African Journal of Biotechnology Vol. 8 (25), pp. 7283-7289, 29 December, 2009
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2009 Academic Journals

Review

Impact of gari consumption on the water resource of Nigeria

O. Adeoti*, T. A. Ayelegun and B. A. Oyewole

Department of Agricultural Engineering, Federal Polytechnic, PMB 5351, Ado Ekiti, Ekiti State, Nigeria.

Accepted 27 November, 2009

The consumption of gari (or roasted cassava granule) is connected to a chain of impacts on the water resource in the country where cassava crop is grown, processed and consumed. The aim of this paper is to assess the impact of gari consumption on the water resource of Nigeria. The paper elaborates on two types of impact: evaporation of infiltrated rainwater for cassava plant growth (green water use) and the abstraction of ground and/or surface water for processing, including that of consumption at household level (blue water use), while water pollution impacts during processing and consumption (at households) are neglected. Using the 2007 cassava production estimates for Nigeria as baseline, the water impact related to the consumption of gari either as snack or as "eba" (gari reconstituted with hot water to form a dough-like paste) is estimated at 10.52 x 10^9 m^3, out of which 0.38% is due to the use of blue water and 91.3% is due to the use of green water (no dilution water impacts measured in this paper). Under the traditional farming practices, the major volume of water needed to grow the cassava plant is from rainwater. For the total water needed in gari consumption starting from cultivation, the water used in the processing and consumption (at household level) is a significant fraction (about 0.4%) of the soil moisture used to grow the cassava plant. However, the impact of this fraction is often significant: One, it is the blue water (abstracted from surface and/or sub-surface sources) that is often scarcely available and two, it is this blue water sources that are also polluted by the waste flows from the processing and consumption sites.

Key words: Water footprint, virtual water, water resource, blue water, green water, roasted cassava granule (or, gari), Nigeria.

INTRODUCTION

Worldwide in 2007, cassava production is estimated at 228.14million tonnes, with Africa responsible for about 52% (FAO, 2008a). Production in Nigeria (in 2007), estimated at about 46 million tonnes, is by far the largest in the world (FAO, 2008a). There is paucity of data on gari production at the global level, but under a conservative estimate, gari production in the sub-Saharan Africa roughly amount to 80% of the total production of fresh cassava root for the region, while gari production in Nigeria accounts for about two-third of fresh (unpeeled) cassava roots. Gari is a granulated, white or yellowish product, depending on production method. Its moisture content varies, but not more than 15% in most cases, which enables it to store for up to one year under normal atmospheric conditions. It swells three to four times its volume when mixed with cold water (FAO, 1998).

The growing natural resources shortage has posed the need to assess the amount of natural resources that are needed in order to consume a certain product. Gari consumption is made possible through the use of human and non-human resources required in the producing countries. One of the non-human resources required is water. Water is needed for growing the plant and water is also needed to process the crop into the final product, gari and also to consume it. Currently, there is thin literature on the impact of gari consumption on water resource. This paper is therefore meant to bridge that gap by assessing the volume of water required to consume gari using the water footprint concept. The concept is an indicator that specifies the amount of water needed to bring a certain product to consumption level in a

*Corresponding author. E-mail: olusegunadeoti@yahoo.co.uk. Tel: +234 (0) 80 34 56 24 76.

country (Chapagain et al., 2005), which by implication is the relative impact of such production-consumption on water resource. The water footprint concept uses the virtual water concept as input, while virtual water could be defined as the amount of water needed to produce a good or a service (Hoekstra and Chapagain, 2007). As a first step, the paper estimates the virtual water content of gari and next, it calculates the water impact of gari consumption in Nigeria, which includes the volume of water needed to consume the product (gari) either as snack (gari mixed with cold water eaten with additives (optional) such as sugar, groundnut, milk, etc) or as "eba" (gari reconstituted with hot water to give a dough-like paste, which is consumed with sauce).

Gari is one of the products of cassava (*Manihot esculenta,* Crantz) and various literatures exist on its processsing steps from fresh root (see for example-Codex Alimentarius Commission, 1995; Apea-Bah et al., 2009; Ogunleye et al., 2008; Oluwamukomi et al., 2007; Sanni, 1995; Nweke, 1996; Bokanga, 1996; FAO, 1998). Cassava, which is native to South America and Southern and Western Mexico, was one of the first crops to be domesticated and there is evidence that it was grown in Peru some 4,000 years ago and in Mexico some 2,000 years ago (Duke, 1983). The plant, which is a root crop (Nwabanne, 2009), is a short-lived shrub which is grown almost anywhere in the area between latitude 30°N and 30°S and is potentially one of the most efficient crops in terms of carbohydrate production per hectare (Bokanga, 1996). It is adapted to temperatures ranging from 18 to 25°C and to rainfall of 50 to 5,000 mm annually and to poor soils with pH ranging from 4 to 9 (O'Hair, 1995). It is believed that from Mid and South America, cassava spreads to other parts of the world in the post-Columbian times and was introduced into the West Coast of Africa and Zaire in the late sixteenth century and was introduced into East Africa (Madagascar and Zanzibar) by the end of the eighteenth century and by 1800, it had reached India and was widely grown in Africa and Southern Asia by the 1850s. By 1994, it was believed to be consumed by some 500 million people in the Tropics, out of which more than 200 million was from the sub-Saharan Africa (IITA, 1994).

The fresh root of cassava, which contains about 65% water (Colombia, 2007), cannot be stored for long because they rot within 2 - 4 days after harvest (Nweke, 1996; Bokanga, 2002; Phillips et al., 2004). The root crop is very rich in carbohydrate [about 30% (Asiedu, 1989)], out of which 25-40% is starch (O'Hair, 1990, 1995). Cassava is the highest producer of carbohydrates with perhaps the exception of sugarcane. The average yield in some producing regions (in 2007) varies from 4 to 23 tons/ha of fresh root (FAO, 2008a), although under good conditions, yields could reach 90 tons/ha of fresh root (Bokanga, 1996). Cassava produces yields on poor or depleted soils where other crops yield essentially nothing and also is well adapted to areas that experience long dry season and uncertain rainfall (Bokanga, 1996; Wang, 2002; Nguyen et al., 2006). A mature cassava root depending on the cultivar, field management and age at maturity, may range in length from 15 to 100 cm and weigh 0.5 to 2.5 kg and the food quality of roots, particularly the starch content, increases with time up to an optimal period of 12 to 15 months after planting (Bokanga, 2002). Cassava may be harvested in 10 - 14 months (Duke, 1983), but at least, it requires 8 months of warm weather to produce a crop (O'Hair, 1995).

IMPACT OF GARI CONSUMPTION ON WATER RESOURCE

From field to end product, gari production passes through a number of stages with different impact on water resource. Under the traditional method (cultivation and processing), these stages of production are often carried out in different locations and consumption can take place as yet in another location. The relation between the production and consumption stages and their impacts on water resource is as shown in Figure 1.

Although the chain from cassava growth to consumption can take several distinct steps, there are three major stages (Figure 1): One, the agricultural stage (cassava root production at field level); two, the processing stage (processing of cassava root into final product, gari) and three, the consumption stage (mostly at the household level). In the first stage, one type of impact exists: evaporation of infiltrated rainwater for cassava growth (refer to in this paper as green water) (the use of fertilizers and chemicals for cassava crop production at field level under traditional farming methods is not yet common in Nigeria). In the second stage, there are two major impacts on water: abstraction of process water from surface and/or groundwater (referred to in this paper as blue water) and pollution of water as a result of the waste flows from the cassava processing sites. The dilution water volumes required to dilute waste flows (waste flows contain soluble cyanide and organic acid, starch and fine particles of grated mash) to such extent that the quantity of the resulting water remains below agreed water quality standards is not made in this paper. In the third stage, two types of impact exist: abstraction of process water from surface and/or sub-surface sources at the household level for the processing of gari for consumption either as snack or as dough-like paste and the waste flows (mostly organic) resulting from the cleaning of utensils used in the consumption process. Also, the dilution water required at this stage has been essentially ignored.

VIRTUAL WATER CONTENT OF GARI

The virtual water content of gari is the volume of water required to produce one unit of gari, generally expressed

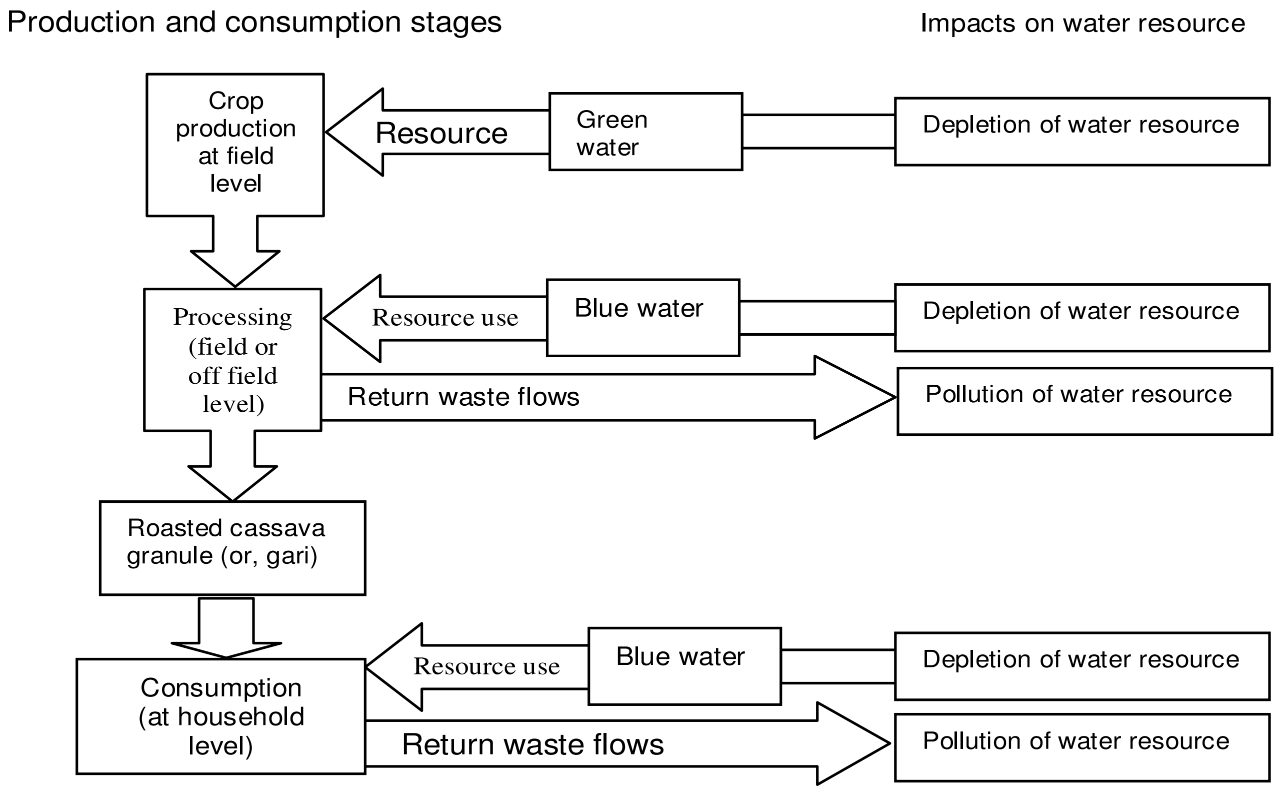

Figure 1. Impact of gari consumption on water resource (under traditional production and processing methods in Nigeria).

in terms of cubic metres of water per tonne of gari. This is different in the different stages of processing to consumption. In the case of cassava root production under rainfed agriculture, the virtual water content of fresh (unpeeled) cassava root is calculated based on the rain water use of the cassava plant (in m^3/ha) and the yield of fresh (unpeeled) cassava root (in tonne/ha). After each processing step, the weight of the remaining product is smaller than the original product. Following the methodology described by Chapagain and Hoekstra (2004), the virtual water content of the resulting product is found by dividing the virtual water content of the original product by the product fraction, while the product fraction (pf) in a certain processing step is the ratio of the weight of the resulting product to the weight of the original product. With this, the virtual water content of the resulting product (in m^3/tonne) becomes larger than the virtual water content of the original product. If a particular processing step requires water (e.g., the process of washing peeled cassava root), the water required (in m^3/tonne of original product, peeled cassava root in this case) is added to the initial virtual water content of the original product before translating it into value for the virtual water content of the resulting product.

Under the traditional farming method (which is more predominant in Nigeria), the volume of water needed to grow the cassava plant in the field has only one component: the use of effective rainfall (or green water) (no irrigation practiced). Effective rainfall is that portion of the total rainfall used by crop. The CROPWAT model developed by the Food and Agriculture of the United Nations (FAO, 2008b) was used to estimate the effective rainfall requirement for the cassava plant (this is lesser than the crop water requirement for a non-water stressed field). The crop coefficients for the cassava plant were taken from Allen et al. (1998). The climate data required as input factor into the CROPWAT model were taken from the CLIMWAT database of FAO (1994a), while data on crop production per unit area of land (in tonne/ha) were obtained from the FAOSTAT database (FAO, 2008a) averaged for the period 2000 to 2007. In the model, an average maturity age of 360 days for cassava plant was used. It is assumed that cassava cultivation would start in the early week of May, while first harvesting will start in the last week of April the following year. The green virtual water content of the cassava root (V_{green}) was estimated as the ratio of the effective rainfall ($P_{effective}$) to the crop yield (Y) according to equation 1.

$$V_{green} = \frac{P_{effective}}{Y} \quad (1)$$

The different processing steps that transform the fresh (unpeeled) cassava root to gari under the traditional processing steps are as shown in Figure 2. From the field

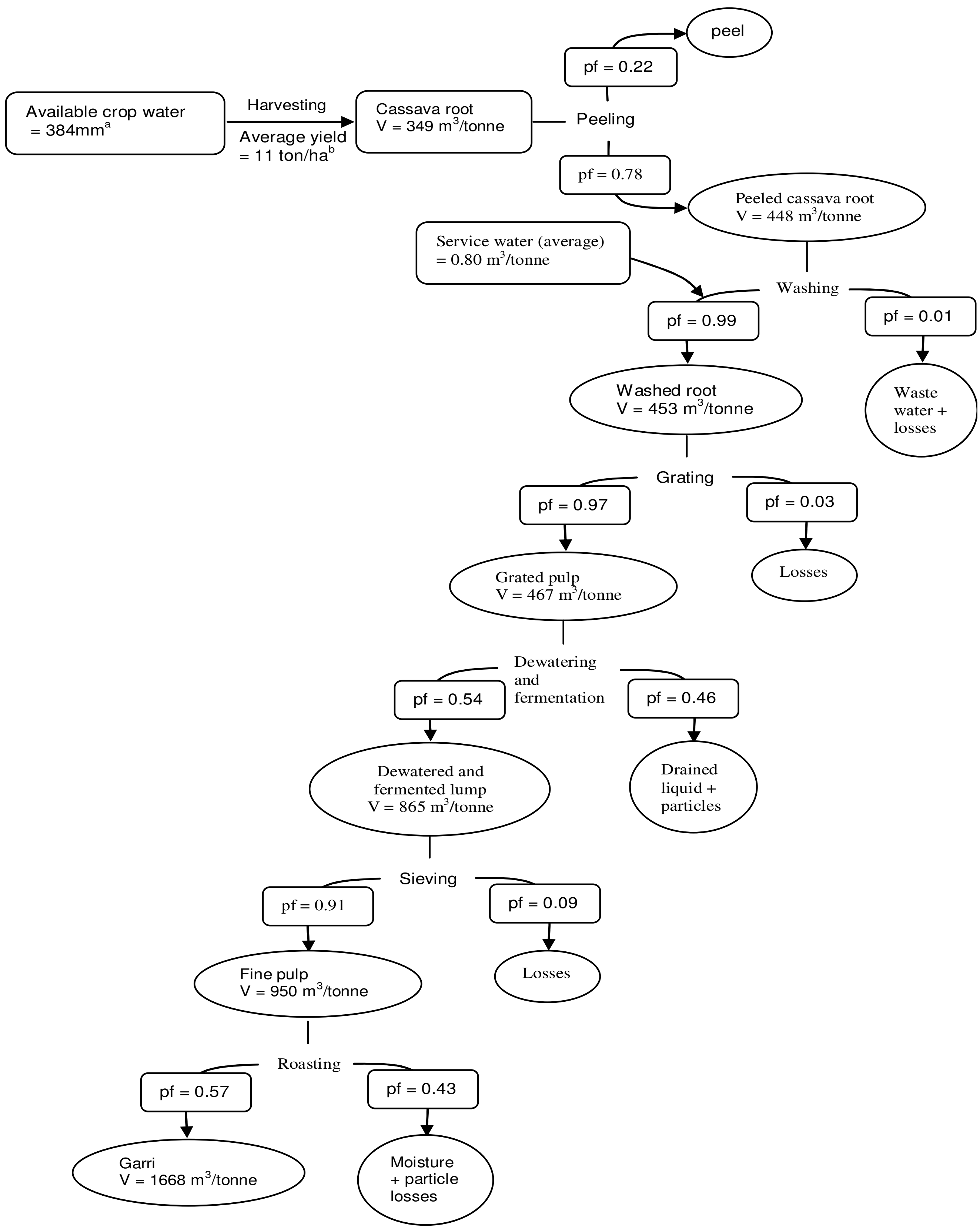

Figure 2. Product tree for gari, showing the product fraction and the virtual water content per processing step (values are for Nigeria, under traditional processing method, rainfed agriculture). [a]Evaluated under rainfed agriculture, averaged for 15 cassava growing States in Nigeria. [b]Average value for 2000 to 2007 (FAO, 2008a). V = Virtual water content; pf = product fraction.

Table 1. Summary sheet of field data.

S/N	Item	1st reading	2nd reading	3rd reading	4th reading
1.	Date of harvest	09/03/09	11/03/09	13/03/09	16/05/ 09
2.	Age of cassava plant at harvest	20 months	20 months	20 months	22months
3.	Weight (Wt.) of fresh (unpeeled) cassava root	17.40 kg	29.48 kg	24.74 kg	137.34 kg
4.	Wt. of peeled fresh cassava root	13.97 kg	23.20 kg	20.40 kg	96.33 kg
5.	Amount of water used for washing	15 litres	18 litres	20 litres	34 litres
6.	Wt. of washed root	13.96 kg	23.19 kg	20.40 kg	96.32 kg
7.	Wt. after grating	12.59 kg	23.03 kg	19.97 kg	95.23 kg
8.	Wt. of dewatered and fermented lumps	7.8 kg	11.35 kg	11.60 kg	45.98 kg
9.	Fermentation period	5 days	5 days	5 days	4 days
10.	Amount of liquid + particle loss	6.19 kg	11.95 kg	8.57 kg	51.28 kg
11.	Wt. after sieving (fine pulp)	7.35 kg	10.97 kg	11.30 kg	45.975 kg
12.	Wt. after roasting (roasted granule)	4.55 kg	6.11 kg	6.50 kg	24.31 kg
13.	Moisture content of roasted granule	10%	7%	8%	6%

analysis carried out (Table 1), from fresh (unpeeled) cassava root the weight reduction occurs in steps. On the average, 22% of the weight of the fresh root is lost to peel (influenced by peel moisture content, cultivar type, peeling technique, etc), while about 99% of the peeled fresh root remains after washing (influenced by handling, removal of unwanted peeled root, etc), 97% of the washed root remains after grating (influenced by handling, machine losses, etc), 54% of the grated root remains after dewatering and fermentation (fermentation period was between 4 and 5 days, Table 1) (also influenced by root moisture content, cultivar type, degree of fineness of pulp, the amount of pressure exerted and the porosity of the containing sack) and 91% of dewatered pulp remains after sieving [influenced by handling, sieve used - raffia or metal, amount of lignifications (or dry matter) removed]. From sieving to roasting, there is yet another weight reduction due to reduction in moisture content. The remaining fraction after roasting is about 23% of the original unpeeled fresh cassava root (influenced by the degree of dryness, age at harvest, etc.). For washing of root, the amount of water used is averaged at 0.8 m^3 per tonne of fresh (peeled) cassava root (Table 1), although this amount depends on the degree of dirt to be removed from the peeled root (e.g., it may be high if roots are harvested shortly after rainfall event and the soil is muddy), the scale of production and the peeling/washing technique employed. Service water required for equipment cleaning (e.g., peeling knives, grating machine and collecting sacks, roasting pan, etc) and for maintaining the sanitary condition of processing site has been essentially ignored in this paper, although it could be substantial depending on field situations.

The average crop water used under rainfed agriculture for 15 cassava producing States in Nigeria is as presented in Figure 2. The water requirement per unit of crop production is influenced by climate evaporative demand which has a direct effect on the water footprint. Also from Figure 2, the virtual water content of fresh (unpeeled) cassava root is 349 m^3/tonne - this represents the relative impact of the production of fresh (unpeeled) cassava root on (soil) water resource, while that of gari is about 1668 m^3/tonne - representing the relative impact of the production of gari on water resource. As seen from Figure 2, the virtual water content of gari (1668 m^3/tonne) is larger than the virtual water content of cas-sava root (349 m^3/tonne) because weight loss (due to end-use requirement, inefficiencies, the technologies adopted, etc) in the various processing steps is account-ted for and also the service water (0.80 m^3/tonne) used. In the paper, the volume of water needed to produce gari from cassava root depends largely on two factors: One, water for cropping (from rain water) and two, water for processing (from surface and/or sub-surface sources). Water for cropping depends on climate and yield per hectare, while yield in turn, depends on cultivar, soil conditions and field management practices used. Water for processing depends on the time of harvest/yield size, processing techniques and the scale of operation.

WATER IMPACT OF GARI CONSUMPTION IN NIGERIA

In 2003 estimates, roughly 92% of fresh (unpeeled) cassava root was used for gari production in Nigeria according to Africabiz Online (2004), but according to FAO (1994b), gari production in Nigeria represents about 70% of cassava-based products. In another study, it is estimated that about 70% of the total cassava root production in Nigeria was processed into gari, akpu and lafun, mostly in the rural areas of the South and Middle belt regions of Nigeria (Government of the Federal Republic of Nigeria, 2006). Under a conservative average of 60% conversion therefore (using the 2007 cassava production estimates as baseline), Nigeria has a gari-production related water footprint of 10.5 x 10^9 m^3, which is about 73 m^3 of water per capita (in 2009 population estimates) on the average. About 91.4% of this impact is due to the use of green water, while about 0.2% is due to the use of blue water. The total water requirement for the production of gari is equivalent to about 5.3% of the estimated water resource of Nigeria.

In Nigeria, gari is consumed in two ways: One, eaten as snack when mixed in cold water with additives (optional) such as groundnut, sugar, milk, etc and two, eaten as “eba” when mixed in hot water to form a dough-like paste which is consumed with sauce (soup or stew). As snack, the quantity of gari needed per person varies from 0.06 to 0.36 kg. Under a moderate average of 0.18 kg per person per cup, about 0.5 x 10^{-4} m^3 of water (blue water) will be needed to drink it, translating to a total of 0.0175 x 10^9 m^3 of water. The Nigerian community therefore has a gari snack-related water impact of 10.5175 x 10^9 m^3. But if gari is consumed as “eba”, at an average of 0.12 kg of gari per person and 3.5 x 10^{-4} m^3 of hot (liquid) water (blue water), the amount of hot water needed (excluding vapourised hot water) is about 0.0184 x 10^9 m^3, translating to a total of eba-related water impact of 10.5184 x 10^9 m^3. Although the amount of water needed to consume gari as eba is slightly higher than that of gari as snack, for simplicity, the average (0.02 x 10^9 m^3 of water) will be used in the rest of this paper. With this, the impact of gari consumption on the water resource of Nigeria therefore translates to 10.52 x 10^9 m^3 of water, out of which 91.3% is green and 0.38% is ob-tained directly from blue water sources in the processing and consumption stages.

Under the traditional farming practices, the major volume of water needed to grow the cassava plant comes from rainwater. For the total water needed in gari consumption starting from cultivation, the water used in the processing and consumption is a significant fraction (about 0.4%) of the soil moisture used to grow the cassava plant. However, the impact of this fraction is often significant, because it is the blue water (abstracted from surface and/or sub-surface sources) that is scarcely available and also, it is this blue water sources that are often polluted by the waste flows from the processing and consumption sites. The water impact of gari consumption measured in this paper (10.52 x 10^9 m^3 of water) is expected to increase if processing dilution water impact (which can be minimised if return flows from processing sites are treated), water impact due to cleaning of processing equipment and machinery and for maintaining a sanitary processing environment and water impacts due to washing of utensils needed for the consumption process of roasted cassava granule and that of vapour water that occurs during boiling of water for making eba at the households are accounted for. In the consumption assumption, gari leakages to (or, from) other countries have been ignored due to paucity of data on the amount of such leakages.

CONCLUSION AND RECOMMENDATIONS

The paper has shown that the impact of gari consumption (in 2007 cassava production estimates) on the water resource of Nigeria is about 10.52 x 10^9 m^3 of water; about 0.38% of this is expected directly from blue water sources-surface and/or sub-surface. Since the cassava crop is produced, processed and consumed in Nigeria under the assumptions made, the estimated water footprint of gari is an indication of the relative impact of gari consumption on the water resource of Nigeria. This impact is expected to increase if pollution water impacts and others, such as, the amount of water loss to vapourisation during water boiling (although not measured in this paper) are taken into consideration.

Rising population and incomes in Nigeria will directly or indirectly call for increase in the production of cassava root and its subsequent increase in gari production and consumption. The burden of this increase will clearly fall on the fresh water resource of Nigeria, which is finite and gradually becoming scarce. To minimise future impacts due to gari consumption on water resource in Nigeria, the following recommendations are made:

1. The need to improve field level yield of cassava root from its present average low level of 11 to over 50 tons/ha. Such improvements should target the provision of high yielding cassava cultivar, soil nutrient enhancers (e.g., the use of organic fertilizers, since the use of mineral fertilizers may further limit blue water availability), proven pests and diseases control methods, etc.
2. The need to minimise processing losses, through the use of appropriate techniques and technologies. For example, eliminating sieving losses by milling oversized lumps could lower the virtual water content of gari by about 8% (adjusting for milling and other handling losses).
3. The need to institute policy provisions that will encourage in-situ treatment of waste flows from processing and consumption sites. In this regard, the national policy on the environment of 1989 should be amended to incurporate this additional task, while the functions of the National Environmental Standards and Regulations Enforcement Agency (NESREA) should be expanded to include the regulation and the provision of infrastructure to facilitate in-situ treatment of waste flows from gari processing and consumption sites by amending the NESREA Act of 2007.

ACKNOWLEDGEMENT

Authors are grateful to Adenike M. Aladegbamigbe for facilitating the field level data collection for this study.

REFERENCES

Africabiz Online (2004). B-Gari’s market in Africa. Africabiz; 1(61)

[Online]. http://businessafrica.net/africabiz/arcvol1/is61front.php (June 9, 2009)

Allen RG, Pereira LS, Raes D, Smith M (1998). Crop evapotranspiration: Guidelines for computing crop water requirements, FAO Irrigation and Drainage Paper, Vol. 56, [Online]. http://www.fao.org/docrep/X0490E/ X0490E00.htm (September 6, 2008)

Apea-Bah FB, Oduro I, Ellis WO, Sofo-Kantanka O (2009). Principal components analysis and age at harvest effect on quality of gari from some elite cassava varieties in Ghana. Afr. J. Biotechnol. 8(9): 1943-1949 [Online]. http://www.academicjournals.org/AJB/PDF/ pdf2009/4May/ApeaBah%20et%20al.pdf (June 9, 2009)

Asiedu JJ (1989). Processing tropical crops-A technological approach. Macmillan, London.

Bokanga M (1996). Biotechnology and cassava processing in Africa. IITA Research, 12: 14-18.

Bokanga M (2002). Chapter xii cassava: Post-harvest Operations [Online]. http://www.fao.org/inpho/content/compend/text/ch12.htm (September 6, 2008)

Chapagain AK, Hoekstra AY (2004). Water footprints of nations. Value of water research report series, vol. 16, UNESCO-IHE, Delft, the Netherlands [Online]. http://www.waterfootprint.org/Reports/ Report16Vol1.pdf (September 6, 2008)

Chapagain AK, Hoekstra AY, Savenije HHG, Gautam R (2005). The water footprint of cotton consumption: An assessment of the impact of worldwide consumption of cotton products on the water resources in the cotton producing countries. Ecological Economics 60(2006): 186-203 [Online]. http://www. waterfootprint.org/Reports/Chapagain_et_al_2006_cotton.pdf(August 19, 2008)

Codex Alimentarius Commission (1995). Codex standard for gari [Online]. www.codexalimentarius.net/download/standards/ 49/CXS_151e.pdf (June 9, 2009)

Colombia C (2007). Technology of South Crown China for cassava industrialization [Online]. http://www.clayuca.org/clayucanet/ edicion10/ presentaciones/china_2007.pdf (September 20, 2008)

Duke JA (1983). Manihot esculenta Crantz. Handbook of energy crops [Online]. http://www.hort.purdue.edu/newcrop/duke_ energy/Manihot_esculenta.html(August 30, 2008)

FAO (1994a). CLIMWAT database [Online]. http://www.fao.org/nr/water/ infores_ databases_climwat.html (August 30, 2008)

FAO (1994b). African experience in the improvement of post-harvest techniques [Online]. http://www.fao.org/docrep/W1544E/ W1544E01.htm (June 13, 2009)

FAO (1998). Chapter 5-Processing of roots and tubers in the tropics [Online]. http://www.fao.org/docrep/x5415e/x5415e05.htm# chapter%205%20%20%20processing%20of%20roots%20and%20tubers (May 25, 2009)

FAO (2008a). FAOSTAT database [Online]. http://faostat.fao.org/ site/567/DesktopDefault.aspx?PageID=567#ancor (September 6, 2008)

FAO (2008b). CROPWAT model [Online]. http://www.fao.org/nr/water/ infores_databases_cropwat.html (August 30, 2008)

Government of the Federal Republic of Nigeria (2006). Cassava production, processing and marketing project [Online]. ftp://ftp.fao. org/docrep/fao/008/ag065e/ag065e00.pdf (June 13, 2009)

Hoekstra AY, Chapagain AK (2007). Water footprints of nations: Water use by people as a function of their consumption pattern. Water Resources Management 21: 35-48 [Online]. http://www. waterfootprint.org/Reports/Hoekstra_and_Chapagain_2007.pdf (August 19, 2008)

IITA (1994). Breeding cassava for safer consumption, higher protein. IITA, Ibadan.

Nguyen TLT, Gheewala SH, Garivait S (2006). Life cycle cost analysis of fuel ethanol produced from cassava in Thailand [Online]. http://www.kmutt. ac.th/see1/cd/file/C-024.pdf (September 20, 2008)

Nwabanne JT (2009). Drying characteristics and engineering properties of fermented ground cassava. Afr. J. Biotechnol. 3(5): 873-876 [Online]. http://www.academicjournals.org/AJB/PDF/pdf2009/6Mar/Nwabanne. pdf (June 9, 2009)

Nweke FI (1996). Cassava processing in sub-Saharan Africa: Implications for expanding cassava production. IITA Research, 12: 7-14.

Ogunleye IO, Adeyemo SB, Adeyemi MB (2008). Effects of moisture contents on the physical, thermal and isothermal drying properties of granular cassava particles. J. Eng. Appl. Sci. 3(5): 416-423 [Online]. http://207.56.205.141/fulltext/jeas/2008/416-423.pdf (June 9, 2009)

O'Hair SK (1990). Tropical root and tuber crops [Online]. http://www.hort.purdue.edu/newcrop/proceedings1990/V1-424.html# Cassava(August 30, 2008)

O'Hair SK (1995). New crop fact sheet: Cassava [Online]. http://www.hort.purdue.edu/newcrop/cropfactsheets/cassava.html# Crop%20Culture%20(Agronomy/Horticulture) (August 30, 2008)

Oluwamukomi MO, Adeyemi IA, Odeyemi OO (2007). Physicochemical properties of Gari fortified with soy-melon blends at different stages of processing. Res. J. Biol. Sci. 2(1): 28-32 [Online]. http://medwelljournals. com/fulltext/rjbs/2007/28-32.pdf (June 9, 2009)

Phillips TP, Taylor DS, Sanni L, Akoroda MO (2004). A cassava industrial revolution in Nigeria: The potential for a new industrial crop [Online]. http:// www.fao.org/docrep/007/y5548e/y5548e00.htm (September 6, 2008)

Sanni MO (1995). The transfer of improved gari production technology [Online]. http://horizon.documentation.ird.fr/exl-doc/pleins_textes/ pleins_textes_6/colloques1/43550.pdf (May 25, 2009)

Wang W (2002). Cassava production for industrial utilization in China - Present and future perspectives [Online]. http://www.ciat.cgiar.org/ asia_cassava/ pdf/proceedings_workshop_02/33.pdf (December 29, 2008)