Development and Evaluation of Enset Fermenting Box

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***ABSTRACT* - Enset (Enset ventricosum) is a traditional staple crop or co-staple food serves as food security for >20% Ethiopian population. It is a multipurpose crop used as human food, animal feed, to shade other crops like coffee and used for decoration and it is a drought resistant crop which makes it risk avoidance crop. The major foods obtained from enset are kocho, bulla and amicho. Kocho needs a lengthy period of processing and preparation, which is carried out by women. Enset fiber is used to make sacks, bags, ropes, mats, construction material and sieves. Fresh enset leaves are used as food wrappers, serving plates and for stall feeding of cattle and used for medicines. The objective of the study was to develop and evaluate enset fermenting box in one of enset growing areas of South West Shewa Zone, Ethiopia. Traditionally, enset fermentation takes place in an earthen pit and on surface. Traditional processing methods causes contamination by flood, dust, rodents and insect, colony infestation, exposed for theft, difficult to manage, takes long period of fermentation. All the necessary components of enset fermenting box was designed by considering average consumption per family size using CATIA V5R19 software. Timber was used to make a box like structure. The inner part of box was totally covered by polyethylene plastic which was recommended for food packing and processing in order to avoid water loss from the system & interferences with the surrounding air in which the fermentation process takes place. Crushed enset was added in all separated compartment of the implement at the time being harvested according to quality requirement. It was allowed to ferment a process, which may last 2-4 months and then, opened at intervals to allow aeration. This was repeated until the desired fermentation quality was reached or the food was needed. Finally, the fermented starch was dried and treated as flour. Using SPSS statistical software version 20 a one-way analysis of variance (ANOVA) was employed to test for significant differences ($p < 0.05$) in the scores of sensory attributes (flavor, taste, color, and overall acceptability) between enset fermented in new technology for 120 days (A) and enset fermented in new technology for 60 days (B) and enset fermented by traditional method for 120 days (C). Following the same harvesting and processing method and the same varieties of enset, kocho powder samples was taken from the sample and compared with both traditional and new enset fermenting technology. Enset flat bread samples mean value of color, odor, flavor, overall acceptance is (A) 7.69, 7.92, 8, 7.92 and for (B) 8.58, 8.33, 7.67, 8.17 and for (C) 6.42, 6.75, 6.67 and 6.58 respectively. Sample Enset fermented in new technology for 60 days B) obtained the highest mean scores for its appearance as compared to other samples. Mean score for flavor was lowest for sample Enset fermented in new technology for 60 days (B) and highest for sample Enset fermented in new technology for 120 days (A).**

Key words: Enset, Fermentation, Sensory evaluation

1. BACK GROUND AND JUSTIFICATION

Enset, (Ensete ventricosum) is known in Asia and Africa (Gebremariam, 1993) but it is cultivated as a food source in Ethiopia (*Morpurgo et al.*, 1993). It is a traditional staple crop or co-staple food in the densely populated South and South-Western parts of Ethiopia (Sisay and Birhanu, 2006; Brandt *et al*, 1997). Enset serves as food security for about 20% of Ethiopian population (Asres and Omprakash, 2014). It is a multipurpose crop used as human food, animal feed, to shade other crops like coffee and used for decoration. Enset is a drought resistant crop which makes it risk avoidance crop.

Enset is grown at an altitude ranges from 1,100-3,000m above sea level, annual rainfall 1,100 -1,500 mm, mostly between March and September, Average temperature 10-21°C, Relative and humidity 63-80%. Enset grows well in most soil types, if they are sufficiently fertile and well drained (Brandt *et al.* 1997). Enset Crop yield per household is 61.46 quintal/ha (Bernard Tanguy *et al.* 2013). The major foods obtained from enset are *kocho*, *bulla* and *amicho*. *Kocho* needs a lengthy period of processing and preparation, which is carried out by women. *Bulla* is unfermented starch of a mature plant, which can be prepared as a pancake or porridge. *Amicho* is the corm of a young plant, which is boiled and consumed as other tuber crops. Due to their low protein content these foods are eaten in combination with protein rich products like milk. Enset fiber is used to make sacks, Bags, Ropes, Mats, construction material and sieves. Fresh enset leaves are used as food wrappers, as serving plates, for feeding of cattle and used for medicines.

Enset in the farming system contributes significantly to the stability of the food supply in several ways. Enset can be stored for long periods, be harvested at any time during the year, be harvested at any stage over a several year period; and Survive stress years that reduce other food sources. E.g. During the 1984-85 and 1992 famine in Ethiopia, when cereal crops were severely damaged kocho became an important diet. However, little research effort is made to improve the processing aspect of the crop and traditional methods are predominantly used by farmers. Traditionally, enset fermentation takes place in an earthen pit and on surface. October to early December was considered to be the appropriate time for processing. So, traditional processing methods are Poor in hygiene (contaminated by flood, dust, rodents and insect), highly exposed for colony infestation, Not portable/underground pit, not Secured/exposed for theft, Difficult to manage, Long period of fermentation.

1.1. Statement of the problem

Lack of technology that can ferment and protect from contamination (dust, rodents and insects)**,** minimized colony infestation**,** easily transportable**,** secured and protected from theft, reduced period of fermentation which can meet needs of the community with the available enset resource with respect to the agro-ecology and settlement patterns in the area leads to low productivities. High work load on women in rural community as compared to men. The workload is expressed in household, farm and social activities. Processing of this staple food is entirely done by women, because traditionally men are not allowed to involve on such activities. Enset processing is labour demanding and time consuming activity which calls for technology to make it efficient and lighten the burden on women. In general the existing enset processing coupled with other farm and household activities has negatively affected the relationship between men and women biasing the work load to women and affecting maternity health (Asfew Zewude, 2012).

1.2. Objective:-

- ✓ To develop and evaluate portable enset fermenting box

2. MATERIALS AND METHODS

2.1. Experimental Site

The machine was fabricated at Bako Agricultural Engineering Research Center work shop and the Center lies between 9^0 04’45’’ to 9^0 07’15’’N latitudes and 37^0 02’ to 37^0 07’E longitudes.

The experiment was conducted in woliso woreda south west shoa Zone of Oromia Regional State, Ethiopia; based on preferable agro ecology (woyina dega) starting from December to March.

2.2. Important materials used

Three enset plants were purchased from farmer, improver and dry baker’s yeast were purchased from a local market. Equipment’s such as mitad, poly ethylene plastic, digital thermo hygrometer, hand lens, weighing balance, mixer, kneader, bowl, knife, digital weighing scale, sieve, bucket, tray, measuring cylinder, baking pans, stirrer and oven were obtained from IQQO food science laboratory and all other chemicals used for analytical grade.

2.3. Working principle

The first stage involves removing the leaf stalks and grading of the corm. Then the fibres were separated out and the pulps were crushed to extract the starch. Crushed enset was added in all separated compartment of the implement at the time being harvested according to quality requirement. Then, it was fermented in new enset fermenting implements and by traditional method for comparison for 60-120 days and new enset fermenting implements was airtight with polyethylene and closed carefully. Then, it was opened at intervals to allow aeration. This was repeated until the desired fermentation quality was reached or the food was needed. Finally, the fermented starch was dried and treated as flour.

2.4. Description of the Machine Components

The initial prototype consisted of basic frame made from angle iron used for supporting and carrying the whole body of the box. Four similar size tires were attached to this frame and used for transportation. Different thickness timbers (cheapest & easily available) were used to make a box like structure. The inner part of this box was totally covered by polyethylene plastic which was recommended by (WHO, 2015) for food packing and processing in order to avoid water loss from the system and interferences with the surrounding air in which the fermentation process was takes place. The box consists of different class which was used to ferment different quality products for commercial purpose, normal home consumption & for special day (holy day, wedding ceremony) consumption and would have a cover which can totally seal the system and allow fermentation and would have a locking mechanism which can secure the system.

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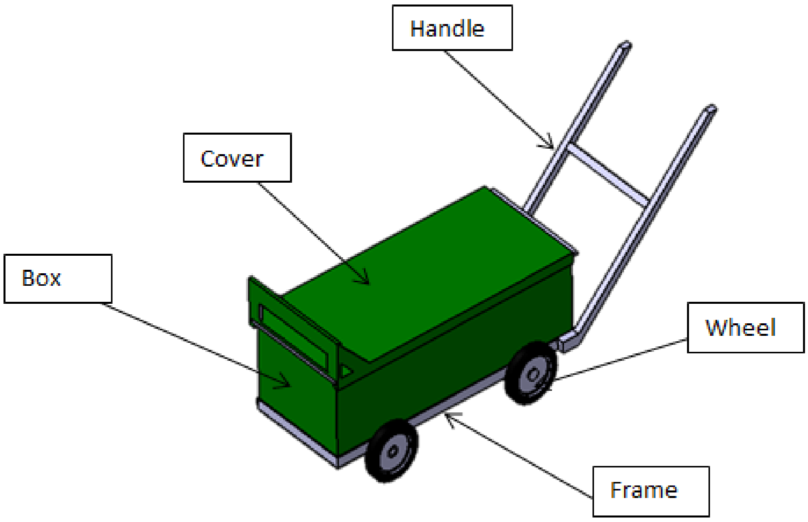

Fig.2.1 Prototype of Enset fermenting machine

2.5. Designing method

An attempt was made by considering factors that affect fermentation such as temperature, humidity, quality, durability, capacity, suitability to operate, simplicity, maintenance, transport, feedback of operators and average consumption per family size to develop all the necessary components using CATIA V5R19 software. Polyethylene (PEL) low density thermal conductivity with 0.33 *(W/m K)*, white pine timber with thermal Conductivity of 0.15*(W/m K)* (Engineering Tool Box, 2001) was used.

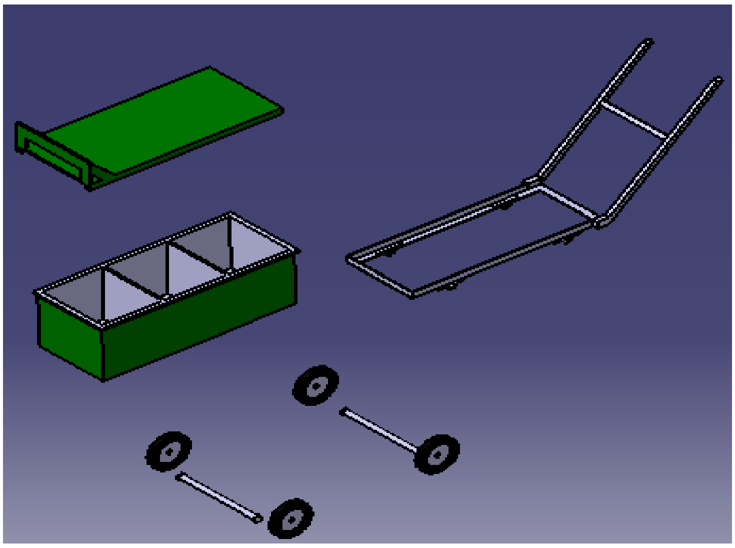

Fig.2.2. Part design of Enset fermenting machine

2.6. Determination of resultant force developed in the box

Pressure at the bottom of fermenter was determined according to (F. M. White, 1999).

$P = \gamma h$, Uniform on the entire plane

Resultant force $F_R = PA = \gamma hA$ (A: at the bottom area of container)

$\text{Mass} = 254\text{kg}, \quad \text{Volume} = \text{b}h^3 = 0.5 \times 0.5 \times 0.6 = 0.15\, m^3$

$$\rho = \frac{M}{V} = \frac{254\, kg}{0.15\, m^3} = \frac{1693.3\, kg}{m^3}$$

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$$\gamma = \rho g = \frac{1693.3\ kg}{m^3} \times \frac{9.81\ m}{s^2} = \frac{16611.27\ kg \times m}{m^3 s^2} = \frac{16.61\ KN}{m^3}$$

$$P = \gamma h = \frac{16.61KN}{m^3} \times 0.5m = \frac{8.305KN}{m^2}$$

$$F_R = PA = \gamma hA = \frac{8.305KN}{m^2} \times 0.5m \times 0.6m = 2.5KN,$$

Where,

$\gamma =$ is the specific weight of the material (weight per unit volume, typically N/m^3 units)

$\rho =$ is the density of the material (mass per unit volume, typically kg/m^3)

$g =$ is acceleration due to gravity (rate of change of velocity in m/s^2, usually given as 9.81 m/s^2)

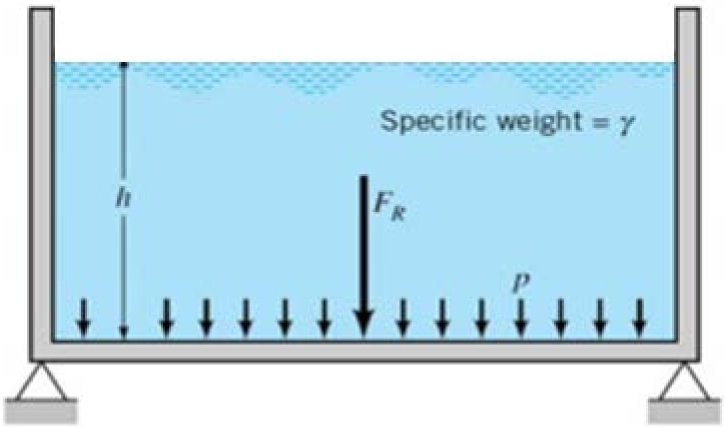

Figure 2.3. Resultant force in the fermenter

According to Nelson Makange (2014) the power of useful work done by human being is given by:

HP = 0.35-0.092 log t

Where, t = Time in minutes

- ✓ For 3-4 hrs continuous work the power developed by the operator would be 0.10-0.13 HP and 0.11 HP taken.
- ✓ Let the operating speed be 0.8 m/s
- ✓ Push= 34.45kg (force developed by an average human worker)

$$push = \frac{75 \times 0.11(HP)}{0.8} = 10.3N$$

$$ns = \frac{60V}{\pi D} = \frac{60 \times 0.8}{\pi \times 0.3} = 50.92\ rpm$$

$$\text{Mt} = \frac{HP \times 4500}{2\pi ns} = \frac{0.11 \times 4500}{2 \times \pi \times 50.92} = 1.55\ Nm$$

Mt= torque on the wheel, Nm

HP = Horse power required and

ns= operation speed (rev/min)

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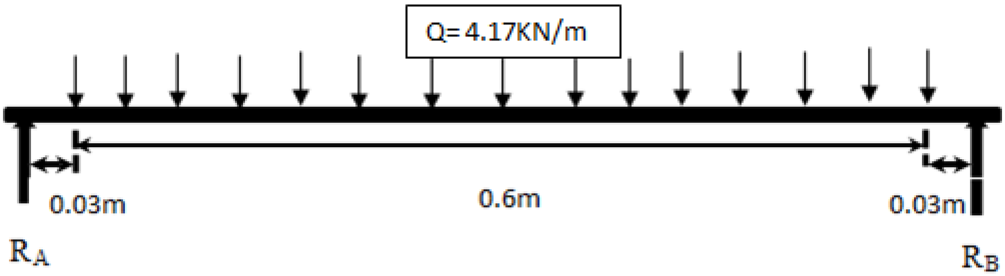

Figure 2.4. The driving wheel shaft showing forces acting on it (all dimensions are in millimeter)

1. A beam was in equilibrium when it was stationary relative to an inertial reference frame. The following conditions were satisfied when a beam, acted upon by a system of forces and moments, was in equilibrium.

$\Sigma F_x = 0$: $H_B = 0$

$\Sigma M_A = 0$: The sum of the moments at the point A:

$- q_1*0.6*(0.03 + 0.6/2) + R_B*0.66 = 0$

$\Sigma M_B = 0$: The sum of the moments at the point B:

$- R_A*0.66 + q_1*0.6*(0.63 - 0.6/2) = 0$

2. Reaction force at the point B:

$R_B = (q_1*0.6*(0.03 + 0.6/2)) / 0.66 = (4.17*0.6*(0.03 + 0.6/2)) / 0.66 = 1.25$ (kN)

3. Reaction at the point A:

$R_A = (q_1*0.6*(0.63 - 0.6/2)) / 0.66 = (4.17*0.6*(0.63 - 0.6/2)) / 0.66 = 1.25$ (kN)

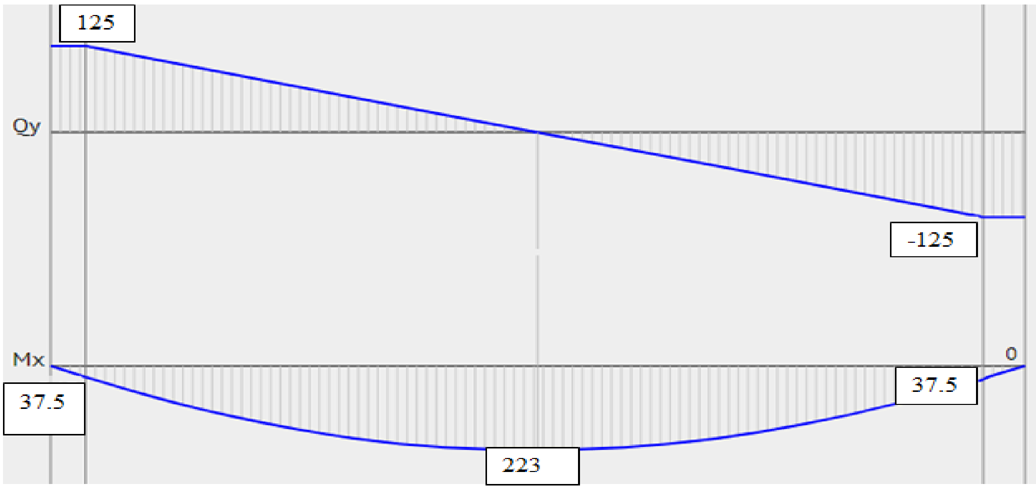

Figure2.5. Shear and bending moment diagrams on the shaft

When first span of the beam was between $0 \le x_1 < 0.03$m, Equations for the bending moment (M):

$M(x_1) = R_A*(x_1)$

The values of M at the edges of the span:

$M_1(0) = 1.25*(0) = 0$ (kN*m)

$M_1(0.03) = 1.25*(0.03) = 0.0375$ (kN*m)

When the second span of the beam was between $0.03 \le x_2 < 0.6$, Equations for the shear force (Q):

$Q(x_2) = R_A - q_1*(x_2 - 0.025)$

The values of Q at the edges of the span:

$Q_2(0.03) = 1.25 – 4.17*(0.03 - 0.03) = 1.25$ (kN)

$Q_2(0.67) = 1.25 – 4.17*(0.63 - 0.03) = -1.25$ (kN)

The value of Q on this span that crosses the horizontal axis.

at x = 0.33,

Equations for the bending moment (M):

$M(x_2) = R_A*(x_2) - q_1*(x_2 - 0.03)^2/2$

The values of M at the edges of the span:

$M_2(0.03) = 1.25*(0.03) – 4.17*(0.03 - 0.03)^2/2 = 0.0375$ (kN*m)

$M_2(0.67) = 1.25*(0.63) – 4.17*(0.63 - 0.03)^2/2 = 0.0369$ (kN*m)

Local extremum at the point x = 0.33:

$M_2(0.33) = 1.25*(0.33) – 4.17*(0.33 - 0.03)^2/2 = 0.223$(kN*m)

Consider third span of the beam $0.63 \leq x_3 < 0.66$

Equations for the shear force (Q):

$Q(x_3) = R_A - q_1*(0.63 - 0.03)$

The values of Q at the edges of the span:

$Q_3(0.60) = 1.25 – 4.17*(0.63 - 0.03) = -1.252$ (kN)

Equations for the bending moment (M):

$M(x_3) = R_A*(x_3) - q_1*(0.63 - 0.03)*[(x_3 - 0.63) + (0.63 - 0.03)/2]$

The values of M at the edges of the span:

$M_3(0.63) = 1.25*(0.63) – 4.17*0.645*(0 + 0.33) = 0.100$ (kN*m)

$M_3(0.66) = 1.25*(0.66) – 4.17*0.645*(0.03 + 0.33) = 0.143$ (kN*m)

$$ds^3 = \frac{16}{\pi\tau}\sqrt{(K_b M_b)^2 + (K_t M_t)^2} = \frac{16}{\pi \times 40 \times 10^6}\sqrt{(1.5 \times 223)^2 + (1 \times 1.55)^2} = 0.036m \approx 36mm$$

where,

ds = wheel shaft diameter, m;
M_b = bending moment, Nm;
M_t = torsional moment, Nm;
Kb=Combined shock and fatigue factor applied to bending moment
Kt=Combined shock and fatigue factor applied to torsional moment
τ = Allowable shear stress of the shaft material, MN/m^2

The values of K_b and K_t were taken as 1.5 and 1.0 respectively for the gradually applied load on the rotating shaft and the allowable shear stress of the shaft (τ) as $40MN/m^2$ based on American Society of Mechanical Engineers **(ASME)**.

2.7. Parameter used and Data analysis

Two x two *(Badadeti and Astara)* type of enset varieties were decorticated and stored in both traditional and enset fermenting technology. Following the same harvesting and processing method and the same varieties of *enset* powder samples was taken from fermented enset to know the effect of implements on fermentation period and food quality. Sensory evaluation quality attributes such as color, flavor, odor and overall acceptance was tested by panelist and the nutritional composition was also conducted in the laboratory.

The data were entered and analyzed using SPSS statistical software version 20. Results were calculated as means and standard deviations of scores used for comparison. A one-way analysis of variance (ANOVA) was employed to test for significant differences ($p < 0.05$) in the scores of sensory attributes (flavor, taste, color, and overall acceptability) between A, B and C incorporated the

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traditional enset based flat breads. The significance of mean difference was determined by Least Significant Difference (LSD) at 5%.

3. RESULT AND DISCUSSION

Badadeti and Astara enset varieties were decorticated and stored in both traditional and enset fermenting technology. The fermenter has three compartments and can ferment up to 300 kg at once and its volume was $0.441m^3$. Mean minimum and maximum relative humidity, temperature inside the box during morning, mid-day and afternoon, was 20%, 96%, and 23 ^{0}c, 29.8 ^{0}c respectively. The fermentation time follow up interval was in the range of 5, 9, 14-120 days base on indigenous knowledge of the farmer. The implement was totally sealed by polyethylene plastic and avoid formation of colony infestation and protect from contamination.

3.1. Sensory Evaluation

Descriptive sensory evaluation was used in the screening of *kocho* bread, based on their sensory quality characteristics. Trained 12 panelists were involved in the sensory evaluation. Cuts of *kocho* bread samples would presented for panelists to evaluate the taste, color, flavor, and overall acceptability of the samples. All panelists allowed for tasting and evaluating the samples for each quality feature using rating scale and all of them instructed to make their own individual assessments according to the evaluation criteria provided for each samples on the basis of taste, color, flavor, and overall acceptability. Finally, the scores of all judges added and divided by the number of judges to find the final mean score and Mean Sensory Scores of Bread produced from enset and significance level was discussed in (Table 3.1) and (Table 3.2)

Figure 2.7. Enset bread preparation and sensory evaluation

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Table 3.1 Mean Sensory Scores of Bread produced from enset and significance level.

Sample Attributes	(I)Sample Mean	(J)Sample Mean	Mean Diff.(I-J)	Std. Error	Sig.	95% Confidence interval	
						Lower Bound	Upper Bound
Color	A	B	-.0917	0.417	0.087	-1.94	0.11
		C	1.250	0.417	0.014*	0.23	2.27
	B	A	0.917	0.417	0.087	-0.11	1.94
		C	2.167	0.417	0.000**	1.14	3.19
	C	A	-1.250	0.417	0.014*	-2.27	-0.23
		B	-2.167	0.417	0.000**	-3.19	-1.14
Odor	A	B	-0.417	0.388	0.537	-1.37	0.54
		C	1.167	0.388	0.014*	0.21	2.12
	B	A	0.417	0.388	0.537	-0.54	1.37
		C	1.583	0.388	0.001**	0.63	2.54
	C	A	-1.167	0.388	0.014*	-2.12	-0.21
		B	-1.583	0.388	0.001**	-2.54	-0.63
Flavor	A	B	0.333	0.422	0.712	-0.70	1.37
		C	1.333	0.422	0.009**	0.30	2.37
	B	A	-0.333	0.422	0.712	-1.37	0.70
		C	1.000	0.422	0.060	-0.04	2.04
	C	A	-1.333	0.422	0.009**	-2.37	-0.30
		B	-1.000	0.422	0.060	-2.04	0.04
Over All Acceptance	A	B	-0.250	0.386	0.795	-1.20	0.70
		C	1.333	0.386	0.004**	0.39	2.28
	B	A	0.250	0.386	0.795	-0.70	1.20
		C	1.583	0.386	0.001**	0.64	2.53
	C	A	-1.333	0.386	0.004**	-2.28	-0.39
		B	-1.583	0.386	0.001**	-2.53	-0.64

Means in the column with different superscript are significantly different at (P<0.05). "A" depicts Enset fermented in new technology for 120 days; "B" depicts Enset fermented in new technology for 60 days "C" depicts Enset fermented by traditional method for120 days.

Table 3.2. Mean Sensory Scores of Bread produced from enset.

Sample	Color	Odor	Flavor	over all
A	7.67 ± 1.07^{a}	7.92 ± 0.79^{a}	8 ± 0.74^{a}	7.92 ± 0.9^{a}
B	8.58 ± 0.67^{b}	8.33 ± 0.78^{b}	7.67 ± 1.15^{a}	8.17 ± 0.94^{b}
C	6.42 ± 1.24^{ab}	6.75 ± 1.22^{ab}	6.67 ± 1.15^{ab}	6.58 ± 0.99^{ab}

Values are means of 12 members sensory panelist score ± SD. Means in the column with different superscript are significantly different at (P<0.05). "A" depicts Enset fermented in new technology for 120 days; "B" depicts Enset fermented in new technology for 60 days "C" depicts Enset fermented by traditional method for 120 days.

3.2. Determination of Proximate Composition of Enset Powder

Proximate analysis was carried out on the Enset powder to determine the moisture, ash, crude fibre, fat, and mineral.

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3.2.1. Moisture Content

The moisture content was determined by hot air oven method as described by (AOAC, 2005). An empty crucible was weighed and 2g of the sample was transferred into the crucible. This was taken into the hot air oven and dried for 24 hours at 100°C. The crucible and its contents were cooled in the desiccator and their weights taken. The loss in weight was regarded as moisture content and expressed as;

$$\%Moisture = \frac{weight\ loss}{weight\ of\ sample} \times 100$$

3.2.2. Ash Content

Ash content was determined using the method of (AOAC, 2005). About 5 g of each sample was weighed into crucibles in duplicate, and then the sample was incinerated in a muffle furnace at 550°C until a light grey ash was observed and a constant weight obtained. The sample was cooled in the desiccator to avoid absorption of moisture and weighed to obtain ash content.

$$Ash(\%) = \frac{weight\ of\ ash}{weight\ of\ sample} \times 100$$

3.2.3. Crude Fibre

Crude fiber was determined using the method of (AOAC, 2005). About 5 g of each sample was weighed into a 500 ml Erlenmeyer flask and 100 ml of TCA digestion reagent was added. It was then brought to boiling and refluxed for exactly 40 minutes counting from the start of boiling. The flask was removed from the heater, cooled a little then filtered through a 15.0 cm number 4 Whatman paper. The residue was washed with hot water stirred once with a spatula and transferred to a porcelain dish. The sample was dried overnight at 105°C. After drying, it was transferred to a desiccator and weighed as W_1. It was then burnt in a muffle furnace at 500°C for 6 hours, allowed to cool, and reweighed as W_2.

$$(\%)crude\ fibre = \frac{W_1 - W_2}{W_0} \times 100$$

W_1= weight of crucible + fiber + ash

W_2= weight of crucible + ash

W_0= Dry weight of food sample

3.2.4. Determination of Mineral Content

The mineral content of the enset samples was determined by using the method described by (AOAC, 2005). The ash obtained from the ash analysis earlier was used in the determination of the minerals content. The ash was placed in porcelain crucibles, and then few drops of distilled water were added, followed by 2ml of concentrated hydrochloric acid. 10 ml of 20% HNO_3 were added, evaporated on the hot plate. The samples were filtered through Whiteman filter paper into 100 ml volumetric flask. The mineral elements; iron, magnesium and calcium were determined by atomic absorbance spectrophotometer. (AA800 perkin Elmer, Germany). The phosphorus in the sample filtrate was determined using Vanadomolybdate reagent at 400 nm using colorimetric method (Colorimeter SP20, Bausch and Lamb).

Table 3.3 Effect of fermentation on proximate composition of kocho (dry weight basis)

	%MC	Ash at 12.5%	Na ppm	K ppm	Ca ppm	Fe ppm	Mg ppm	Zn ppm	P ppm
A	6.83 ±0.27	0.97 ±0.04	497.72 ±73.94	2785.84 ±184.00	3666.48 ±50.82	34.00 ±0.63	1409.91 ±43.93	19.72 ±1.22	12.57 ±0.46
B	7.33 ±0.08	1.07 ±0.14	639.85 ±30.96	3550.28 ±144.47	3363.17 ±150.40	40.28 ±2.51	1545.98 ±145.65	26.81 ±3.68	15.49 ±0.910
C	7.16 ±0.19	0.86 ±0.03	520.60 ±81.06	2525.88 ±83.44	3849.57 ±113.44	36.06 ±1.27	1548.11 ±119.32	17.43 ±5.55	11.72 ±.30

“

A” depicts Enset fermented in new technology for 120 days; “B” depicts Enset fermented in new technology for 60 days “C” depicts Enset fermented by traditional method for120 days.

4. CONCLUSION AND RECOMMENDATION

In general, the results on sensory evaluation (Tables 1, 2, 3, 4) revealed that all enset flat bread samples were acceptable. However, for “A” the mean value of color, odor, flavor, overall acceptance were 7.69, 7.92, 8, 7.92 and for “B” (8.58), (8.33), (7.67), (8.17) and for “C” (6.42), (6.75), (6.67) and (6.58) respectively. This indicates that all “A”, “B” and “C” are in the range of acceptable market value but in terms of significance level when we compare “C” with “A” and “B” there is mean difference at ($p<0.05$) level.

There exist a non-significant difference ($p>0.05$) for color, flavor, taste and over all acceptance among all the samples. Sample “B” obtained the highest mean scores for its appearance as compared to other samples and it was statistically different from sample “C” (Traditional method) but not from sample “A” ($p < 0.05$). Mean score for flavor was lowest for sample “B” and highest for sample “A”. Sample “C” was significantly higher ($p < 0.05$) than sample “A” for flavor but the mean difference of “B” samples from the traditional method sample was statistically not significant ($p >0.05$).

4.1. Recommendation

- Even if enset fermenting technology reduces time of fermentation, improve quality of fermented enset, reduce women's work load, and improve enset quality, further study and demonstration is necessary.
- During processing/fermenting, hermetic sealing is necessary to minimize colony formation.
- Water discharge gets is only opened during discharging unwanted water.

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5. REFERENCE

[1] AOAC. 2005. Official methods of analysis 18th ed. Arlington, V.A Association of Official Analytical Chemist PP. 806-842.
[2] Asfaw Zewudie. 2012. A case study in Enemorena Ener district, Guragie zone, Southern Nations, Nationalities and Peoples Regional State, Ethiopia A research project submitted to van Hall Larenstein University of applied sciences in partial fulfillments the requirements for the degree of master of development, specialization in Rural Development and Gender, Wageningen The Netherlands.
[3] Asres Ayele and Omprakash Sahu . 2014. Extension of Enset Plant Product for Rural Development in Ethiopia. Department of Chemical Engineering, KIOT, Wollo University, Kombolcha (SW), Ethiopia March, 2014.
[4] Bernard Tanguy, Abate, Gashew Lemma, Solomon. 2013. Agricultural Cooperative in Ethiopia results of the 2012 ATA Baseline Survey.
[5] Brandt A. et al. 1997. The Tree against Hunger. Enset Based Agricultural Systems in Ethiopia.
[6] Brandt, S. A., Spring, A., Hiebsch, C., McCabe, J. T., Tabogie, E. Diro, M., Wolde-Michael, G., Yntiso, G. Shigeta M., and Tesfaye, S.. 1997. The "Tree Against Hunger". Enset-Based Agricultural Systems in Ethiopia. American Association for the Advancement of Science with Awassa Agricultural Research Center, Kyoto University Center for African Area Studies and University of Florida, Washington, DC, USA, 66 pp.
[7] Engineering Tool Box. 2001. Available online at: https://www.engineeringtoolbox.com [Accessed 29/10/2019].
[8] F. M. White. 1999. Fluid Mechanics, McGraw-Hill.
[9] Gebremariam, S. 1993. Enset research in Ethiopia: 1976-1984. pp. 204-220. In: Abate, T., Hiebsch, C., Brandt, S. A. and Gebremariam, S. (eds). Enset-Based Sustainable Agriculture in Ethiopia.
[10] Henderson, H. K. and Ellen H. eds., 1995. Gender and agricultural development: surveying the field. Arizona: The University of Arizona press/Tuscon.
[11] IFAD= International Fund of Agriculture Development.2009. Gender in Agriculture sourcebook. World Bank Publications.
[12] Khurmi R.S., Gupta J.K. 2008. A textbook on Machine Design, 2008 edition.
[13] Leeuwis C. 2004. Communication for rural innovation: rethinking agricultural extension. 3rd edition. Black well publishing.
[14] Nelson Makange. 2014. The Role of Farm Power in Agriculture, Sokoine University of Agriculture (SUA)
[15] Sisay, A. and Birhanu, T. 2006. Enset production constraints in West Shewa Zone of Oromiya: the case of "Tortorsa". Mirimir. 1:2