Determination of Juice Removal Difficulty from Mash Cake in Cassava Mash Dewatering Operation

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Abstract

Cassava processing equipment operators have limited knowledge; this militates against the success recorded in the research so far in cassava mash dewatering. New dewatering schemes to make food processing economical to handle are in progress. Common dewatering processes use a variety of mechanical means such as screw presses and belt presses. Experiments were conducted using three samples of TMS 4(2) 1425 variety while evaluating the difficulty of separating juice from mash cake. Average specific cake resistance (α) of 5×1011 m/kg was obtained confirming that it is moderately easy to dewatering.

Keywords

Mash Cake; Cassava; Mash; Dewatering; Cake Resistance; Cassava juice; Flour; Separation.

Introduction

Cassava, are both important household food security and income generating crops in many African countries [1]. Well over five million people in Africa depend on this crop for food, feed and income. Many of these people are the poorest of the poor. Cassava is in used more in processed forms for food [2]. Cassava represents an important part of the economies of most regions of Africa. However, due to the perishability of the crop (table 1), processing is necessary to increase shelf-life [3].

Table 1. Crop losses in less-developed countries

Crop	Estimated loss (%)	Crop	Estimated loss (%)
Apples	14	Papayas	40-100
Avocados	43	Plantain	35-199
Bananas	20-80	Potatoes	5-40
Cabbage	37	Onions	16-35
Carrots	44	Raisins	20-95
Cassava	10-25	Stone fruit	28
Cauliflower	49	Sweet potatoes	35-95
Citrus	20-95	Tomatoes	5-50
Grapes	27	Yams	10-60
Lettuce	62		

Source : http://www.nepadst.org/platforms/foodloss.shtml

Overcoming the perishability of the crops, enhancing nutritional value and adding economic value through processing are the main ways of enlarging food security in Africa. Available technologies for processing roots and tubers limit these crops from reaching their full potential as sources of both food and income [4]. The development and introduction of new processing technologies offer potential to improve food security and local industrialization [5]. Research information on mechanization of planting and harvesting of cassava are available [6]. There are on-going researches on manual and mechanized processing of cassava [7]. Mechanized cassava processing is now established activity and there are several cassava processing plants [11]. Despite the steady increase in the rate of adoption of mechanized cassava processing there are factors which militate against the adoption of the technology. Mechanized cassava processing is often not a viable venture because the products have to compete with traditional products which are under-priced. The traditional processors rely on family labour which is not perceived as cost. To process cassava tuber the juice has to be removed and this juice is toxic [8]. Removal of juice from cassava is one of the most difficult processes [7]. Cassava processors cannot afford large and costly equipment they often depend on local ways and dewatering methods available [9]. Cassava processing equipment operators in traditional and small scale cassava processing plants also have limited managerial capabilities and training due to little formal education and this militates against the success recorded in the research so far in cassava mash dewatering.

Cake dewatering process involved removal of filtrate trapped within the void-age of a filter cake. This is done by the application of de-saturating forces on the cake. The force may be mechanical, as when the cake is compressed to reduce its void volume and at the same time its moisture content or the force may be hydrodynamic to effect displacement of the retained filtrate by sucking or blowing air through the cake. De-watering by compressing reduces the cake moisture content although the saturation remains at unity. It is desirable to be able to predict the level of discharge from a filter, and the time required to reach that level. Both factors are of considerable practical importance as subsequent processing steps usually impose limitations on the acceptable moisture level in the discharged solids. The cake solids constitute the final product, and the cake must be transported bone dry. The criteria are to minimize the cost of thermal drying by minimizing the amount of moisture to be removed. In many processes efficient dewatering of the cake is economically beneficial. If the void volume of a filter cake is completely filled with a fluid, it is said to be saturated with that fluid. If the voids are only partially filled by a fluid, the fractional volume of voids occupied by the fluid is referred to as the saturation S of that fluid. For simplicity and uniformity it is usual practice to express the saturation in terms of the wetting fluid.

S = (Volume of wetting fluid in cake) / (Void volume of cake) (1)

A second term commonly used to express the quantity of liquid held by the cake is the moisture content, defined as the weight of liquid in the cake per unit weight of dry solids, i.e.:

$$M = S\frac{\in}{1-\in}\cdot\frac{\rho}{\rho_s} \tag{2}$$

where M= Moisture content, $\in$ = Volume of void divided by volume of cake, ρ= liquid density and ρ_s= cake density.

For any particular pressure gradient across the cake, residual filtrate will drain from the voids until a balance between the capillary forces and the drainage force is obtained; dewatering then ceases. When large pressure gradients are used and a maximum amount of liquid is withdrawn from the cake. The liquid remaining gives rise to a 'residual equilibrium saturation' or 'irreducible saturation'. The final cake moisture content is dependent on the process variables, the properties of the liquid and the structure of the cake [11].

New dewatering schemes to make food processing economical to handle are well known. Common dewatering processes use a variety of mechanical means such as screw presses, belt presses, and vacuum filters etc. How difficult can it be to remove juice from cassava mash cake?

The objective of this paper was to determine ease of removing the juice during dewatering cassava mash.

Material and Method

Mash was made from cassava tuber by grating, a TMS 4(2) 1425 variety was used Cassava mash cake is a compressible material and the specific resistance α changes with the pressure drop across the cake, the function α:

$$\alpha=f(\Delta p) \qquad (3)$$

$$\alpha=\alpha_0(\Delta p_c)^n \qquad (4)$$

From Kolawole et al., (2007) the cake resistance can be rated as average cake resistance α_{av}. Darcy's basic filtration equation relating the flow rate Q of a filtrate of viscosity μ through a bed of thickness L and face area A to the driving pressure Δp can we written in the form:

$$Q = K\frac{A\Delta p}{\mu L} \qquad (5)$$

where K = the permeability and R = the resistance to juice flow, then the medium thickness divided by the permeability will give the value of the resistance R =L/K. The resistant from the filter as R and mash cake as Rc, then L=(R+Rc)K. Equation 5 can be written as:

$$Q = \frac{A\Delta p}{\mu R} \qquad (6)$$

but general filtration equation [6]:

$$Q = \frac{\Delta pA}{\alpha\mu c(V/A) + \mu R} \quad (7)$$

and in reciprocal form, equation 7 can be written as:

$$\frac{dt}{dV} = \alpha\nu c\frac{V}{A^2\Delta p} + \frac{\mu R}{A\Delta p} \quad (8)$$

Thus giving time per unit flow, the mathematical simplicity of the equations defines two constants a_1 and b_1: $a_1 = \alpha\mu c$ and $b_1 = \mu R$. The experimental determination of α and R, was done in the form:

$$\frac{t}{V} = aV + b \quad (9)$$

where $a = \frac{a_1}{2A^2\Delta p}$ and $b = \frac{b_1}{A\Delta p}$. This gives a straight line when t/V was plotted against V (figure 1).

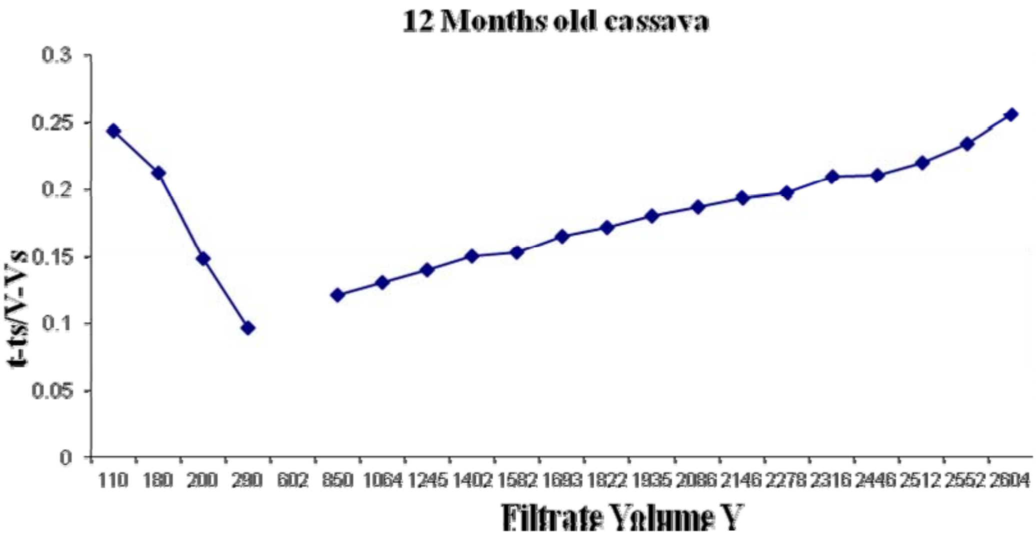

Figure 1. *Plot of t/v versus V for 12 months old cassava*

The increasing resistance of cakes with pressure, was obtained with test data from constant pressure operations the function α=f(Δp) was employed directly using equation:

$$\Delta p = \Delta p_c + \Delta p_m \quad (10)$$

where P_c is the pressure on cake and P_m is the pressure receive by filter medium and pressure at wish the moisture content of the cassava mash meets the processing requirement, 46-50% moisture content wet basis [4].

Sample A

At a pressure of ΔP = 48300 N/m², μ of water is 0.001Ns/M² (Adopted for cassava juice at 20^0C). C is the concentration of cassava juice obtained from the pressed water 18kg/m³. Area of cylindrical press radius = 0.03m = πr^2 = 0.0707m²

Slope = 5714286s/m^6	a = 5714286s/m^6
Intersect = 75000s/m^3	b = 40600s/m³
Vs = 0.000602m³	b + aVs = intersect
ΔP = 48300 N/m²	$a=\alpha\mu c/2A^2\Delta P$
μ =0.001	$b=\mu R/A\Delta P$
C = 18kg/m^3	$\alpha = 2A^2a\Delta P/\mu c$
A = 0.0707m^2	$\alpha = 1.533\times10^{11}$m/kg

Sample B

$b= \mu R/(\Delta P\times A)$

$R= (\Delta P\times A\times b)/\mu = 1.386\times10^{11}$/m

Sample C

From $a=\alpha\mu/2A^2\Delta P \rightarrow \alpha = 2A^2\Delta Pa/\mu C=5.365\times10^{11}$

R calculated from $b = \mu R/A\Delta P$ = 7776s/m³

$R = A\ \Delta Pb \div \mu = 2.6654\times10^{11}$ s/m^3	μ= 0.001Ns/m
Slope = 114,427 861 S/m^6	C = 18kg/m³
Intersect = 1,160,00 S/m³	A = 0.0707m²
Vs = 0.00173m³	b+aVs = intersect
t_s =180sec	b= 962,039.80
ΔP = 48300N/m²	

Calculating α from a = $\alpha\mu C\rightarrow \alpha=2A^2\Delta pa/\mu C = 3.0696 \times 10^{11}$ m/kg

$b = \mu C/ A\Delta P$

$R = A\Delta Pb/\mu = 3.285 \times 10^{11}$/m

From the samples, average specific cake resistance (α), m/kg .

Sample A: α is 1.533×10^{11}m/kg ;

Sample B: α is 5.365×10^{11};

Sample C: α is 3.0696 × 10^{11} m/kg.

The results above were compared with Table 2.

Table 2. Ease of Separation

Ease of Separation	Average Specific Cake Resistance (α), m/kg
Very Easy	$1x10^{9}$
Easy	$1x10^{10}$
Moderate	$1x10^{11}$
Difficult	$1x10^{12}$
Very Difficult	$1x10^{13}$

Source: [5]

Results and Discussion

From table 2, it was confirmed that average specific cake resistant of $1X10^{11}$ is a moderate ease to separate. Cassava mash has average resistance of $5X10^{11}$ this will be moderate when it comes to ease of juice separation from the cake. Separating mash cake from liquids is an important step in cassava mash processing; this operation is known as dewatering. Methods for doing this depend on the discovered qualities and how well the solid and liquid are mixed together. These experiments prove that separating cassava cake from the liquids in a grated mash cannot be accomplished with very easy.

Solid-liquid mixtures of mash is heterogeneous, this consists of two distinct separation boundaries. The result of this experiment proved that machines may be needed. Moderate force required for the liquid to be separated from solid will need the use of pressure to reduce the liquid level. Decantation as a method may rely on sedimentation, if coarse particles of the solid are heavier than the liquid, it will not settle down at the bottom due to the interaction of solid and liquid. If the liquid is poured out, the mixture will still need additional means to force the liquid out. Filtration method may be selected to separate the mixtures of the mash through a porous material. The insoluble solid might be trapped in residue this may require more pressure to force out the liquid. Filtration in addition to little pressure to expression the liquid might help overcome the obstacles. Some fine particles of solid that dissolved in the liquid may be passing through the filters. The liquid will not be in pure form since pressure was used, finer filter may help if the smaller particles are needed for other uses in form of starch for laundry.

Overcoming the perishability of cassava through research is the only way to enhancing the nutritional value and economic value of cassava. Making processing easy is the main way of enlarging food security in the world. The limits associated with available technologies for processing roots and tubers crops are now receiving attention; the crops are reaching their full potential as sources of both food and income.

Conclusion

This report made it clear that cassava mash cake is not ease to dewater but processing with simple machine can increase the shelf-life. New technologies for processing the roots and tubers can now be scientifically developed. Introduction of processing technologies will offer potentials to improve food security and local industrialization. This information will go a long way to assist design engineers and food technologists to improve cassava processing.

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