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Full Length Research Paper

Extension of Enset Plant Product for Rural Development in Ethiopia

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For years kocho and bulla has been produced traditionally from Enset plant. More than 20 percent population of the country, concentrated in the highlands of southern and south eastern Ethiopia, depend upon enset for human food, fiber, animal forage, construction materials, medicines, means of earning cash income and insurance against hunger. Kocho and bulla processing equipment design is very crucial to upgrade the traditional processing towards modern style where might turn the value added kocho and bulla based product for export market. The whole plant design focused on transforming the traditional, which is unhygienic and tiresome, too efficient and quality guaranteed industrial level. Using Enset plant as raw material kocho and bulla flour is produced for large scale industry which is easy to handle and use.

Keywords: Components, energy enset, flour, material

INTRODUCTION

Ethiopia comes under the low income country according to World Bank estimation. The source of income mostly depends on the natural resources and climate. Mostly annually income comes from the crops. Ethiopia's crop agriculture is complex, involving substantial variation in crops grown across the country's different regions and ecologies. Five major cereals (teff, wheat, maize, sorghum and barley) are the core of Ethiopia's agriculture and food economy, accounting for about three-quarters of total area cultivated, 29 percent of agricultural GDP in 2005/06 (14 percent of total GDP) and 64 percent of calories consumed. There has been substantial growth in cereals, in terms of area cultivated, yields and production since 2000, but yields are low by international standards and overall production is highly susceptible to weather shocks, particularly droughts.

Thus, both raising production levels and reducing its variability are essential aspects of improving food security in Ethiopia, both to help ensure adequate food availability, as well as to increase household incomes.

Ethiopia's crop agriculture in general, and the cereals sub-sector in particular, face serious challenges. We show in this paper that much of the increase in production in the past decade has been due to increases in area cultivated. However, little suitable uncultivated land remains in the highlands, apart from pasture land. Soil degradation from erosion and soil compaction also threatens crop yields (Hamza and Anderson 2005; Taddesse 2001). Furthermore, uncertain rainfall and very low levels of irrigation make intensive cultivation with improved seeds and fertilizer risky (McCann 1995). The estimated crop yield per household shown in Table 1.

From the above table it was found that average 6146 Kg/ha Enset was yield. Enset is one of the potential indigenous crops for food production (Taye, 1984; Endale, 1997) and can be grown everywhere in Ethiopia. Even though it is grown in many administrative regions, the dwellers of the central and southwestern parts of Ethiopia are the only people that use enset as a staple and co-staple crop (Simmonds, 1958). Cultivation is estimated to cover more than 224,400 hectares of land (Stanley, 1966; Taye, 1984). The majority of enset production is confined to Sidama, Shoa, Keffa, GamoGoffa and Illubabor administrative regions (Addis, 2005). The Enset was shown in Figure 1.

The preparation of enset for processing is a very time-consuming and hard work. By social custom, almost all the operations connected with enset processing are the exclusive responsibility of women in the family (Almeida, 2004). The major foods obtained from enset are kocho, Bulla and Amicho. Some researchers are also

Table 1. Crop yield per household (kg/ha) (Ethiopia ATA Baseline Survey, 2012)

S.No	Crops	Mean Production (Kg/ha)	Standard Error
1	White teff	850	67
2	Black/mixed teff	660	45
3	Barley	1,247	64
4	Wheat	1,368	102
5	Maize	2,496	569
6	Sorghum	1,129	108
7	Finger millet	784	104
8	Other cereals	1,400	151
9	Faba/horse bean	1,123	98
10	Field peas	735	82
11	Haricot beans	1,384	411
12	Chick-peas	965	157
13	Grass peas/vetch	1,328	243
14	Other pulses	590	99
15	Neug	357	48
16	Sesame	478	52
17	Other oilseeds	752	92
18	Cabbage	9,466	3,755
19	Red peppers	1,975	331
20	Other vegetables	33,171	29,951
21	Onion	3,832	768
22	Potato	4,886	654
23	Taro/godere	8,471	1,454
24	Other root crops	6,112	928
25	Banana	8,759	1,503
26	Other fruit	125,333	88,369
27	Chat	2,174	620
28	Coffee	2,378	793
29	Hops	7,667	2,941
30	**Enset**	**6,146**	**1,216**
31	Other permanent	18,914	3,642

conducted research on using enset for industrial starch manufacturing .but, this research focuses on processing kocho and bulla in industry level to solve the problems existed on processing aspects by designing speciallyfermenter, squeezerand dryer (Brandt and Fattovich, 1990).

Ethiopia is a country, which has high production of Enset plantation (Chiche, 1995). Even though, the production is high, the utilization of Enset plant is insignificant. Ethiopia has the capacity to produce more to be self-food secure, which can fully give every person the daily requirement of the balanced diet. The main problem is the inability to produce at a commercial scale and the loss of its product during harvesting, processing and the improper storage of the final product before consumption and lack of knowledge about nutrition (Clark, 2006). Even though there is enough food, the people are not accustomed to vary their meal to fulfill the irnutritional requirement. This is due to the lack of knowledge of the people on the balanced diet, the lack of income to purchase foods, and to use different raw materials as a source of food. Now day industrialization is growing at a much faster rate and among this, food and beverage processing industries cover most of the percentages. Therefore utilization of different raw materials, which are locally available, at a processing scale is necessary in order to sub stain from scarcity of

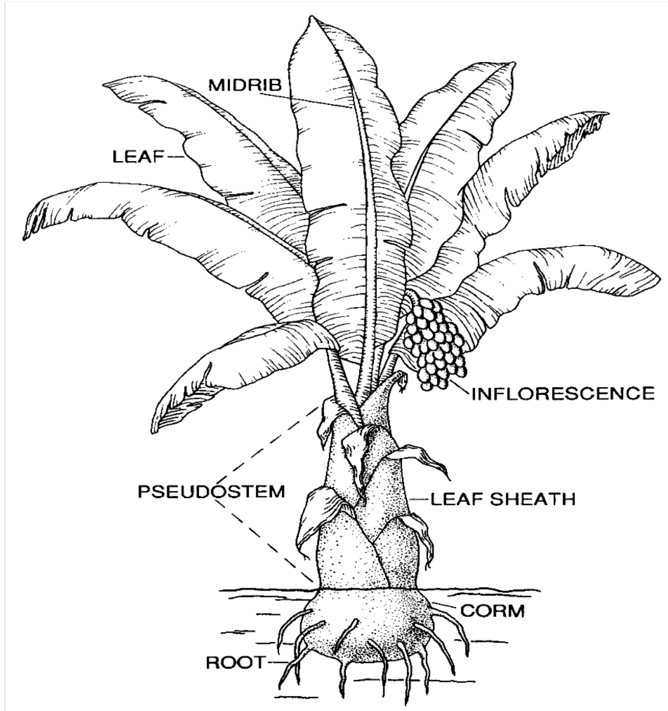


Figure1. Enset plant (Enset ventricosum)

food. In this regard attempted has been made to study the production of Kocho and bulla in large scale industry.

MATERIAL AND METHODS

Material

Enset was found in most part of the Ethiopia. Enset belongs to the order Scitaminae, family Musaceae. The genus *Ensete* comprises of 5-7 species, half of which are African, the other half Asian in origin. It looks like a large thick, single–stemmed banana plant. Both enset and banana have an underground corm, a bundle of leaf sheaths that form the pseudostem, and large leaves (Urga et al., 2006). Enset, however, is usually larger than banana, reaching upto 10 meters and with a pseudostem up to one meter in diameter. The leaves are more erect than those of a banana plant, have the shape of a lance head and may be five meters long and nearly one meter wide. Its pseudostem dilates at the base to a circumference of 1.5 to 3.0 m. Depending on the variety and ecological condition of its cultivation, the pseudostem length ranges from 2 to 5 m. The pseudostem and leaf midribs color vary considerably; some are purple to dark red but most are light green with variegated brown patches (Taye, 1984). The picture of Enset plant is shown in Figure1.

Method of preparation (Shank and Ertiro, 2008)

Harvesting and transportation

Enset is usually harvested just before flowering, the preferred harvesting time is just when the plant flowers. The time duration required to flower depends upon climatic conditions, clone type, and management. Hence, the flowering time varies from 3 to 15 years but is optimally around 6 or 7 years.

Raw material storage

This helps to fasten the processing eliminating transportation delay and efficient use of employer's energy without time wastage by waiting raw material. To forecast how much enset is processed in a day and also to control deterioration of the raw material by storing for long time. It stored at room temperature.

Enset washing

The enset is washed to remove the soils,insects,dusts and any unwanted impurities which may decrease the quality of the product.

Leaf sheath Separation: - After harvesting leaves and older leaf sheaths are first removed from the designated plants. The internal leaf sheaths (commonly up to two meters in length) are separated from the pseudostem down to the true stem, which is about a 20 centimeter section between corm and pseudostem. Then the true stem is separated or stumped from the underground corm. The concave side of the leaf sheath is peeled and cut into pieces of about one meter length and split lengthwise in order to shorten the leaf sheath to a workable size.

Decorticating and Grating

Then the leaf sheath is decorticated using a decorticating machine which helps to reduce the size. There is variation in the way that the corm is grated in different places. One practice is to uproot the corm and remove any soil from its surface.at this stage the pseudostem and corm reduced to small pieces and ready for squeezing.

Squeezing

Squeezer is used to separate kocho and bulla from decorticated and chopped enset by adding water, which added to aid the extraction of bulla, with the application of some force using presser. Then the Kocho is send to the fermenter and Bulla is collected in received tank.

Fermentation

After the completion of decorticating and grating, the leaf sheath pulp is spread on fresh enset leaves covering the tank in the ground, after which the grated corm is spread on the processed pulp. A starter is added to aid in fermentation. This starter consists either of already fermented *kocho* to which various spices and herbs are added or fermenting agents are prepared from the inner portion of the corm and then mixed with the decorticated pulp and grated corm after some weeks. Turning, mixing, rinsing, and chopping continue over a period of time until the mixture partially ferments, when it is then referred to as *kocho*. The total time period for this fermentation to occur ranges from 15 to 20 days. Then the fermented *kocho* is stored in fermenter tank that placed in the ground. The *kocho* must be left in a storage tank for a minimum of a month, but it can be stored for many months and even for several years. The fermenter tank is opened at intervals to allow aeration.

This is repeated until the desired fermentation quality is reached or the food is needed and increasingly exported to urban markets.

Sedimentation

This helps to separate bulla from impurities before it left for fermentation and drying.by density difference the water becomes at the top and bulla settles down. The bulla easily collected at the cone shape of the cylinder and the water left either for further process or drainage system.

Filter Bag

It is used to remove fine fibers and other impurities by filtering kocho to get purified product and also increasing the efficiency of the dryer by removing some amounts of water.

Drying

The moisture contained in bulla and kocho is removed by using drying process. The drying performed by either in open air (sun drying) or using industrial drying equipment like that of rotary drum dryer in order to conduct the process in short period of time.

Pulverize

It used for cutting to reduce the size of dried kocho and bulla prepared for sieving of flavored product in the standard size.

Sieve

This separates big size products from specified sizes. The oversize left at the top and the size that we need to use only left at end of the sieve passing through series of sieves of different size.

Bagging and Storing

Finally the products stored in storage tanks and distributed to the market by packing and making it easy for handling.

RESULT AND DISCUSSION

Material Balance

The Capacity of the Plant

1. The process is a semi-batch continuous
2. Plant capacity……………………….1020kg/day Kocho and 280kg/day Bulla
3. Working days………………………300
4. Working time per day………………16 hours
5. Production rate per year.……………306,000kgKocho and 84,000kg Bulla

Basis of assumptions 1000 Kg (KalekirstosYohannes, 2010). The flow diagram of production is shown in Figure 2.

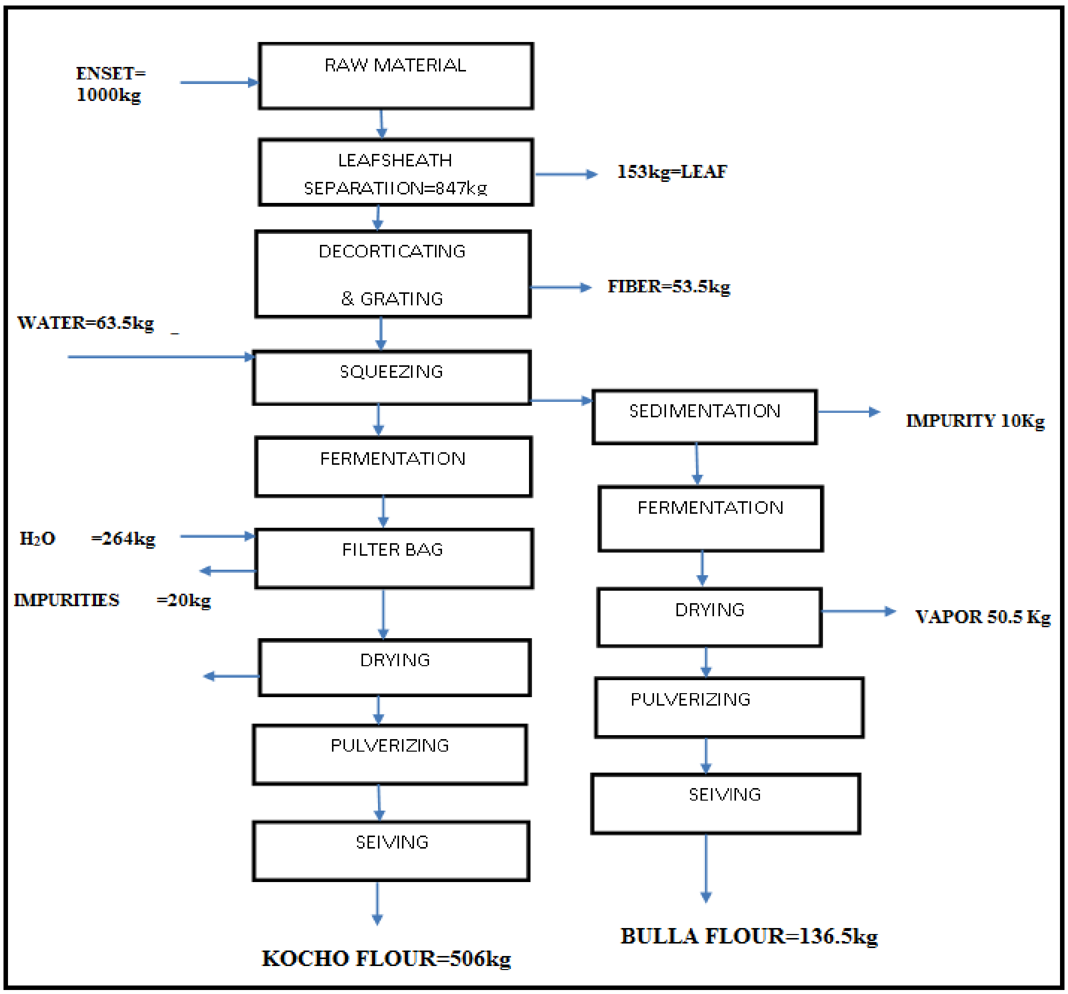
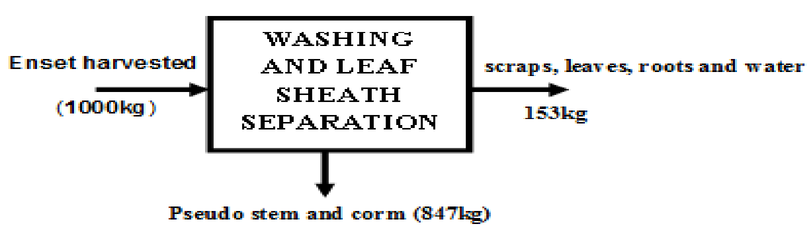


Figure 2. Flow diagram of kocho and bulla process

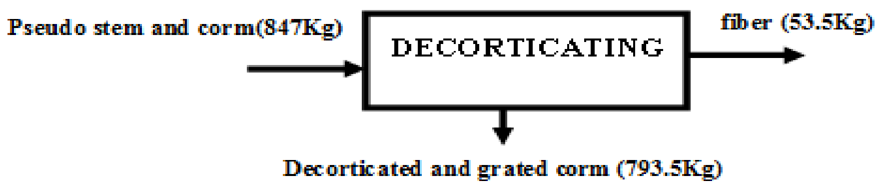
Material balance on washing and leaf sheath separation

Assumption: - During cutting and forming of Enset plant 15.3% is removed in the form of scraps, leaves, roots, and water**.**



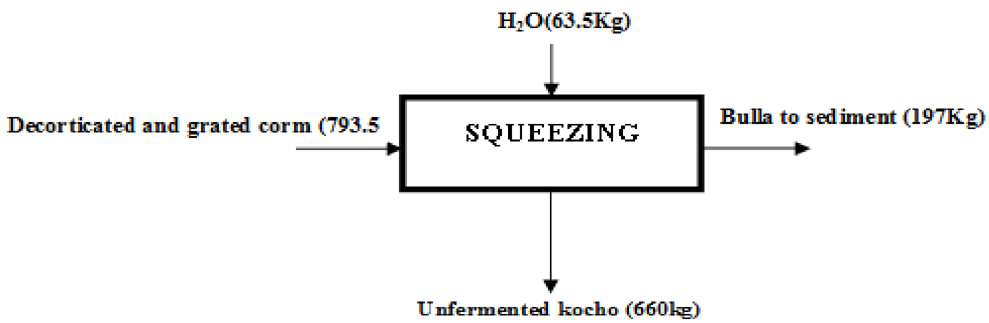
Material balance on decorticator

Assumption: - During chopping of Enset Pseudo stem and corm 6.31 % loss in the form of fiber and other.



Material balance on squeezer

Assumption:-during squeezing 23 % goes to bulla process line and 77% to kocho process line and water is added 8% of the Decorticated and grated corm to the squeezer.

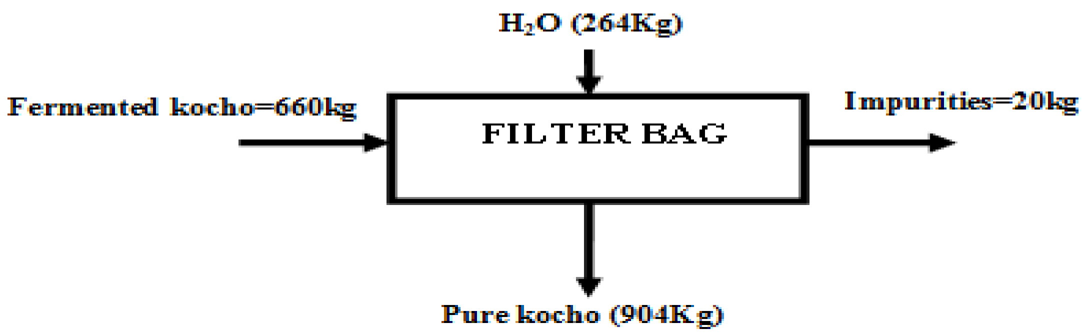


Material balances on kocho fermenter

Assumption:- The fermentation process is assumed to be no losing in the weight.

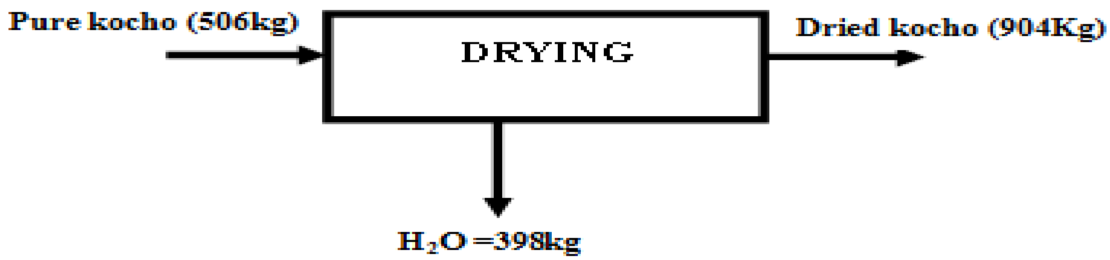
Material balances on Filter Bag

Assumption: - water added 40% of fermented kocho and the impurity is 3% of fermented kocho



Material balance on dryer

Assumption: - During drying the total loss in the form of water vapor accounts **44%** of the initial weight.(the moisture content of kocho 55% and dried kocho is 9%).



Material balance on kocho pulverizer

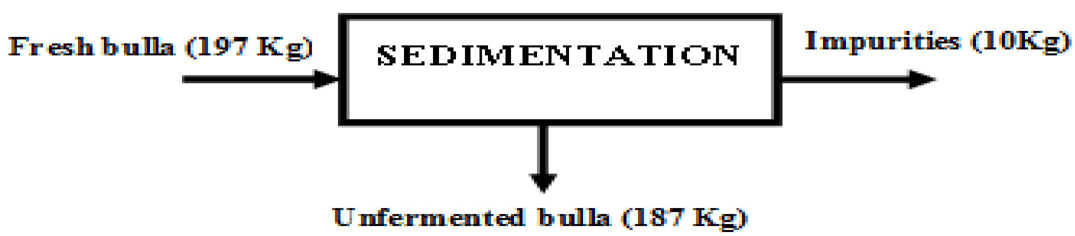
Assumption: - during pulverizing loss is insignificant

Material balance on kocho sieve

Assumption: - during screening loss is insignificant

Material balance on Bulla sedimentation

Assumption: - from fresh bulla the impurity account 5%

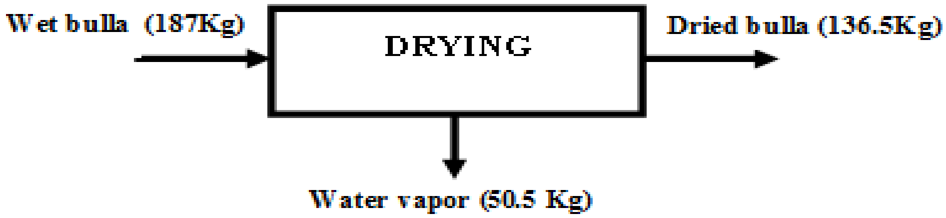


Material balance on bulla fermenter

Assumption: - The fermentation process is assumed to be no losing in the weight

Material balance on bulla dryer

Assumption: - During drying the total loss in the form of water vapor accounts **27%** of the initial weight (moisture content of wet bulla is 38% and moisture content of dried bulla is 11%).



Material balance on bulla pulverizer
Assumption: - almost no loss in the pulverizer

Material balance on bulla sieve

Assumption: - almost no loss in the sieve

Energy Balance

Energy balance around the pre heater and the dryer (figure 3)
Assuming no heat absorbed in the dryer,
Total heat input = total heat output **(2)**

$$m_{s1} h_{s1} + m_{W1} h_{W1} + m_{a1} (1+k) h_1 + Q + Q_{add} = m_{s2} h_{s2} + m_{W2} h_{W2} + m_{a3} (1+k_3) h_3 + Q_{loss}$$

If the mass flow rate of the dry material and dry air are considered to be constant, $m_{s1}=m_{s2}=m_s=$ constant and $m_{a1}=m_{a2}=m_{a3}=m_a$ =constant, then the above equation becomes

$$m_s h_{s1} + m_{W1} h_{W1} + m_a (1+k) h_1 + Q + Q_{add} = m_s h_{s2} + m_{W2} h_{W2} + m_a (1+k_3) h_3 + Q_{loss}$$

Where: -
m_s – Mass of dry substance
m_a – mass of air
K – Mass of moisture carried by unit mass of dry air
h- Enthalpy

For ideal dryers, the following assumptions are taken

1. All heating process is carried out(accomplished) in the pre heater i.e heat is supplied only in the heater.
2. There is no heating of any sort in the dryer i.e $Q_{add}=0$.
3. A heat loss to the surrounding from the dryer is negligible $Q_{loss}=0$
4. The enthalpy of the material remains unchanged during drying so that $h_{s1}=h_{s2}=h \cong$ constant.
5. The enthalpy of the moisture contained in the material that is in the gas phase is negligible compared to latent heat of vaporization so that $h_{W1} \cong h_{W2} \cong 0$ and $h_{v1} \cong h_{v3} \cong 0$

Then the equation becomes: -

$$m_a (1+k) h_1 + Q = m_a (1+k_3) h_3 \quad \textbf{(3)}$$

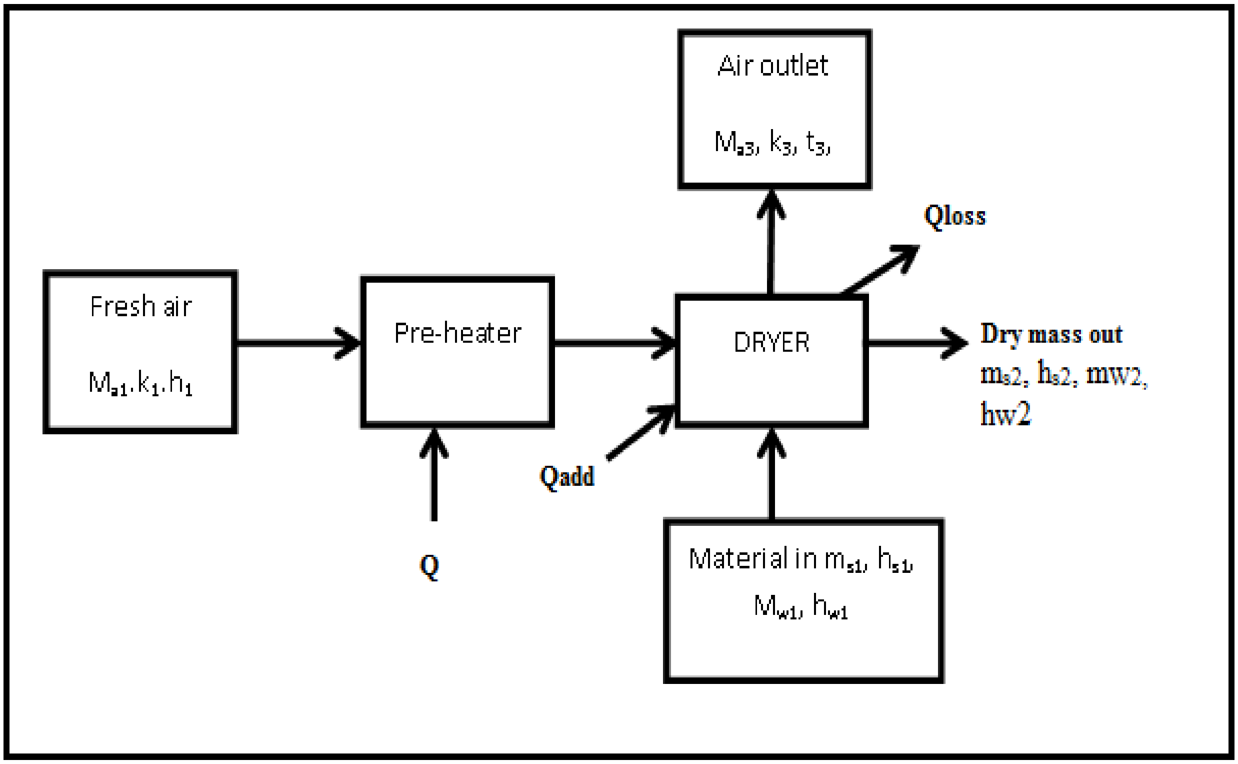


Figure 3. Typical drying process

Calculation of the air demand and power consumption of the dryer
Available data
Flow rate of bulla entering to the dryer can be found as
m_s- (0.38 – 0.11) m_s = 0.14tpd
m_s= 0.2tpd=0.2ton/day*1000Kg/ton*1day/8hrs*1hr/3600sec= 0.07 Kg/sec
Inlet temperature of air=343K
Outlet temperature of air=320K
Humidity of entering air= 0.01
Heat capacity of air = 1.03KJ/kgK
Heat capacity of water =1.88KJ/kgK
Heat capacity of bulla **=** 1.22 KJ/kgK
Inlet temperature of fresh bulla =298K
Out let temperature of fresh bulla =310K
Maximum allowable mass velocity of air is = 1.2kg/m^2
With an inlet temperature of 343K and humidity of 0.01kg of moisture/kg of dry air (reading from the psychometric chart, we get the inlet wet bulb temperature to be 312 K. assuming NTU=1.5 (Coulson and Richardson's V-2) then for adiabatic drying, the out let air temperature of T_3 is given by T_3=320 K.
The solids out let temperature is taken to be 310K.from steam table ,the latent heat of vaporization of water at 312K is 2410 KJ/Kg. for a mass of solids of 0.007 kg/sec and out let and inlet moisture contents of 0.11 kg/kg dry air and 0.38 kg/kg dry air respectively.

$m_s(w_1 – w_2) = \Delta m_w$
Mass of evaporated water = 0.07kg/sec (0.38-0.11) = 0.02kg/sec
For unit mass of solids, the heat duty includes
1. Heat to the solids =Q_s= 1.22(310-298) = 14.5KJ/kg
2. Heat vaporization=Q_v= 2410(0.38 – 0.11) = 538 KJ/kg
3. Heat to raise the remaining moisture to the solids out let temperatures 0.11(1.88 + 1.22) * (310 – 298) = 4.09 KJ/kg
4. Heat to raise evaporated moisture to the air out let temperature (0.38 – 0.11) * 1.88 * (320 – 312) = 4.06KJ/kg
5. The total heat duty becomes (14.5 + 538 + 4.09 + 4.06)KJ/kg =560KJ/kg
6. The power required for drying is Q = (560KJ/kg)(0.07kg/sec)=39.2KW

From Coulson's and Richardson's volume 1 fig 13.4, the humid heat of the entering air is 1.03 KJ/kg and making energy balance.
$m_a(1+k1) = Q/[C_{pa}(T1 – T3)]$
$m_a(1 + 0.01) = \frac{39.2}{1.03(343-320)}$ =1.64
Then mass flow rate of the dry air is
m_a =1.64/1.01 kg/s = 1.62kg/s
The humidity of out let air is
K_3=0.01 + (0.15/1.62) = 0.1 kg moisture / kg dry air

CONCLUSION

The products that produced from enset kocho and bulla are in the leading position. For years kocho and bulla has been produced traditionally which is inefficient, tiresome, unhygienic, degrading and gender biased. But, by using chemical engineering principles it is possible to manufacture in industry level. Processing kocho and bulla in industry level improves the decorticating, squeezing, fermentation techniques by adding additional processes drying and pulverizing. It is possible to distribute packed flour kocho and bulla both in the local and for export market. Processing kocho and bulla in the industry level creates new business and job opportunities, allow enset growing farmers get improved income and make them to have good market link for their supply, help the country to generate new income source from export market, it contributes to the food security and optimum resource utilization in Ethiopia, saves time specially that of women participating in this sector and improves their wastage of energy by eliminating their discrimination using improved equipment's, May be in the future it initiates to produce other food products like biscuit by using the flour that produced depending on the method that indicated in this project, helps to produce increased quality product by adhering the unhygienic processing system and easily handled product, and used as import substitution for starch based products and supplies raw material, fiber, for textile factories.

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