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Energy Consumption Pattern of Value Added Products of Pearl Millet

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Authors' contributions

This work was carried out in collaboration among all authors. Author RK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors YVKS and MKG managed the analyses of the study. Authors VMK and MM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Pearl millet is one of the major food crops in most of the arid and semi arid cropping region of India. Being the fourth most important cereal crop, pearl millet gives more nutrients and minerals to the rural people. The main purpose of the present study was to carry out an analysis of energy utilized during processing of pearl millet for preparing two different bakery products (i.e. cake and biscuits) under laboratory conditions. The present study was conducted at established lab. of Centre for Excellence, Pearl Millet, HAU, Hisar. In this lab, processing of pearl millet is done on regular basis for preparation of cakes and biscuits for demonstration as well as selling purpose through ATIC (Agriculture Technology and Information Centre) of HAU, Hisar. Pearl millet processing involves various unit operations such as cleaning, drying, milling, baking and packaging. Basically two types of energy i.e. manual and electrical were used during processing of pearl millet. Electricity was the

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main energy source for the value added products of pearl millet. Electricity was used to run electric oven, spiral mixer, dough maker, mill, packaging machine, lights etc. In pearl millet processing, some of the operations were done manually like, cleaning, sun drying, feeding of biscuits in package and weighing etc. Manual energy used was around 8% while electrical energy used was around 92%.

Keywords: Pearl millet; processing; energy auditing; value-added products.

1. INTRODUCTION

Pearl millet is one of the major *kharif* food crops of arid and semi-arid cropping region of India. Pearl millet is considered as a poor man's crop. It is rich in protein, fat and mineral content. Pearl millet is a sustenance that delivers a big part of nutrition to large segment of population of semi arid tropical region in Africa and Asia [1]. It is sans gluten and low cost cereal, which is resistant to drought and nutrient-poor soil. Pearl millet is produced in Africa and Asia around 56% and 41% of total world production [2]. In addition, as pearl millet sans gluten which is introduced for its low concentration of carbohydrate and glycemic index [3 and 4]. Due to its low concentration viability of various bakery produces like bread, pasta and biscuits considered by some authors [5. 6 and 7], planning to take the place of entire wheat flour with millet flour. Aiming to replace whole-wheat flour with millet flour. In India, almost 46% of the grain production of pearl millet goes for human food use, 37.5% for cattle feed, 7.7% for poultry feed 8.8% for alcohol industry and only a small fraction (0.4%) is used for seed purpose [6].

Pearl millet can be cultivated in each one of those soils and climatic conditions where other cereal crops, for example, maize or rice, could not make due under rainfed conditions. In the rainfed locales of the nation, pearl millet is stable food of a majority of the poor small land holders as well as feed and fodder for animals. About 89.5% of the cultivated area under pearl millet is rainfed i.e. without irrigation. Pearl millet exceeds expectations every other cereals since it requires low info cost, develop in brief span and is considered as nutritious sustenance, feed and fodder crop.

Pearl millet rank first under the class of millets in India, in terms of area, production and productivity. The state of Rajasthan, Uttar Pradesh, Maharashtra, Haryana and Gujarat represent over 90% of all out zone under pearl millet and contribute similar level of production. There has been decrease in area of course cereals over the years and got shifted to pulses and oilseeds in kharif season. India is the largest producer of pearl millet in the world contributing an area of 7.1 Mha, production of 9.1 MT (Million Tonnes) per year with average productivity of 1272 kg/ha during 2014-15 while in Haryana area under pearl millet was 0.38 Mha with production and average productivity of 0.67 MT (Million Tonnes) and 1749 kg /ha, respectively [8].

For, any effective energy management program energy audit is the fundamental and necessary step for execution. It highlights the pattern of energy utilization in pearl millet processing, where and how much energy is utilized in the framework. It offers a chance to investigate energy consumption, to minimize losses and improving the efficiency of the system by using energy efficient equipment.

Today world has reached a stage, where energy is getting to be major cost factor in almost all processes in everyday life. Also, in many organizations energy and profit are closely related that the financial and energy audits are completely interconnected. Most of the organizations are weak in monitoring track of the energy spent and thus devouring more energy than what is required for ideal work. Energy review distinctly addresses these programmes. Any sparing in energy usage directly leads to the gainfulness of the organization. Hence for each organization it is necessary to give careful consideration towards the energy saving opportunities available to them, through proper energy audit. The present study is an attempt to highlight the pattern of energy utilization in pearl millet cultivation. [9].

2. MATERIALS AND METHODS

2.1 Selection of Work Area

This research work was carried out at Pearl Millet Lab., Centre for Excellence, CCS HAU, Hisar for studying energy use pattern during processing of pearl millet.

2.2 Pearl Millet Processing

As no large scale pearl millet processing unit was found in the state of Haryana, therefore, energy use pattern during pearl millet processing was studied in the established lab. of Centre for Excellence, Pearl Millet, HAU Hisar [10 and 11].

2.3 Manual Energy

Manual energy was calculated by the multiplication of number of person involved in processing operation with time [11].

$$Em = 0.075 \times N \times T$$

Where,

Em = Manual energy, kW
N = Number of person involved in operation
T = Time taken to complete process, h
0.075 is the average power of human labour in kW

2.4 Electrical Energy

Electrical energy used by the equipment was obtained by finding the rated power of each motor and the number of hours of operation. A motor efficiency of 80% was assumed to compute the electric input. Electric energy consumed by various unit operations during the pearl millet processing. Electrical equipments used in processing were milling machine, mixer, electric oven and spiral mixer. Required energy was calculated by following formulae [11].

$$Ep = \eta \times P \times T$$

Where,

Ep = Electrical energy consumed, kWh
P = Rated power of motor, kW
T = Time of operation, h
η = power efficiency (0.8)

3. RESULTS AND DISCUSSION

The study reveals the various unit operations carried out for the value added pearl millet products preparation as showed Fig. 1 below. Various unit operations such as drying, milling, mixing, baking and packaging were completed with the help of different equipments like dryer, Flour mill, oven and packaging sealer.

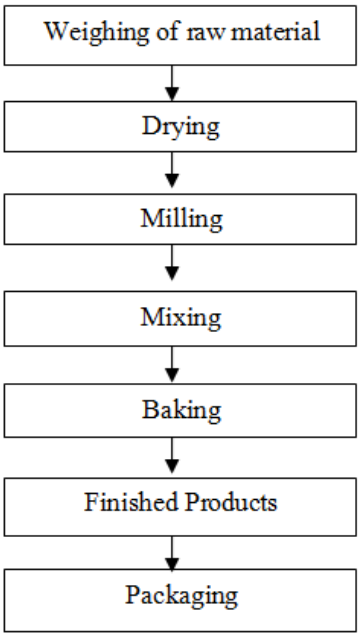

Fig. 1. Flow chart for biscuits and cake preparation

The energy consumption pattern during making of cakes and biscuits is given in Table 1. Manual energy (0.056 kWh/kg) was higher as compared to cake making (0.038 kWh/kg). Milling machine was used in both preparations and consumed same energy. Spiral mixer consumed higher (0.084 kWh/kg) energy as compared to simple mixer (0.047 kWh/kg) used for biscuit making. Baking time was same for both the products thus energy consumed by oven was same (i.e. 5.760 kWh/kg). Spiral mixer was used for making dough while simple mixer was used for making paste for cake. It can be seen from the table that for making 1kg of cake and 1kg of biscuits around 6.1 kWh/kg of energy is used. Basically two types of energy i.e. manual and electrical energy were used during processing of pearl millet for preparation of cake and biscuits. Electricity was the main energy source for pearl millet processing. Electricity was used to run electric oven, mixer, dough maker, mill, packaging machine, lights etc. In pearl millet processing, some of the operations were done manually namely, cleaning, making of biscuits, sun drying, feeding of biscuits in package and weighing etc. These operations was taken time 45 minutes for the biscuit preparation and 30 minutes for the cake preparation.

Basically two types of energy i.e. manual and electrical were used for processing of pearl

Table 1. Energy consumption pattern during processing

Energy Source	Energy use during cake making (kWh/kg)	Energy Source	Energy use during biscuit making (kWh /kg)
Manual (Paste Making)	0.056	Manual	0.038
Electrical appliances		**Electrical appliances**	
Milling Machine**	0.204	Milling Machine**	0.204
Spiral Mixer**	0.047	Mixer**	0.084
Electric Oven**	5.760	Electric Oven**	5.760
Total Energy	6.067	Total Energy	6.086

*** Electrical energy*

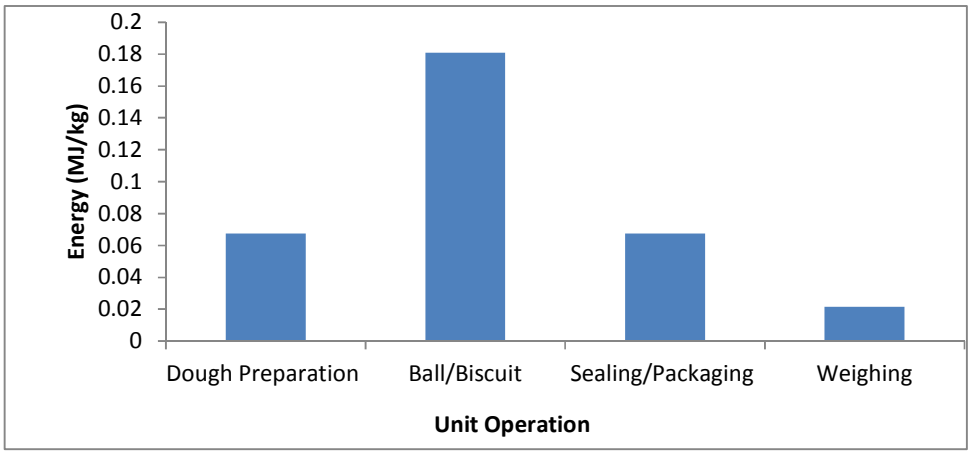

Fig. 2. Manual energy consumptions on different unit operation while biscuit preparation

millet. Manual energy used was around 8% while electrical energy used was around 92%. These findings are similar to many researchers [10,11 and 12] those reported for sugar production in Nigeria, rice milling industries and wheat processing in Nigeria. No large scale processing unit for pearl millet production was found in the state of Haryana. It was found after the study that there was a lot of scope of using some unconventional form of energy like solar energy in place of electrical energy for its conservation in pearl millet processing. Fig. 2 shows the highest energy consumed by ball/biscuits preparation followed by dough preparation, sealing/ packaging and weighing.

4. CONCLUSION

This research work covers the processing of pearl millet for the making of biscuit and cake at Centre of Excellence, Pearl Millet processing Lab., CCS HAU, Hisar. Electrical and manual energy were the two major sources of energy input in the production of biscuits and cakes. The energy used in the production of biscuits and cake was 6.086kWh/kg and 6.067kWh/kg. Manual energy used was around 8% while electrical energy used was around 92%. The highly energy intensive operation was energy consumption of Electric oven. Electricity was the main energy source for the value added products of pearl millet.

Highest electrical energy consumed in cake and biscuits preparation by electric oven (5.760) followed by spiral mixer (0.047), simple mixer (0.087) milling machine (0.204).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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