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Pineapple Processing in Central Uganda: A Case of Drying and *Munaanansi* Production

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Introduction

Uganda's fruits industry is growing at a fast rate, and pineapples are one of the most dominant fruits grown, processed, and traded in Uganda (Bonabana-Wabbi et al., 1991). However, pineapples are highly perishable like the majority of fruits. This is due to their high moisture content estimated to be over 80% (Sharma, Chen, & Vu Lan, 2009). They require immediate consumption after harvest, or processing and refrigeration if they are to be consumed later. They are seasonal meaning that some periods of the year such as Dec to Mar experience high pineapple supply. This leads to low market prices as well as increased loss and wastage. The supply chain involves farmers, middlemen, processors, exporters, and final consumers. The pineapples are destined to both local and international markets, and consumed fresh or processed into juice, wine, or dried chips (MFPED, 2016; Santoshkumar & Patil, 2006). However, the surplus or the unsold is left to rot leading to wastage (Namuwoza & Tushemerirwe, 2011). Apart from extending shelf life, processing reduces losses and wastage in the supply chain of pineapples (Kiaya, 2014), and the main processing methods in Uganda are drying, juice extraction, and wine and munaanansi production. There is, however, limited information on the current performance of the above processing methods (MAAIF, 2011). This hinders the estimation of current process performance and the possibility of improving and optimizing these processes. This research sought to establish the performance state of drying and munaanansi production in three central districts of Uganda i.e. Kampala, Wakiso, and Kayunga. These districts were chosen as they are at the centre of pineapple activities in Uganda. Munaanansi is a local drink made out of pineapples or pineapple peels as the main raw material with tea leaves, sugar, and ginger as ingredients. Pineapples or pineapple peels are crushed, mixed with water and crushed ginger in a suitable cooking pan. The pan is placed on a cooking stove, tea leaves added towards boiling, and sugar added after filtering and cooling. The final product is packaged, refrigerated, and retailed as a soft drink mainly in relatively small retail shops.

Materials and methods

Drying: three processors involved in drying of pineapples and other fruits were selected and tagged as follows: Kasangati in Wakiso (S01), Kawempe in Kampala (S02) and Kangulumira in Kayunga (S03). The choice was based on willingness to participate and processors' significance in the drying field.

The quantity of pineapples (kg) to be dried on a particular day (before peeling), and quantity (kg) of waste (peels, cut-offs, cores, and juice) (after peeling and slicing) were determined using an electronic scale (BSE001, max 150 kg, and d = 100 g). At the end of every drying cycle; S01 and S03 immediately sorted the final products separating browned or burned from the good ones.

Quantities (kg) of both were measured and recorded using VOLTCRAFT scale (TS-600, max 600 g, and d: 0.1 g). The moisture content (MC) for both fresh and dry pineapples were determined using the absolute moisture meter (PCE-MA110, max 110 g, and d = 0.001 g). Biomass to be used weighted using a Salter hanging scale (235 -6M, max 100 kg and d = 0.5 kg), and electrical energy (kWh) measured throughout the drying period using an electrical meter (DDS228, IEC 61036, 10(60) A, Veto, single phase). Inlet and outlet temperatures at each of the dryers were recorded throughout the drying cycle at 5 minutes intervals by fixing K-type thermocouples (-200 °C to 1,260 °C± 2.2 ^{0}C) at both inlet and outlet of each drying unit. The average values were later derived and graphs displaying temperature variations at 0.5 hour intervals generated. Measurements were carried out twice at S01 i.e (Jan and Apr 2017) for three days each, once at S02 and S03 for six and five days respectively.

Munaanansi production: five munaanansi producers were randomly selected from Kampala Central of Uganda where the drink is most popular, and tagged: producer one (P01), producer two (P02), producer three (P03), producer four (P04), and producer five (P05). The following were measured: quantity (kg) of pineapples or pineapple peels, amount of water used (kg), amount of munanaansi produced (kg), and amount of pomace (waste or remains after filtering) (kg) using an electronic scale (BSE001), mass of firewood or charcoal (kg) to be used using Salter hanging scale, and amount of tea leaves (g) using VOLTCRAFT scale between Nov 2016 and Jan 2017 but not daily. Six measurements were carried out at P01, two at P02, one at P03, five at P04 and P05; the averages of which were later determined.

Results and discussion

Drying: there was non-uniform distribution of temperatures; trays had to be switched periodically to allow uniform drying of the products especially at S01 and S02. The average inlet and outlet temperatures, drying ratios, percentage (%) of waste, and fuel consumption required to obtain 1 kg of dried pineapples is shown in Table 1.

Table 1: Average drying temperature, drying ratios, %age of waste, and per unit values

Unit	Inlet Temp(^{0}C)	Outlet Temp (^{0}C)	Drying ratio	%age waste	EE (kWh/kg)	Biomass (kg/kg)	Diesel (l/kg)	Petrol (l/kg)	MC Dry (%)
S01-Jan	69.50	47.11	17:1	57.57	6.78	2.48	1.29	0.64	13.30
S01-Apr	55.22	40.15	16:1	61.98	4.11	0	0.98	0	11.78
S02-Mar	118.26	59.2	22:1	62.10	3.07	3.48	0	0	13.10
S03-Feb	44.79	45.62	16:1	58.17	0	0	0	0	17.04

The highest average inlet (118.26 ^{0}C) and outlet (59.2 ^{0}C) temperatures were exhibited by drying unit at S02 with an average drying time of 18.7 hours. The performance values for S01 measured in Jan and Apr showed meaningful differences e.g. moisture content (MC), fuel consumption, and drying ratio were better in Apr. This might be attributed to the operational and behavioural changes effected after the Jan measurements e.g. half loading of the drying units (which could have aided better movement of air inside the drying units thus more even distribution of temperature), replacing the petrol generator with diesel one, and better utilization of electrical energy. S01 in Apr and S03 exhibited the lowest drying ratios of 16:1 although S03 attained the highest final moisture content of 17.04%. This means, the drying ratio could be worse if MC of 11.78% was to be achieved for example. The inlet and outlet temperature variations are shown in Figures 1 – 3.

In Jan 2017, the inlet temperature at S01 varied between 52 ^{0}C and 79 ^{0}C while it varied between 52 ^{0}C and 66 ^{0}C in Apr. The outlet temperature at same company varied between 32 ^{0}C and 71 ^{0}C in Jan and between 29 ^{0}C and 60 ^{0}C in Apr. The major reason was that the set temperature was between 75 – 80 ^{0}C in Jan, but changed to not more than 65 ^{0}C by Apr.

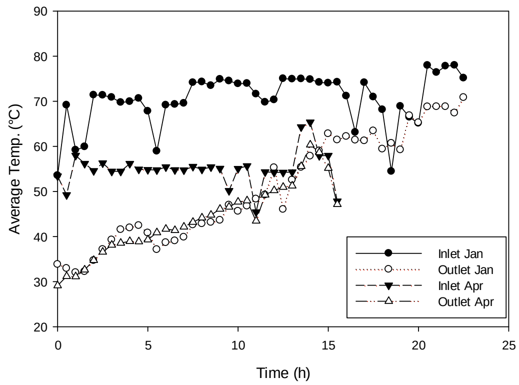

Figure 1: Average inlet and outlet temperature variations at S01 (Jan and Apr)

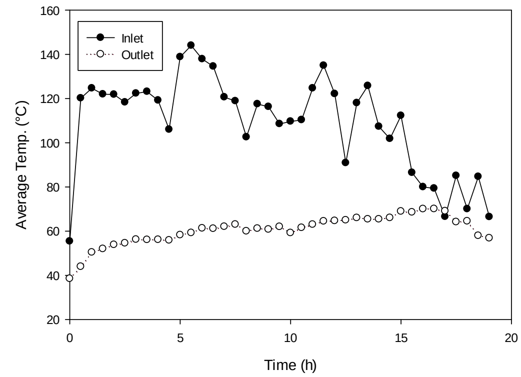

Figure 2: Average inlet and outlet temperature variations at S02

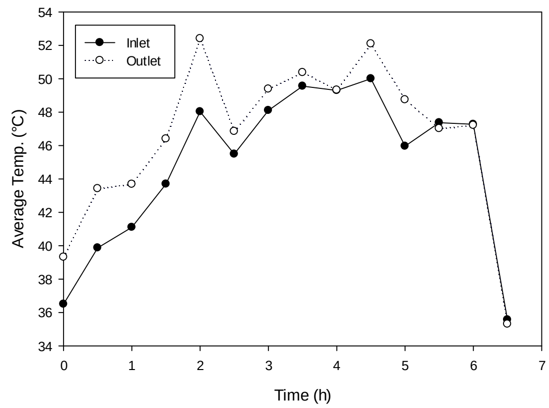

Figure 3: Average inlet and outlet temperature variations at S03

The inlet temperature for S02 varied between 54 ^{0}C and 145 ^{0}C while the outlet varied between 37 ^{0}C and 71 ^{0}C. Unlike S01 and S02 who employ hybrid dryers; the inlet temperature for S03 is generally less than the outlet temperature. This could be explained by the fact that the incoming air is almost at ambient temperature especially at the beginning of drying but heated up inside the solar collector. The displayed temperatures for S03 are daily averages because one drying cycle took about 48 hours. So there were daily recording breaks every after daily drying cycles of about 6 hours. The inlet temperature varied between 36 ^{0}C and 51 ^{0}C while the outlet varied between 38 ^{0}C and 53 ^{0}C. The observed temperatures are comparable to what is reported by other researchers who investigated the effect of temperature on quality and nutritional value of dried products (Akoy, 2014; Murthy, 2009). Although quality investigation was beyond the scope of this research, visual observations indicated that dried pineapples by S01 had the best appearance.

Munaanansi: Table 2 displays the respective quantities required to produce 1 l of munaanansi.

Table 2: Per unit values of measured parameters for five producers

P01-P05	Pineapples (kg/l)	Water (l/l)	Fuel (kg/l)	Pomace (kg/l)	Fuel
P01	0.13	0.98	0.19	0.1	Wood
P02	0.22	0.98	0.19	0.13	Char
P03	0.09	1.08	0.54	0.05	Wood
P04	0.23	1.04	0.08	0.11	Char
P05	0.32	1.14	0.26	0.29	Wood
Average	**0.20**	**1.04**	**0.25**	**0.14**	**-**

To produce 1 l of munaanansi; 0.25 kg of fuel (charcoal or firewood), 1.04 l of water, and 0.2 kg of pineapples or pineapples peels are required leading to the generation of 0.15 kg of pomace (waste). Individually, P03 exhibited the worst fuel consumption performance which could be attributed to having an open three stone firewood stove located in open space. The rest had their cook stoves located in cooking structures (kitchen).

Conclusions

Processing of pineapples not only adds value and extends shelf life of pineapples, but is also a source of income and employment directly or indirectly and creates linkages between actors right from the farmers to consumers. Drying pineapples is one of the most developed and formalized processing methods, and mainly dominated by solar energy. Like the rest of the methods, drying is still faced with a number of challenges such as lack of modern drying equipment. The drying systems at S01 and S02 seem advanced, but most of the operations are still manual. The market for dried products is still locally limited since fresh pineapples are generally available which leaves almost only the international market. Most of the dried pineapples are exported to Europe and USA where the market is said to be growing. Munaanansi production is still primitively produced; e.g. using traditional inefficient cook stoves. The producers tend to target local market, and produce for subsistence. However, the product has a lot of potential especially locally where it is already well known, but it can also be popularized internationally as a soft drink. A number of optimization approaches can be employed ranging from behavioural and operational to technological and equipment changes. Automation and replacement of inefficient devices are some of the short term strategies for the minimization of resource wastage especially energy.

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