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Millet residue resulting from the production of millet beer: Quantification, Estimation of water content and Re-use options in Ngaoundere, Garoua and Maroua (Cameroon)

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ABSTRACT

This work involves the quantification, estimation of water content and re-uses options of millet residue in Ngaoundere, Garoua and Maroua with the aim of finding better management options for this waste. Thus, a survey of 22 quarters that constitute the selling points of millet beer locally called «bil-bil» in these towns was done. Here questionnaires were administered to the producers and consumers of «bil-bil» to evaluate the quantities of residues produced and re-use options. Samples of residue were collected at different selling points and dried both in the sun and oven for 48 hours to determine the water content. The duration of the drying process was determined by measuring the time used to obtain a constant mass. The study revealed that nearly 100 % of the producers are women while most of the consumers are low income earner of both sexes. Results also showed 6269 kg, 3818 kg and 1951 kg of residue generated in Maroua, Ngaoundere and Garoua respectively per week during the period of the survey and about 62 % of the residue is used in feeding animals. Depending on the atmospheric conditions, it takes 16 hours in the sun to get dry completely and 24 hours in the oven at 100 °C, giving the water content of 72 % and 84.4 % for the samples using the oven and solar energy respectively. This waste is a problem for the inhabitants and their environments, so, adequate policy and regulatory systems can help improve its management.

Keywords: Beer; Brewery; Millet; Waste management; Maroua

INTRODUCTION

African countries and Asian countries are experiencing rapid population, economic and industrial growth and these are making environmental conservation a difficult task. In urban areas, the careless disposal of industrial effluents and other wastes on road sides, in rivers & lakes for example may contribute greatly to the poor quality of river water [1].

One of such waste is millet residue which is obtained from the production of millet beer commonly called «bil-bil» in Cameroon, using millet and water as raw materials [2]. There are several steps in the production process, which include malting, milling, mashing, lautering, boiling, fermenting, conditioning, filtering, and packaging [3]. Millet residue is obtained from the filtration step of the process. Three types of filtering media are commonly used in the three Northern regions of Cameroon: bags of 50 kg or 100 kg, woven baskets with dry leaves and a combination of the bags and the woven baskets. [4]. The solid residue obtained after filtration has an odor and can contain between 22-28 % dry matter, 28-32 % protein, starch 7 %, cellulose 15 % , fats 10 % and mineral elements 5 % [5]. These residues are mainly external hulls of grains that contain lignocelluloses (lignin, hemicelluloses, and cellulose) which cannot be digested by yeast during the brewing process due to the presence of lignin. After recovery, the residue can be used as animal feed (e.g. breastfeeding cow requires 9 kg of residue in its diet, while mature cow and small

ruminants require 7½ kg and1kg of residue respectively), fertilizers, human consumption, and laxatives, dried for long term conservation or transformed into biofuels [4].

Despite these re-use options, most of the residues are dumped in the environment, where they may be contaminated by fungi or release toxic compounds. As a result, fungal toxins or polyphenol compounds that resist bacterial degradation can leach out, posing a risk to human and environmental health. This is how some water sources around the towns, have become polluted [6]. A greater percentage of it is abandoned around the vicinity of human habitation attracting the housefly which is usually a vector of various diseases such as typhoid fever, cholera, dysentery and trachoma. This causes damage to human health and quality of life due to its smell.

The sustainable management of solid waste streams is imperative in order to minimize environmental and public health risks around the world. Unfortunately, while the balance between the specific components of this system in delivering sustainable waste management are already well understood and established in most developed countries, this is not often the case for developing countries such as Cameroon [7].

This work therefore, involves the quantification, estimation of water content and re-uses options of millet residue in Ngaoundere, Garoua and Maroua with the aim of finding better management options for this waste to protect human health and the environment.

1.1. Study area

Cameroon is a developing country in Central Africa with a surface area of 475,650 km^2 and a population of 19 406100 habitants and expected to be 21 917 602 by 2015 [8]. Its geographical position as well as that of the Northern region of Cameroon showing its vegetation is presented in Figure 1 [9]. The climate of the northern regions of Cameroon (Sudano–Sahelian climate) is characterized by a very long dry season (November to May) which is favorable for the cultivation of millet which is the main ingredient of millet beer locally called «bil-bil» [10]. Millet is the staple food of the people in these towns and besides using it in brewing millet beer, it is also use in making other food products. The brewing uses a lot of wood causing deforestation in these Sudano–Sahelian towns, where re-forestation is one of Cameroon government's challenges because the effects of climatic changes such as flooding have become very recurrent [11].

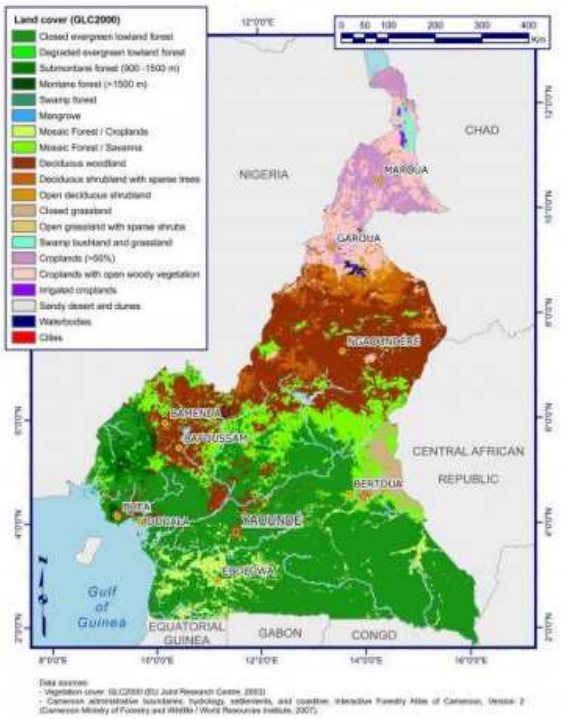

Figure 1 Map of Cameroon showing its vegetation cover as of 2003

EXPERIMENTAL SECTION

A survey (9th February-25th April 2013) of the selling points of «bil-bil» called «cabarets» in Maroua (10 quarters), Garoua (07 quarters) and Ngaoundere (05 quarters) was done followed by the administration of questionnaires to the

producers and consumers of «bil-bil». Samples of residues resulting from «bil-bil» production were collected at different selling points in the three towns and dried both in the sun and oven to determine the water content. For drying in the oven: different masses (heavier mass: 1800 g, lighter mass: 38 g) of the residue were collected, weighed in aluminium foil papers and put in the oven at a temperature of 100 ^{0}C. For drying in the sun: samples of the residue with different masses (heavier mass: 1500 g, lighter mass: 1000 g) were collected, weighed and put in the sun under the following average conditions: temperature 35 ^{0}C, pressure 9600 Pa, humidity 62 % and wind SW 4.5 ms. Samples in the oven and sun were collected and reweighed after 6, 24 and 48 hours.

The water content was calculated by using the following equation (1);

$$\text{Water content} = \frac{\textit{initial mass of residue} - \textit{final mass of residue}}{\textit{initial mass of residue}} \times 100 \quad \ldots\ldots\ldots (1)$$

The duration of the drying process was determined by measuring the time used to obtain a constant mass.

RESULTS AND DISCUSSION

3.1. Number of quarters and people involved in this activity per town

A survey of selling points in these three towns revealed that mainly women are implicated in these activities. Tables 1, 2 and 3 present the total number of persons (number of consumers plus producers) involve in these activities in the different selling points per quarter in the different towns of Ngaoundere, Garoua and Maroua respectively.

Table 1 Number of quarters and consumers plus producers surveyed in Ngaoundere

Quarter	Representative population	No of consumers	No of producers
Joli Soir	126	71	55
Burkina	25	6	19
ONAREF	11	3	9
Nowegienne	14	3	11
Bamianga	10	1	9
	Total: 186		

Table 2 Number of quarters and consumers plus producers surveyed in Garoua

Quarter	Representative population	No of consumers	No of producers
Njamboutou	13	5	8
Sodecoton	4	1	3
Bamileke	12	8	4
Romde Adjia	19	9	10
Yelwa	7	1	6
Soweto	9	2	7
Ngalbidje	23	8	15
	Total: 87		

Table 3 Number of quarters and consumers plus producers surveyed in Maroua

Quarter	Representative population	No of consumers	No of producers
Pont vert	58	22	36
Baoliwol	23	14	9
Pitoare	15	5	10
Domayo	29	6	23
Harde	49	9	40
Pallar	25	19	6
Missinglieo	13	4	9
Ourotchede	22	3	19
Zilend	16	9	7
Founangue	15	6	9
	Total: 265		

The study also revealed that this activity is practiced by people with diverse professional backgrounds with ages ranging from 16 to 56 years with those between 26 and 35 years constituting the majority. However, nearly 100 % of the producers are entirely women while most of the consumers are low income earners (students, job seekers, farmers) of both sexes. It should be noted also that most producers are also high consumers.

The variations in the number of persons involved in this activity in different towns stems principally from the level of urban development in these three towns. More people are involved in Maroua (265**)** and Ngaoundere (186) than

Garoua (87) because though highly populated, Maroua and Ngaoundere have many remote quarters that favours the practice of this activity unlike in Garoua that harbours many big government and industrial activities with good urban network. Thus, very little space for this activity (that contributes in poor hygienic situation of the town) resulting from strict control by the municipal authorities.

3.2. Quantity of residue produced per week

DJANAN et al., 2002 [12] reported that, 62.5 kg of millet produces 37.5 kg of residues (or 60 %) [54]. This relation permitted the estimation of the quantity of residue produced after brewing as it was noticed from this study that, the quantity of millet used by producers ranged mostly between 25-100 kg per quarter per week. This estimate thus showed that 6269 kg, 3818 kg and 1951 kg of residue were generated in Maroua, Ngaoundere and Garoua respectively per week during the period of the survey. These findings are summarized in Figure 2 below.

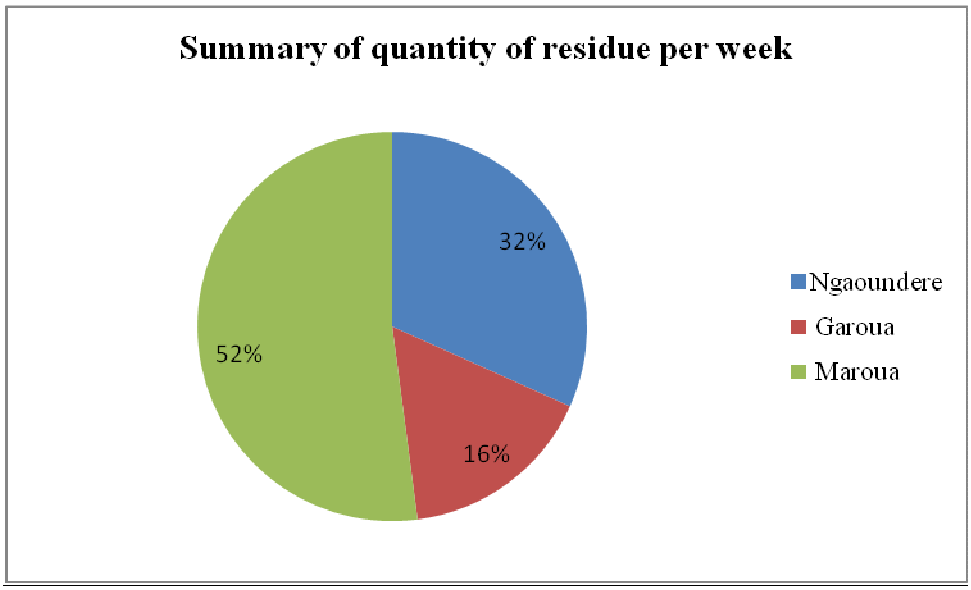

Figure 2 The quantity of residue produced in each town per week

It is evident from Figure 2, Maroua produces the highest quantity of millet residue, followed by Ngaoundere and lastly, Garoua. This can also be explained on the basis of the existence of many remote quarters in Maroua and Ngaoundere.

3.3. Re-use options of the residue

There exist many re-use options for this residue [13] due mainly to its lignocelluloses (lignin, hemicelluloses, and cellulose), fats and mineral elements contents [5]. It presents exceptional nutritive qualities for animals in general. It can also be exploited in the production of biofuels and enrichment of the soil. Despite the fact that, a good number of re-use options are practiced in these towns, as presented in Figure 3 below, this study however, revealed that most of it is stored in old clay pots, basins, and bags and dumped around the road sides.

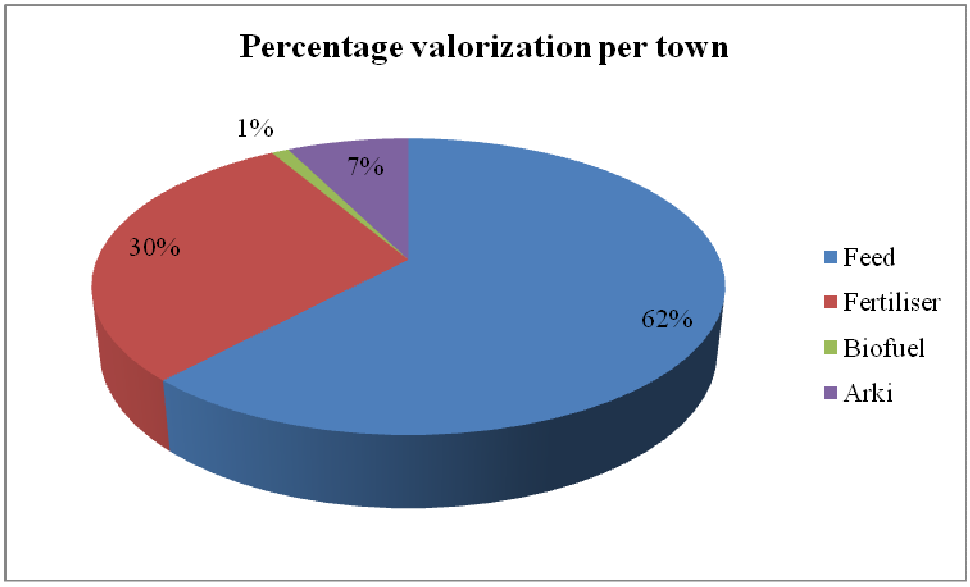

Figure 3 Summary of re-use options of the residue in the three towns

In general, the highest percentage (62 %) of the residue is used in feeding animals in all the three towns. This is obvious as cattle's rearing is the main activity in these three towns. Table 4, shows composition of diets containing the residue fed to some animals.

Table 4 Composition of diets containing millet residue fed to some animals [14]

Breastfeeding cow	Mature Cow	Small ruminants
9kg of residue from «bil-bil»	7½ kg of residue from «bil-bil»	1kg of residue from «bil-bil»
2¼ kg of millet chaff	2 kg of millet chaff	1/4kg of millet chaff

The least (1 %) re-use option is in biofuels. This because though the residue is not environmentally friendly when disposed it takes time to ferment, thus many people, mostly the rural population prefer other rapid sources of fuel (e.g. wood). The application of the residue as fertilizer is predominant in Ngaoundere because here, beside cattle rearing cultivation of a variety of other crops is practiced owing to its Sahelian and equatorial climates. "Arki" is used to describe another local drink very rich in alcohol resulting from a lengthy fermentation period. The use of residue to produce this drink is highest in Maroua. Maroua is characterized by very rural population with low incomes and having one of the lowest schoolarisation rates in Cameroon, thus, elucidating the high consumption of arki as most people are unemployed and lack adequate knowledge on the dangers of this drink.

3.4. Analyses of the water content of the residue

Results show that it takes 48 hours on average for drying to be complete (constant mass) for both oven (Figures 4 and 5) and sun drying (Figures 6 and 7). The constant weight implies all the water in the residue had evaporated. Thus, this measured mass obtain is that of the final dried sample and the water content is estimated using equation (1). For drying in the oven, the final quantity of dry matter in percentage obtained was 28 % for all the samples, giving a percentage water content of 72 % in those samples, Tables 5 and 6. For the samples in the sun, the final quantity of dry matter in percentage obtained was 84.4 % giving a percentage water content of 15.6 %, Tables 7 and 8. The difference in the water content of the samples in the sun and oven is probably due to the absorption of moisture by the samples in the sun since it was exposed to the humidity of the atmosphere. Generally, there was no observable color change of the samples during and after the drying process. However, the texture changed from sticky to crispy and the odor disappeared thus not attracting flies. Showing, the organic matter evaporated with drying.

Table 5 Changes in mass of the heavier sample with time in the oven

Mass(g)	Percentage loss in mass	Time(h)
1800	0	0
1361	23.4	6
572	68.2	24
517	71.2	30
503	72	48
Water content		**72%**

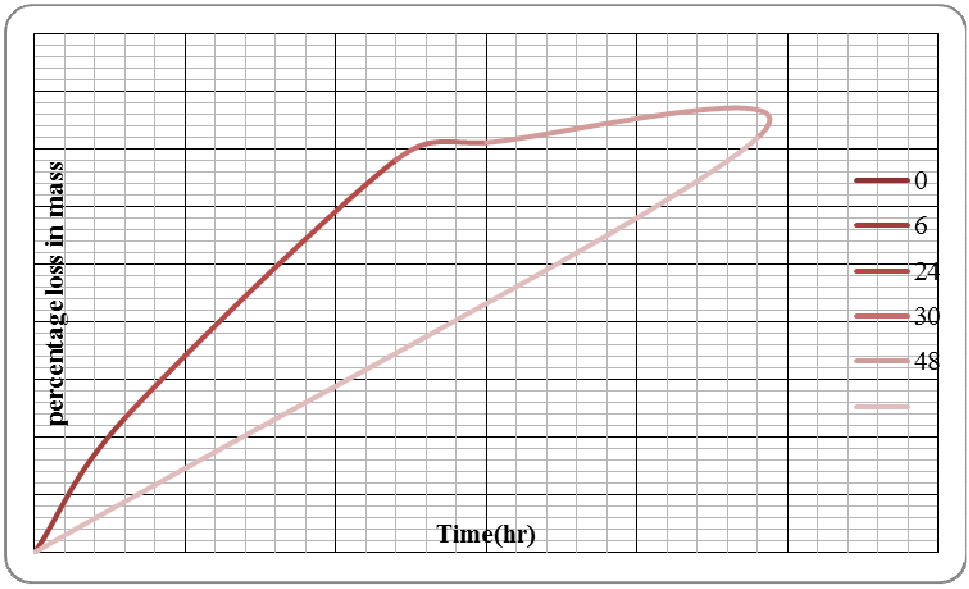

Figure 4 Percentage loss in mass against time for the heavier sample dried in the oven

The curve Figure 4, shows a general increase in the percentage loss in mass with the gradient steeper at the beginning (between 0 and 26 hours) showing that the rate of percentage loss in mass is highest at the beginning and gradually decrease as all the water is lost.

Table 6 Change in mass for the lighter sample with time in the oven

Mass(g)	Percentage loss in mass	Time(h)
38	0	0
10.95	71.2	24
10.87	71.4	48
10.8	72	72
Water content		**72%**

The same quantity of water content obtained (72 %) for heavier and lighter samples dried in the oven are principally due to controlled conditions in the oven. It also indicate that water contain in the residue is physically adsorbed which can easily be lost in the same quantity by heating despite the quantity of residue concerned

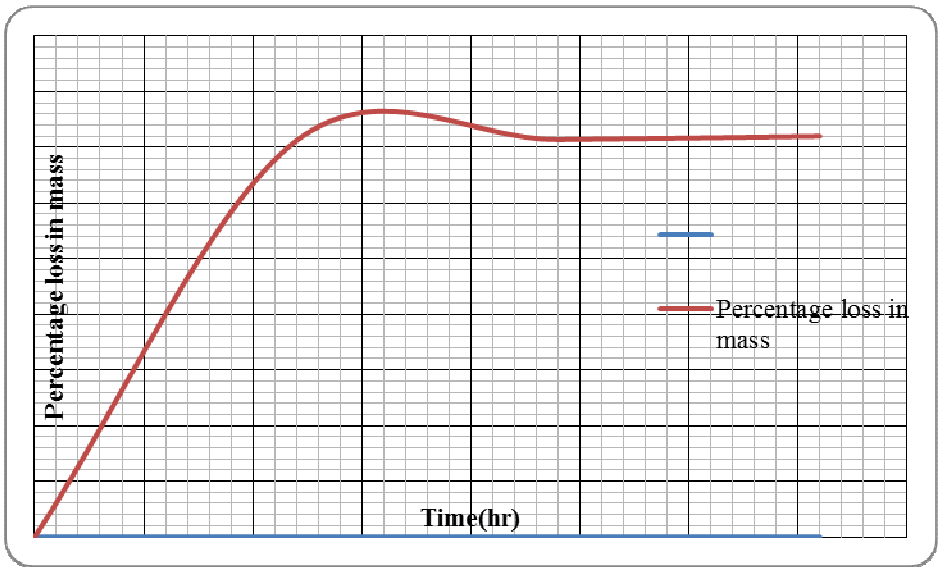

Figure 5 Percentage loss in mass against time for the lighter sample dried in the oven

The curve Figure 5, shows a rapid initial increase in the percentage loss in mass of the lighter samples (between 0-32 hours) and a slight increase between (32- 46 hours) and finally a constant after forty-eight hours. The surface area of heating for lighter samples is greater than for heavier samples. Thus, the behaviour of the curve Figure 5 (absent

in heavier samples, Figure 4), may be due to the formation of new compound(s) or impurities which are more stable to heat at 100 °C.

Table 7 Change in mass for the lighter sample in the sun

Mass(g)	Percentage loss in mass	Time(h)
1000	0	0
212	78.8	6
143	85.7	24
134	86.6	30
133	86.7	48
Water content		**86.7%**

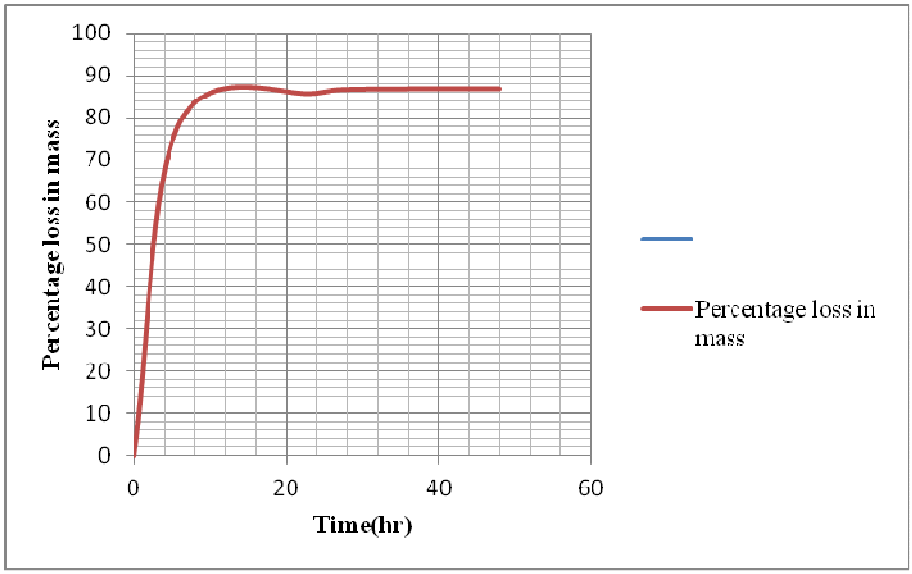

Figure 6 Percentage loss in mass with time for the lighter sample dried in the sun

Table 8 Change in mass of heavier sample in the sun

Mass(g)	Percentage change in mass	Time(h)
1500	0	0
441	70.6	6
292	80.5	24
271	81.9	30
270	82	48
Water Content		**82%**

The difference in water content for heavier and lighter samples dried in the sun, 82 % (Table 8) and 86.7 % (Table 7) respectively, is to be expected as the lighter samples provide a greater surface exposure to the sun than the heavier samples. Also is difficult to perfectly control atmospheric conditions during the dying period. The difference of about 4 % between the heavier and lighter samples better illustrate this. This water content of over 80 % for these samples is also an indication that the water is only physically adsorbed on the residue surface which can easily be lost in the same quantity if dried under same controlled conditions.

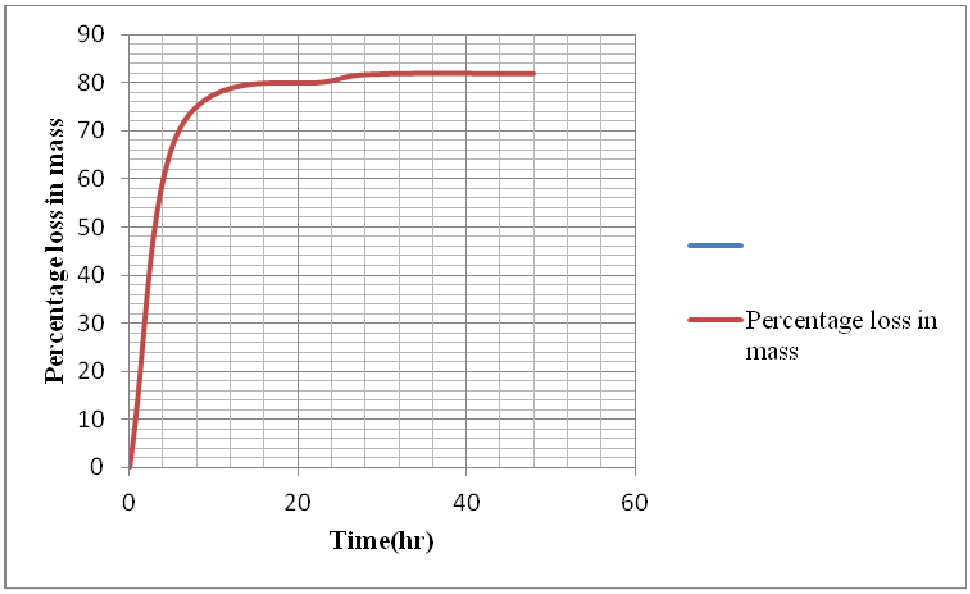

Figure 7 Percentage loss in mass against time for the heavier sample dried in the sun

From the shape of the graphs, Figures 6 and 7 for drying in the sun, it is seen that it takes a shorter time for a large quantity of water to be lost, 0- 16 hours for heavier and lighter samples. It is also observe that for the heavier samples Figure 7, the weight loss stays constant from 16-24 hours and then increase again while for the lighter sample Figure 6, the weight loss decrease from 16-24 hours and increase from 24-26 hours. The behaviour of heavier samples may simply be due to the re-absorption of atmospheric water which may be the same factor responsible for the increase in weight loss from 24-26 hours for the lighter samples. However, the decrease in weight loss for the lighter samples can be attributed to the presence of some impurities or formation of new compound(s) which are stable at atmospheric temperatures.

CONCLUSION

The production and consumption of millet beer «bil-bil» is highly practiced in less developed zones of the towns studied because the inhabitants are mostly less educated, unemployed or farmers with very low incomes as a liter of this drink cost just about 10 US dollar cents compared to more than one US dollar for the cheapest bottle of well refined beer. The volume of the residue produced is relatively high (approximately 12000 kg) in the three towns studied which though had many re-use options still had a good portion of it being dumped in to the environment without any control measures. This study revealed that drying the residue in the sun (which is cheaper for the local population) eliminated the highest percentage of water (84 % on average) and this could possibly increase re-use options and avoid dumping of non dried residue (as any form of drying eliminates the odour) which is responsible for a number of health and enviromental problems in these towns e.g. cholera. However, This dumping is a crucial problem in these towns like those of other cities of developing countries, where the lack of adequate treatment of different types of waste, remains one of the major problems to be solved [15].

Due to the culture, climate, poverty and low educational levels in the Maroua, Garoua and Ngaoundere, the cultivation of millet, production and consumption of millet beer and generation of millet residue will continue to rise in these areas. So, the government through the local organs as well as civil society and nongovernmental organizations amongst others can improve the management of the waste through: sensitization on the dangers of the waste and the millet beer, better management options for the residue, improved production process for the millet beer that will generate less waste and proper organization of the production to management of the waste through adequate policy and regulatory systems.

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