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Analysis of energy usage in the production of three selected cassava-based foods in Nigeria

S.O. Jekayinfa [a,*], J.O. Olajide [b]

[a] Department of Agricultural Engineering, Ladoke Akintola University of Technology, P.M.B. 4000, Ogbomoso, Oyo State, Nigeria
[b] Department of Food Science and Engineering, Ladoke Akintola University of Technology, P.M.B. 4000, Ogbomoso, Oyo State, Nigeria

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Abstract

A study was conducted in 18 cassava processing mills situated in the southwestern part of Nigeria to investigate the energy utilization pattern in the production of three different cassava products, viz: 'gari', cassava flour and cassava starch. Six mills specializing in the production of each of the products were randomly selected for investigation. The computation of energy use was done using the spreadsheet program on Microsoft Excel. Optimization models were developed to minimize the total energy input into each production line. The results of the study showed that the observed energy requirements per tonne of fresh cassava tuber for production of gari, starch and flour were 327.17, 357.35 and 345 MJ, respectively. The study identified the most energy-intensive operations in each production line and concluded from optimization results that the total minimum energy inputs required for the production of gari, cassava starch and cassava flour per tonne of fresh cassava tuber were 290.53, 305.20 and 315.60 MJ, respectively.

Keywords: Cassava products; Energy requirement; Unit operation; Optimization models

1. Introduction

1.1. Energy use and analysis in food processing

Energy and food are major concerns of most of the developing countries such as Nigeria. About 70% of Nigerian population depends on agriculture which contributes more than 40% to the gross national product of the country. With the introduction of high-yielding varieties, intensive cropping systems, increased usage of fertilizers and chemicals, and high level of farm mechanization, the modern agriculture has become energy intensive. As in other industries, rising fuel cost and supply limitations plague every sector of Nigerian agricultural industry and these industries are now, more than ever before sensing the need for energy related research to reduce costs through energy conservation and prevent possible shut downs consequent to reduced availability of energy resources.

Few processing factories have any precise idea of the energy consumption of different production areas and in the absence of detailed internal monitoring, the energy efficiencies of different operations is also usually unknown. Knowledge of energy consumption for each product in a factory is useful for several purposes such as budgeting, evaluation of energy consumption for a given product, forecasting energy requirement in a plant, and for planning plant expansion. A limited number of studies have been reported in literature on the determination of energy contents of field operations. These include a study reported by Chang, Chang, and Kim (1996) involving the development of an energy model and a computer simulation model to assess the requirements of electricity, fuel and labour for rice handling, drying, storage and milling processes in Rice Processing Complex (RPC) in Korea.

Harper and Tribelhorn (1995) compared the relative energy costs of village – prepared and country processed

* Corresponding author. Tel.: +234 8033942248.
E-mail address: jekaysol@yahoo.com (S.O. Jekayinfa).

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Nomenclature

Pl	peeling
W	washing
G	grating
D	dewatering
GD	grinding
C	chipping
S	sieving
F	frying
FG	filtering
R	re-sieving
P	post-grinding
M	mixing
SW	starch washing
ML	milling
DR	drying
CB	cake breaking
Z	production output of a particular cassava product

Subscript

g	gari
s	cassava starch
f	cassava flour

weaning foods, both made from the same ingredients, but processed differently before being used. Palaniappan and Subramanian (1998) analysed the 5-year energy consumption data for 25 tea factories in South India. The variation in energy consumption in killowatt hour per kg of tea made in both CTC and orthodox factories-based on factors such as type of tea produced, production capacity of factories climate, etc., were analysed. They also studied the specific energy consumption for the different processes. The consumption of direct energy from major sources in tea industry in Assam India was studied by Baruah and Bhattacharya (1996). They submitted that a tea garden required an estimated 18,408 MJ/ha of human energy in the first year. Other similar works reported in literature relating to evaluation of energy efficiency in processing industries include cashew-nut processing in Nigeria (Jekayinfa & Bamgboye, 2003, 2006); palm-kernel oil processing in Nigeria (Jekayinfa & Bamgboye, 2004, 2007) rice production in Bangladesh (Islam, Rahman, Saker, Ahduzzaman, & Baqui, 2001) sugar-beet production in Morocco (Mrini, Senhaji, & Pimentel, 2002) and, energy and labour use in Italian agriculture (Pellizzi, 1992). This study was undertaken to investigate the energy use pattern in the selected cassava processing mills in southwestern Nigeria and to develop predictive models that could estimate and optimize the energy demand of each unit operation for different selected cassava products.

1.2. Cassava

Cassava (*Manihot esculenta Crantz*) is a perennial vegetatively propagated shrub commonly cultivated within the lowland tropics. The world production of cassava root increased from 70 million tonnes in 1960 to 154 million tonnes in 1991 (CIAT, 1993). Subsequently, the estimated annual global production of cassava between 1998 and 2001 was 168 million tonnes fresh weight out of which about 70% was produced in Nigeria, Brazil, Thailand, Indonesia and Democratic Republic of Congo (FAO, 2001).

Cassava is the second most important staple, after maize in terms of calories consumed and a major source of calories for about 40% of the African population (Nweke, 1992). It thus alleviates food crisis in Africa because of its agricultural advantages. The main advantages are higher yield per unit area of land as well as per unit of labour compared to other cereals under similar conditions. It is tolerant to drought and produces on poor soils where other staples fail. Cassava roots are rich in carbohydrates, but other nutrients are in low levels (Cock, 1985).

Nigeria still remains the largest cassava producer in the World producing about 35 metric tonnes/annum. Nigeria's *primum inter pares* position is mainly due to the distribution of the high yielding, disease resistant varieties. These cassava varieties were developed by the International Institute of Tropical Agriculture (IITA), and other national research institutes like the National Root Crop Research Institute (NRCRI), as well as the Federal Government's effort in increasing food crops through their various programmes like the National Accelerated Food Production Programme, Operation Feed the Nation, the Agricultural Development Project assisted by IFAD Cassava Multiplication Programme, which according to Oke (2005) could give as high a yield as 80–90 tonnes/ha.

One of the major problems associated with cassava is the rapid post harvest deterioration, which renders it unpalatable as food. Initially, deterioration is due to physiological processes, which occur within 2–3 days of harvest, and are subsequently followed by microbial deterioration within 5–7 days (Beeching, Dodge, Moore, & Wenham, 1994). Deterioration necessitates the prompt consumption or processing of cassava soon after harvest.

Processing of cassava is necessary for several reasons: it is a means of removing or reducing the potentially toxic cyanogenic glucosides present in the fresh cassava. Processing as a means of preservation yields products that have different characteristics and thus create variety in cassava diets. Numerous methods of processing have been developed for cassava in different parts of the world and these