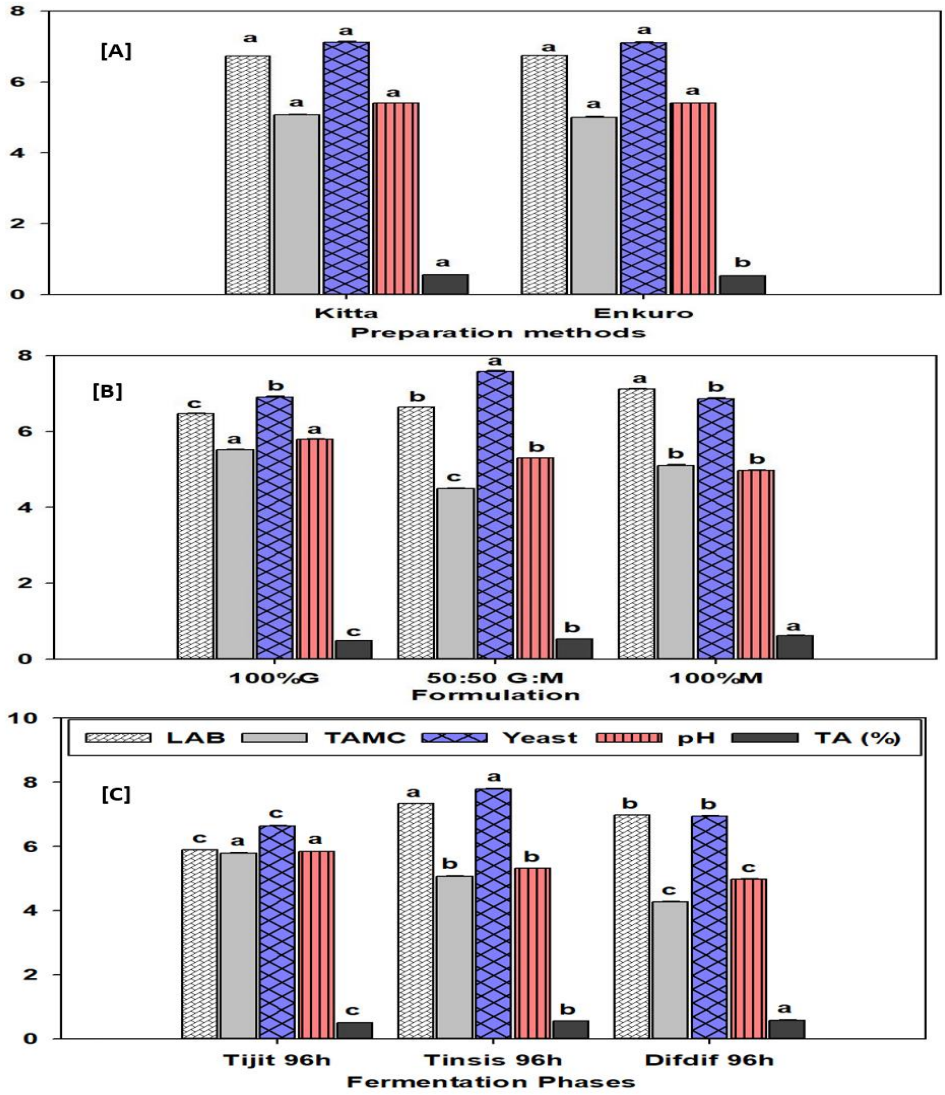

Figure 2. Biochemical properties of *Tella* for different Preparations [A], Formulations [B] and Fermentation phases [C]; LAB = Lactic acid bacteria; TAMC = total aerobic mesophilic count; TA = titratable acidity; G = *Gesho*; M = moringa; values are least square means with standard error as error bars and bars with different letters are significantly different ($p<0.05$).

Table 1. Biochemical properties of *tella* samples as influenced by combined effects of formulation and fermentation phases

Variables	LAB (Log10 CFU/mL)[1]	TAMC (Log10 CFU/mL)	YEAST (Log10 CFU/mL)	pH	TA
Preparations by formulations					
Kitta, 100%G	6.47^{c}	5.56^{a}	6.93^{b}	5.86^{a}	0.50^{d}
Kitta, 50:50 G:M	6.62^{b}	4.49^{d}	7.60^{a}	5.31^{c}	0.54^{c}
Kitta, 100%M	7.12^{a}	5.17^{b}	6.87^{b}	4.98^{d}	0.64^{a}
Enkuro, 100%G	6.50^{c}	5.48^{a}	6.88^{a}	5.80^{b}	0.47^{e}
Enkuro, 50:50 G:M	6.60^{b}	4.50^{d}	7.58^{a}	5.31^{c}	0.50^{c}
Enkuro, 100%M	7.13^{a}	5.06^{c}	6.87^{b}	4.98^{d}	0.60^{b}
SE	0.0079	0.025	0.038	0.0086	0.0058
Formulation by phase					
100%G, Tijit 96h	5.30^{g}	6.66^{a}	6.55^{c}	6.20^{a}	0.47^{g}

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100%G, Tinsis 96h	7.30[b]	5.01[d]	7.40[b]	5.80[b]	0.49f[g]
100%G, Difdif 96h	6.85[e]	4.89[d]	6.78[c]	5.60[c]	0.50[ef]
50:50 G:M, Tijit 96h	5.50[f]	5.28[c]	6.63[c]	5.73[b]	0.51[def]
50:50 G:M, Tinsis 96h	7.41[a]	4.86[d]	8.80[a]	5.50[d]	0.53[cde]
50:50 G:M, Difdif 96h	6.92[d]	3.35[f]	7.35[b]	4.74[e]	0.56[c]
100%M, Tijit 96h	6.91[d]	5.43[b]	6.73[c]	5.60[c]	0.50[cde]
100%M, Tinsis 96h	7.32[b]	5.35[b]c	7.18[b]	4.70[e]	0.60[b]
100%M, Difdif 96h	7.15[c]	4.56[e]	6.7[c]	4.59[f]	0.69[a]
SE	0.0097	0.031	0.047	011	0071

[1] Values are least square means with standard error; SE = standard error; G = *gesho*; M = moringa

3.1.2. Yeast and Biochemical Changes over Storage

The biochemical changes in *tella* from the different preparations and formulations was significantly changing over storage period for up to 10 days (Figure 3, Table 2). There was no influence of the preparation methods on the on the yeast cells, pH and TA levels (Figure 3 [A]). However, the formulation and storage days after the 96 hrs. fermentation, significantly influenced the yeast count, pH and TA of the *tella* samples singly (Figure 3 [B&C]) and in combination (Table 2). The yeast count showed a drastic decline between the 5 and 10 days of storage, which corresponded to the decrease in the pH and increasing acidity.

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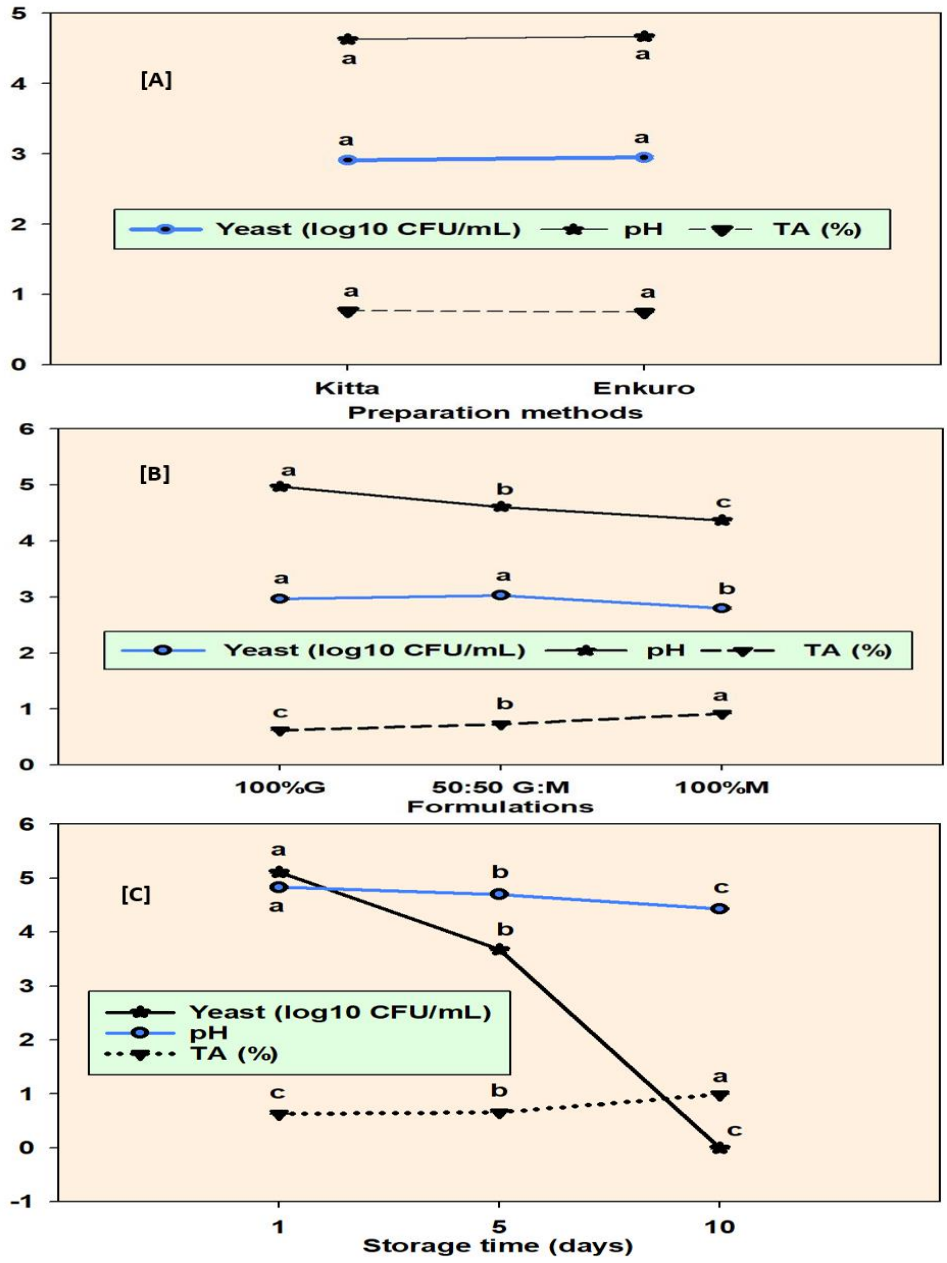

Figure 3. Shelf life of *tella* for different preparation methods [A], formulations [B] and storage time [C]; TA = Titratable acidity; G = *gesho*; M = moringa; CFU = colony forming units; values are least square means with standard errors as error bars and those with different connecting letters are significantly different ($p<0.05$).

Table 2. Shelf life of *tella* for different preparation methods [A], formulations [B] and storage time [C]; TA = Titratable acidity; G = *gesho*; M = moringa; CFU = colony forming units; values are least square means with standard errors as error bars and those with different connecting letters are significantly different ($p<0.05$).

Variables	Yeast (Log10 CFU/mL)[1]	pH	TA
Preparations by formulations			
Kitta, 100%G	2.98^{ab}	4.97^{a}	0.63^{d}
Kitta, 50:50 G:M	3.01^{a}	4.56^{c}	0.74^{c}
Kitta, 100%M	2.73^{c}	4.37^{d}	0.94^{a}
Enkuro, 100%G	2.95^{ab}	4.97^{a}	0.62^{d}
Enkuro, 50:50 G:M	3.05^{a}	4.67^{b}	0.72^{c}
Enkuro, 100%M	2.86^{bc}	4.37^{d}	0.91^{b}

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SE	0.0297	0.021	0.006
Preparation by storage (days)			
Kitta, 1	5.10^{a}	4.83^{a}	0.63^{c}
Kitta, 5	3.63^{c}	4.64^{b}	0.68^{b}
Kitta, 10	ND	4.43^{c}	0.99^{a}
Enkuro, 1	5.12^{a}	4.83^{a}	0.63^{c}
Enkuro, 5	3.73^{b}	4.76^{a}	0.65^{c}
Enkuro, 10	ND	4.42^{c}	0.98^{a}
Formulation by storage (days)			
100%G, 1	5.23^{a}	5.31^{a}	0.54^{e}
100%G, 5	3.68^{d}	4.99^{b}	0.55^{e}
100%G, 10	ND	4.61^{d}	0.75^{d}
50:50 G:M, 1	5.23^{a}	4.65^{cd}	0.59^{e}
50:50 G:M, 5	3.87^{c}	4.76^{c}	0.62^{e}
50:50 G:M, 10	ND	4.44^{ef}	0.99^{b}
100%M, 1	4.89^{b}	4.53^{de}	0.75^{d}
100%M, 5	3.50^{d}	4.35^{fg}	0.79^{c}
100%M, 10	ND	4.23^{g}	1.23^{a}
SE	0.036	0.026	0.007

[1] Values are least square means with standard error; SE = standard error; ND = not detected; G = *gesho*; M = moringa; values are least square means with standard errors as error bars and those with different connecting letters are significantly different ($p<0.05$).

3.2. Dietary Minerals of Tella from Different Preparations and Formulations

The main effect of formulation on the dietary mineral contents of *tella* was statistically meaningful (Figure 4 [B&D]). There was no significant variation in the mineral levels due to the preparation techniques (*kitta* versus *enkuro*). The highest mineral contents were observed for the formulation with the 50% substitution of *gesho* with moringa. The second highest levels all assessed minerals (except for Zn), were recorded for the 100% substation of *gesho* with moringa, indicating that moringa has mineral concentration higher than that of *gesho*. The increase in concentrations of the Ca and Mg minerals in the 50% substitution of *gesho* with moringa, was higher than just the summation of the two components, which indicates indicated some sort of synergistic effect of interest. The increased levels of the two minerals more than the sum of the two presents a great nutritional desirability of blended *gesho* and moringa in *tella* preparation. The increased levels of Ca and Mg, opens an interesting research dimension in *tella* and other Ethnic foods of similar preparations.

Considering the interactions of preparation methods with the formulations, the Zn, Ca, Mg, Na, K and Fe ranged from (mgL^{-1}) 0.81 to 1.20, 4.76 to 9.96, 3.16 to 7.21, 61.22 to 120.67, 250 to 320 and 0.008 to 0.030, respectively (Table 3). The formulation with the 50% *gesho* substation with moringa (50:50 *gesho* – moringa blends) exhibited higher levels of mineral concentrations in a consistent trend regardless of the adjunct preparation (*kitta* or *enkuro*). Ca and Mg concentrations obtained from *tella* samples in the current work is lower and K and Na levels were higher than the values reported by Tekle et al. [5]. The difference might be due to the variations in ingredients.

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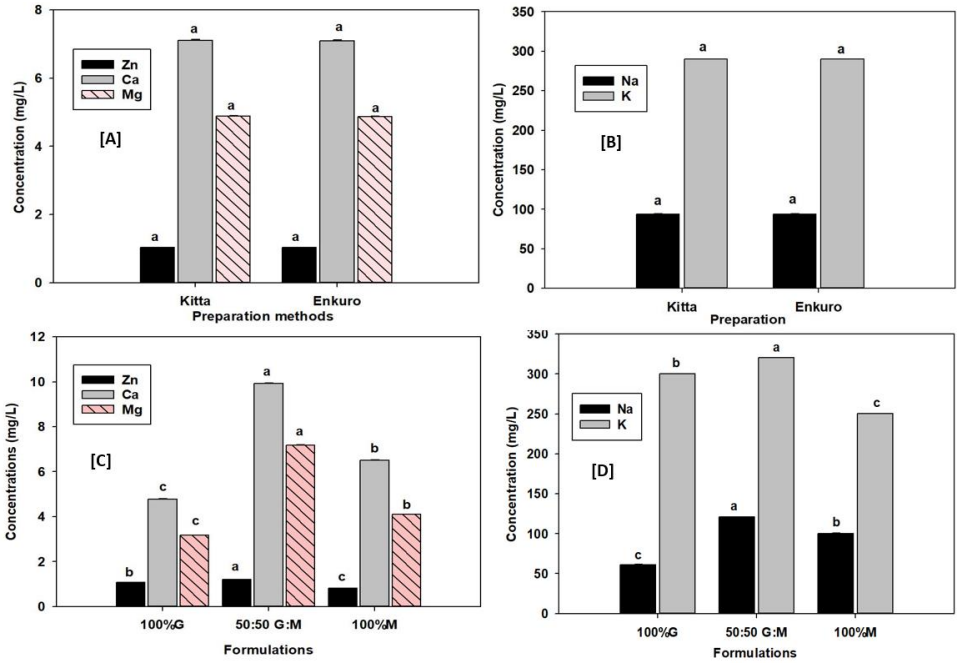

Figure 4. Mineral composition of *tella* for different preparations [A, B] and formulations [C, D]; G = *gesho*; M = moringa; values are least square means with standard errors as error bars and those with different connecting letters are significantly different ($p<0.05$).

Table 3. Dietary mineral contents of *tella* samples as influenced by preparation and formulation

Variables	Zn (mg/L)[1]	Ca (mg/L)	Mg(mg/L)	Na(mg/L)	K (mg/L)	Fe (mg/L)
Preparations by formulations						
Kitta, 100%G	1.07^{b}	4.76^{c}	3.17^{c}	61.26^{c}	300^{b}	0.008^{c}
Kitta, 50:50 G:M	1.20^{a}	9.88^{a}	7.21^{a}	120.67^{a}	320^{a}	0.026^{a}
Kitta, 100%M	0.81^{c}	6.52^{b}	4.31^{b}	100.32^{b}	250^{c}	0.019^{b}
Enkuro, 100%G	1.07^{b}	4.78^{c}	3.16^{c}	61.22^{c}	300^{b}	0.008^{c}
Enkuro, 50:50 G:M	1.20^{a}	9.96^{a}	7.15^{a}	120.67^{a}	320^{a}	0.030^{a}
Enkuro, 100%M	0.81^{c}	6.51^{b}	4.31^{b}	100.32^{b}	250^{c}	0.020^{b}
SE	0.011	0.041	0.0196	0.158	0.038	0.0009

[1] Values are least square means with standard error; SE = standard error; G = *gesho*; M = moringa; values are least square means with standard errors as error bars and those with different connecting letters are significantly different ($p<0.05$).

3.3. Sensory Acceptability of Tella from Different Preparations and Formulations

The sensory acceptability of *tella* samples was significantly influenced by the adjunct preparation methods (color) and formulations (Table 4). *Kitta*-based *tella* had higher score for color than the *enkuro*-based counterpart. The other sensory attributes (aroma, taste and overall acceptability) remained unaffected by adjunct preparation methods.

The formulations also influenced the sensory preference of *tella* samples. *Tella* samples made from 100% *gesho* and that with 50% moringa substituting *gesho*, were better liked in terms of all the sensory attributes considered. The comparatively lower scores of samples with 100% moringa might be due to the completely new and unfamiliar sensory profiles coming from moringa.

Table 4. Sensory acceptability of *tella* from the different preparations and formulations

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Variables[1]	Color	aroma	Taste	OA
Preparations				
Kitta	4.477[a]	3.82[a]	3.75[a]	3.92[a]
Enkuro	4.24[b]	3.77[a]	3.62[a]	3.94[a]
SE	0.055	0.06	0.066	0.06
Formulations				
100%G	4.38[ab]	4.23[a]	4.07[a]	4.24[a]
100%M	4.46[a]	4.27[a]	4.17[a]	4.33[a]
50:50 G:M	4.23[b]	2.88[b]	2.80[b]	3.22[b]
SE	0.067	0.073	0.080	0.073
Preparations by formulations				
Kitta, 100%M	4.53a	4.30[a]	4.05[a]	4.07[a]
Kitta, 50:50 G:M	4.23[ab]	4.16[a]	4.086[a]	4.41[a]
Kitta, 100%M	4.55a	4.35[a]	4.41[a]	4.41[a]
Enkuro, 100%G	4.37[ab]	4.20[a]	3.94[a]	4.23[a]
Enkuro, 50:50 G:M	4.34[ab]	2.81[b]	2.79[b]	3.27[b]
Enkuro, 100%M	4.12[b]	2.96[b]	2.82[b]	3.16[b]
SE	0.099	0.11	0.11858044	0.11

[1] Values are least square means with standard error; SE = standard error; G = *gesho*; M = moringa; values are least square means with standard errors as error bars and those with different connecting letters are significantly different ($p<0.05$).

Looking at the interactions of preparation methods and formulations, *kitta*-based *tella* with 100 *gesho* (traditional control) and 50% substituted by moringa had better preference than the rest although there was no clear statistical segregation. The general evaluation of the *tella* samples was that all samples were liked by consumers with the scores for overall acceptability ranging from 3.16 to 4.41. The overall average scores of all the tested sensory parameters were 3.94 on the scale of 5, with being the best (like extremely) and 1 being poorest (dislike extremely).

4. Discussion

The dynamics in the biochemical properties indicated that the addition of moringa play important nutritional roles (micronutrients [8–10]) and also suppresses yeast activities and promotes LAB, which, coupled with the culture of consuming *tella* unheated after fermentation, creates opportunity for probiotic application. Further investigations into the nutritional and health beneficial potentials of *tella* and many other indigenous African and Asian foods may present a great opportunity in human nutrition and health.

The drops in the yeast count and the pH of the product, as well as the accumulation of the TA, were likely due to other factor such as the depletion of the fermentable carbohydrates and the inhibitory effects of the acid and alcohol levels. The drop in pH from 5.31 for the 100% *gesho* formulation on the first day to below 4.50 for the 50% and 100% moringa incorporated samples indicates that the product is in a pH condition unfavorable for many pathogenic organisms, presenting an additional technical functionality to the product in addition to its micronutrient and probiotic potential. The decreasing trend of yeast count over the fermentation and storage times was faster in the present study than those reported previously [13].

The dietary mineral results from the current research are generally, promising as a means of nutritional intervention in communities with significant practices of *tella* consumption. The result also presented a great lesson of dietary interventions for addressing micronutrient deficiencies of the Ethiopian populations residing in the central and northern parts of the country, which makes up the vast majority of the Orthodox Christians, often falling short of micronutrient intakes due to recurrent fasting practices [18].

The sensory analysis result implies that substitution of *gesho* (a less nutritious, at least not well characterized), with moringa that is well characterized crop and reportedly superior nutritionally can be a sound and acceptable strategy as local dietary intervention in areas with micronutrient challenges in Ethiopia. The research also documented lessons to improve the nutritional and probiotic functionalities of popular indigenous diets in African and elsewhere.

5. Conclusions

The substation of *gesho* with a more nutritious leaves of moringa resulted in products of higher nutritional contents (micronutrients). The substation of *gesho* with moringa also suppressed the activities and counts of yeast cells, suppressing alcohol production and favoring LAB activities and lactic acid production. This enhanced the probiotic potential of *tella*, leaving it appealing to the nutrition of adults in central and northern Ethiopia. A 50% substation of *gesho* with moringa resulted in *tella* of higher nutritional (dietary minerals) and sensory acceptability.

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Informed Consent Statement: Informed consent was obtained from all sensory panelists involved in the study.

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