Adoption of Mechanized Postharvest Cassava Processing Technologies, and the Determinants of High Quality Cassava Flour (HQCF) Processing in Tanzania

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Summary

In this study, the factors influencing the adoption of mechanized technologies for processing cassava into a value-added high quality cassava flour (HQCF) by rural households in Tanzania were examined. A structured questionnaire was used to collect data from 400 households in villages which carry out both mechanized and non-mechanized cassava processing activities. The questionnaire focused on the households' socio-economic characteristics and their adoption parameters. Data were analysed using descriptive statistics and the double-hurdle model. The study revealed a positive correlation between the level of awareness of mechanized cassava processing technologies and their rate of adoption. In addition, the adoption decisions made by the households were significantly influenced by a number of factors, such as the gender of the processors, the distance of the processing sites to the nearest tarmac road, and the cost of capital required to invest in HQCF processing technology. The amount invested by households in the processing of HQCF was influenced by the number of adult females in the household, the education level of the processors, farming experience and the distance from the processing plant to the nearest product market. This suggests that mechanized post-harvest processing of HQCF at the household level was influenced by access to product market. Therefore, the study recommends increased promotion of postharvest processing technologies, access to capital and enhanced infrastructures, especially rural roads to facilitate improved access to markets for HQCF in Tanzania.

Résumé

Adoption de technologies mécanisées de transformation post-récolte du manioc et déterminants de la production de farine de manioc de haute qualité (FMHQ) en Tanzanie.

Dans cette étude, les facteurs qui influencent l'adoption de technologies mécanisées de transformation du manioc en farine de haute qualité (FMHQ) à haute valeur ajoutée par les ménages ruraux en Tanzanie ont été examinés. Un questionnaire structuré a été utilisé pour recueillir des données auprès de 400 ménages dans les villages qui font la transformation mécanisée et non mécanisée du manioc. Le questionnaire était axé sur les caractéristiques socio-économiques des ménages et leurs paramètres d'adoption. Les données ont été analysées à l'aide de statistiques descriptives et selon la méthodologie du «double-hurdle model». L'étude a montré une corrélation positive entre le niveau de sensibilisation aux technologies de transformation mécanisée du manioc et leur taux d'adoption. En outre, les décisions d'adoption prises par les ménages ont été fortement influencées par un certain nombre de facteurs, tels que le genre des transformateurs, la distance entre les sites de transformation la plus proche routes asphaltées et le coût de la technologie de transformation du manioc en FMHQ. Le montant investi par les ménages dans la production de FMQH a été influencé par le nombre de femmes adultes dans le ménage, le niveau d'éducation des transformateurs, l'expérience en

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agriculture et la distance entre l'unité de transformation et le marché le plus proche. Cela montre que la transformation mécanisée post-récolte du manioc en FMQH au niveau des ménages a été influencée par l'accès au marché. Par conséquent, l'étude recommande la promotion accrue de technologies de transformation post-récolte, l'accès au capital et aux infrastructures améliorées, en particulier des routes rurales permettant un accès facile aux marchés pour les FMQH en Tanzanie.

Introduction

Cassava is an important food item for rural communities in Tanzania, being the second most important staple food crop after maize, and contributing almost 22% of the country's total energy intake (1). The importance of cassava as a food crop in Tanzania is mainly the result of it having been identified as a key food security crop by successive governments since the 1970s. This classification is based on its tolerance to poor soils and resistance to drought (2). As a consequence, it fits well into the food security strategy of smallholders, more so than other food staples such as maize and rice, often serving as the food of last resort; to ameliorate the effect of food deficits that occur from sporadic harsh weather conditions, those that reduce the yields of cereal crops. For example, cassava production was stable between 1996/97 and 1997/98, during the El-Nino-influenced flooding season that severely affected cereal crops such as maize, sorghum and millet. Production was also stable from 2001 to 2005, when drought had a significant adverse effect on cereals production. Poor families also use it to ward-away starvation during lean times of the year, when seasonal harvests run-out.

The main response to food shortages in developing countries is to invest in food production activities, meaning agricultural research institutions often give little thought to improving postharvest processing, so as to reduce food losses, extend shelf lives or increase the safety and quality of food. Many years of investment in crop production technologies has generated a great number of innovative technologies aimed at crop production and protection.

As early as the 1930s, research on cassava was intensified in East and Southern African (ESA) countries, and at this time efforts were mostly devoted to tackling production constraints. However, a food crisis in developing countries, and particularly in Africa, has persisted (3).

Then from the late 1970s to the early 1980s, national and international research institutions, including the International Institute of Tropical Agriculture (IITA), introduced an array of new Tropical Manioc Selection (TMS) cassava varieties (TMS). These TMS varieties were resistant to cassava mosaic disease (CMD), which was devastating cassava in most parts of East Africa (3) at that time. The biological control of major pests and the diffusion of planting materials for the new varieties dominated the research agenda, and the new technologies introduced assisted many countries to stabilize their food supply levels. However, commercial, mechanized processing technologies, as practiced in most parts of South-East Asia and West Africa, got little priority in East Africa, where cassava remained a famine reserve crop or a rural food staple (2). Evidently, the active postharvest processing of cassava in West Africa, and especially in Nigeria, was a primary factor in helping advance the status of the crop to that of an urban staple. Processing ensured the proper storage of the harvested crop and its transformation into food products that met consumer requirements on quality, convenience and safety (2). While the annual total cassava output in the West African countries of Nigeria and Ghana exhibited continuous increases, production in many countries of East and Southern Africa remained stagnant (4).

The many years of production-oriented research that took place in ESA, especially in Tanzania, did not translate into a significant increase in cassava production. Labour-intensive traditional processing operations such as manual peeling, and size-reduction practices such as the pounding of dried cassava with a mortar and pestle, continued to act as major constraints. Sun-drying and storage environments were often heavily contaminated, causing cross-contamination of cassava foods (4). As a result, in the 1990s, the export of cassava chips from Malawi and Tanzania to the EU, for the manufacture of animal feeds, was terminated, part of the reason being the insufficient supply and poor quality of the chips (3).

However, around this time, in Ghana and Nigeria the status of cassava changed, from that of a rural staple food item to an urban food and cash crop, as here TMS varieties were being distributed as in ESA, but with more focus on strengthening of small-scale mechanized processing of gari. Gari is a creamy-white, granular flour made from grated, fermented and gelatinized fresh cassava roots. Gari has a slightly fermented flavour and a slightly sour taste, and is widely processed and consumed in Nigeria and other West African countries (2).

Similar technologies were being used to process cassava into other intermediate products that were then traded and used as raw materials in the animal feed mills of Asia (6). Ugwu (7) observed that, among other factors, the availability of appropriate postharvest and marketing infrastructures was necessary to sustain the increase in cassava production levels seen in Nigeria. Also, technological innovation along the whole production-processing-marketing supply chain was the backbone of agricultural productivity gains (8).

Hence, there is strong evidence to suggest that inadequate research and a lack of information given to the farmers in relation to appropriate processing technologies has contributed to the under-development of the cassava sub-sector in many African cassava growing countries, excluding Nigeria, Ghana and to some extent the Democratic Republic of Congo (DRC). The subsequent inability to reduce labour inputs and transform the crop into marketable forms has; thus, constituted a barrier to productivity growth.

Over the last decade, national and international research organizations such as the International Institute of Tropical Agriculture (IITA), having observed the deficiency in the past approaches to expanding cassava production, have introduced small-scale mechanized cassava processing technologies and new market innovations to smallholder rural-based cassava farmers in ESA countries. The purpose of this work has been to enable the transformation of cassava products into widely traded commodities that contribute to the economic growth of ESA nations. The hypothesis behind this has been that the introduction of small-scale cassava processing activities should have a positive multiplier effect on all participants in the cassava value chain, including smallholder farmers, processors, traders and consumers, as well as the industries using cassava derivative products as raw materials. Researchers have since introduced and promoted an extensive range of processing technologies that allow farmers to harvest and process cassava into shelf-stable value-added products. The adoption of these simple, mechanized post-harvest processing steps (such as grating, chipping and pressing), and technologies which facilitate the production of high-quality cassava flour (Cassava Flour or HQCF) and cassava chips by smallholders, was expected to increase the demand for fresh cassava in rural areas. In addition, they were expected to enhance farmers' willingness to adopt improved production technologies, particularly new varieties, fertilizers and improved farming practices, which would help increase cassava productivity and expand production. Hence, after ten years of intervention, it is pertinent to evaluate the objective of promoting mechanized post-harvest cassava processing technologies among smallholders; to establish the lessons learned and to advise policymakers on evidence-based strategies to achieve cassava production. This study, therefore, represents an assessment of the level of adoption of mechanized postharvest cassava technologies by small-scale cassava processors, and the determinants of HQCF processing in Tanzania. The study examines adoption rates; pinpointing and analysing the parameters that may possibly influence the adoption of HQCF among smallholders in Tanzania.

Methodology

A household survey of smallholder cassava processors was carried out in Tanzania, among villages where mechanized postharvest cassava processing technologies were introduced by researchers (intervention villages), and also among those where such technologies were not introduced (non-intervention villages). The intervention villages were purposively selected from the Coast and Mtwara regions; on the east coast and in the south of Tanzania respectively, while the non-intervention villages were purposively selected from the Lindi and Ruvuma regions, which are situated in the south and western parts of Tanzania respectively. The non-intervention villages were used as the controls to measure and contrast the rate of adoption of cassava processing technologies among processors in the intervention area.

The study used mainly primary data obtained through a socioeconomic survey conducted between February and March 2014. The main data collection instrument used was a well-structured questionnaire administered among the cassava processors by trained enumerators and research supervisors. The data collected covered topic areas such as socio-economic variables, including age, education level, household size, cassava processing and production experience, membership of associations and level of access to credit. Data were also collected on the employment of labour, marketing activities and cassava product sales among the processors, as well as the processors' level of participation in mechanized technology testing and adoption, and their perception of the impacts of mechanized processing techniques. A random sampling procedure was used to administer a total of 400 questionnaires, 200 each in the intervention and non-intervention villages. The primary data collected were supplemented by secondary data obtained from cassava processing research reports and other secondary sources taken from literature on the subject.

spreadsheet, and then analysed using descriptive statistics and a double-hurdle regression model.

The Empirical double-hurdle model

To describe each household's level of adoption of mechanized cassava processing technologies, we employed a model which considers an adoption decision as a two-stage process. First, the household has to decide to cassava into HQCF or another processed product or even not to process at all. Second, if the decision is made to adopt to process cassava into HQCF, the household must then decide how much it will invest in HQCF processing technologies. This second decision will also depend on other factors, including availability of capita and its cost to assess the opportunity forgone if money is invested in HQCF processing. To this end, the double-hurdle model was employed (9, 10, and 11).

According to the double-hurdle model, the households' processing decisions can be formulated in Equation I:

$$i_j = \begin{cases} i_j^* & \text{if } i^*_j \geq 0 \text{ and } d_j = 1 \\ 0 & \text{if } i^*_j \leq 0 \text{ and } d_j = 0 \end{cases} \quad \text{(I)}$$

Where *ij* is the observed level of processing (i.e. the quantity of cassava processed by a household), *dj* is a binary variable describing the decision to adopt HQCF processing or not, and *j* is the household index and i*j is the latent value of the processing volume.

The double-hurdle model consists of two regressions; a binary choice model is estimated during the first step, while the second step involves the estimation of a truncated regression model (Equations II and III), Vis:

1st step: $d_j = \varphi' z_j + \theta_j$ (II)

2nd step: $ij = \beta' xj + \varepsilon$ (II)

Where $\theta j \sim N$ (0, 1) and "*j N 0*; *σ2*". Vectors *zj* and *xj* are the vectors of explanatory variables in binominal and truncated regression models, respectively.

Accordingly, in our empirical analysis we employed two dependent variables; a binary variable signaling whether or not a particular household had adopted HQCF technology, and a further variable which represented the amount of investment in HQCF that had taken place.

Results and Discussion

Specific characteristics of the study processing enterprises:

Table 1 shows the specific characteristics of the processors in both the intervention and non-intervention villages. The mean number of members in the cassava processing enterprises was found to be 27 (ρ=0.01). The table reveals that the average age of the leaders of the cassava processor associations in the intervention villages was 49 years (significant at a 1% level), while in the non-intervention villages it was found to be 42 years. There seemed to be a predominance of older processors involved in the mechanized processing, possibly an indication of how the technologies were introduced to the study area, through the actions of farmers' associations rather than individuals. Due to the antecedents of the study locations, older people are more likely to form associations than the young in order to access information, technologies, credit or other services. The mean length of experience of the processors in the intervention villages was 7 years (ρ= 0.01), reflecting the length of time mechanized processing technologies have been used in Tanzania. On the other hand, non-mechanized or traditional cassava processing has been used by processors in the non-intervention villages for decades. The average distance from the processing plant to the nearest local market in the intervention villages was 30 kilometres (ρ= 0.01); while in the non-intervention villages, the average distance to the nearest local market was 14 kilometres. During the introduction of various processing technologies, farmers living in remote locations and who did not have access to the market for their cassava were probably targeted and exposed to the technologies.

As will be shown later in this study, although mechanized processing was adopted to increase the shelf-life of fresh cassava roots and reduce postharvest losses, the long distance of such localities to the city markets had adverse implications for the profitability of such enterprises, giving the feeling that there would not be market for the processed products, and so, small profit margins. The longer the distance to the market for the processors, the higher the marketing costs due to transportation (12, 13). If the price received is too small to offset transportation and other transaction costs, income levels will be reduced, and this may, in turn, affect farmers' welfare (13).

Respondents' awareness of postharvest mechanized cassava processing technologies:

In the adoption process for a new technology, potential users must first of all be aware of the existence of the new technology, including its advantages, before they can accept or adopt it. Among the processors, 87% and 62% in the intervention and non-intervention villages respectively reported that they were aware of the post-harvest technology of using raised sun-drying platforms (Figure 1), which represent an improvement on the traditional practice of drying cassava on the floor. Other technologies that the processors in the intervention villages reported being aware of included mechanized grating (77%), dewatering (74%) and chipping (63%). These were the mechanized technologies introduced to the villages by researchers in the past 10-15 years. Such levels of awareness are also likely to have had a positive influence on the adoption rates for these cassava processing technologies.

Adoption rates of postharvest cassava processing technologies:

Figure 2 shows that most of the adopters of the different processing technologies were domiciled in the intervention villages. There tended to be a positive correlation between the level of awareness of mechanized processing technologies and their adoption rates (Table 2), and this positive correlation confirms the significance of knowledge in relation to a given technology on its rate of adoption.

Among the respondents, the sun-drying of grated or chipped cassava on raised platforms was the technology most adopted in the intervention and non-intervention villages, at 83% and 64% respectively. The second most adopted practice was the use of cassava graters, with adoption rates of 69% and 4% in the intervention and non-

Table 1

Specific characteristics of processing enterprises.

Variable	Mean	Std Deviation	Minimum	Maximum
Number of members in cassava processing enterprises				
Mechanized processing intervention villages	26.6***	21.3	1.0	121.0
Non-Intervention villages	5.0	3.6	1.0	20.0
Total	19.0	20.1	1.0	121.0
Age of processor				
Mechanized processing intervention villages	49.4***	11.4	18.0	92.0
Non-Intervention villages	42.2	13.7	4.0	91.0
Total	45.8	13.1	4.0	92.0
Years of Experience in cassava processing				
Mechanized processing intervention villages	7.3***	7.5	0.5	45.0
Non-Intervention villages	20.2	13.8	1.0	71.0
Total	13.8	12.8	0.5	71.0
Distance of processing centre to nearest local market (kilometres)				
Mechanized processing intervention villages	29.5***	27.2	0.1	120.0
Non-Intervention villages	13.6	11.2	0.0	79.0
Total	21.7	22.3	0.0	120.0

*** Significant at 0.01 level

Table 2

Test of significance for awareness and adoption of post-harvest cassava processing technologies in Tanzania.

Post-harvest cassava processing technologies	Intervention villages			Non-intervention villages		
	Awareness (%)	Adoption (%)	X^2 test	Awareness (%)	Adoption (%)	X^2 test
Sun-drying on raised platform	87.4%	82.9%	0.067*	63.7%	62.3%	0.54
HQCF processing technology	74.4%	64.3%	0.032**	17.1%	3.0%	0.021**
Cassava chips processing technology	62.8%	55.3%	0.04**	14.1%	3.7%	0.00***

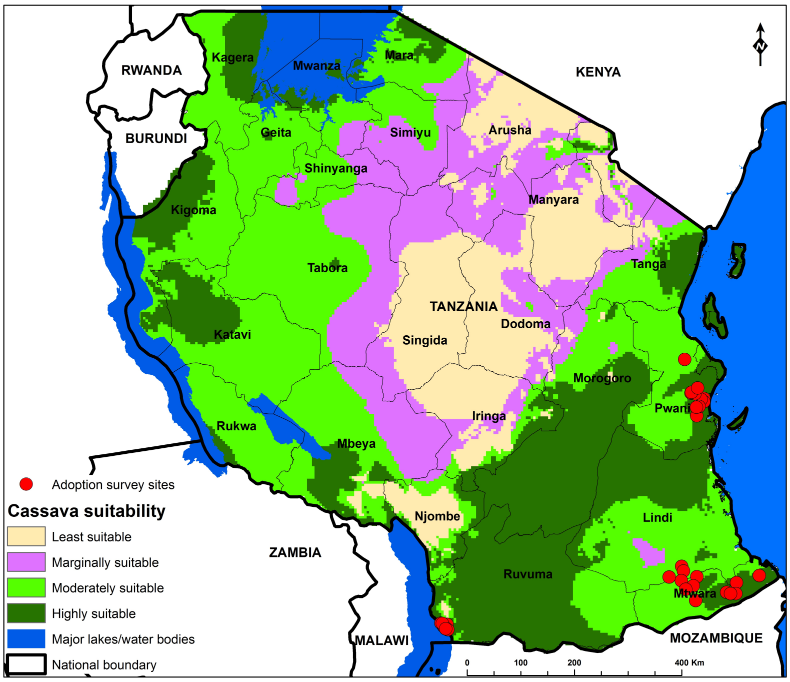

Figure 1: Map showing study locations.

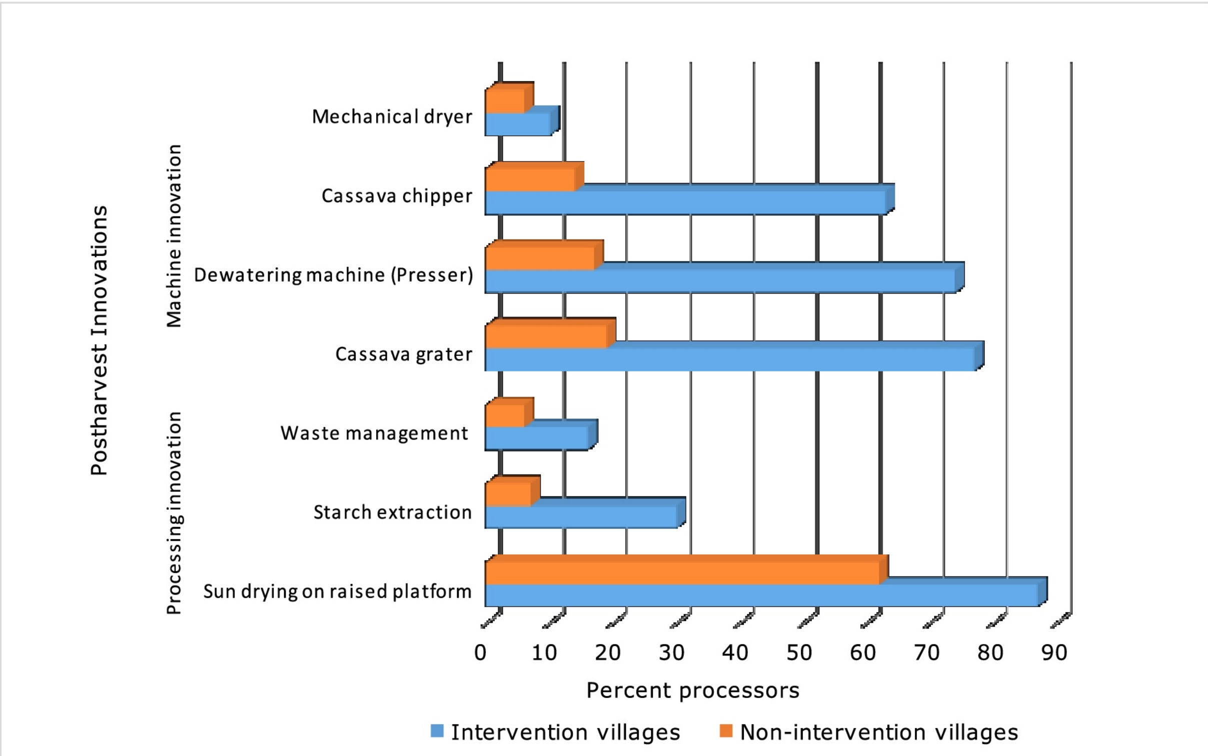

Figure 2: Awareness levels for Cassava processing technologies.

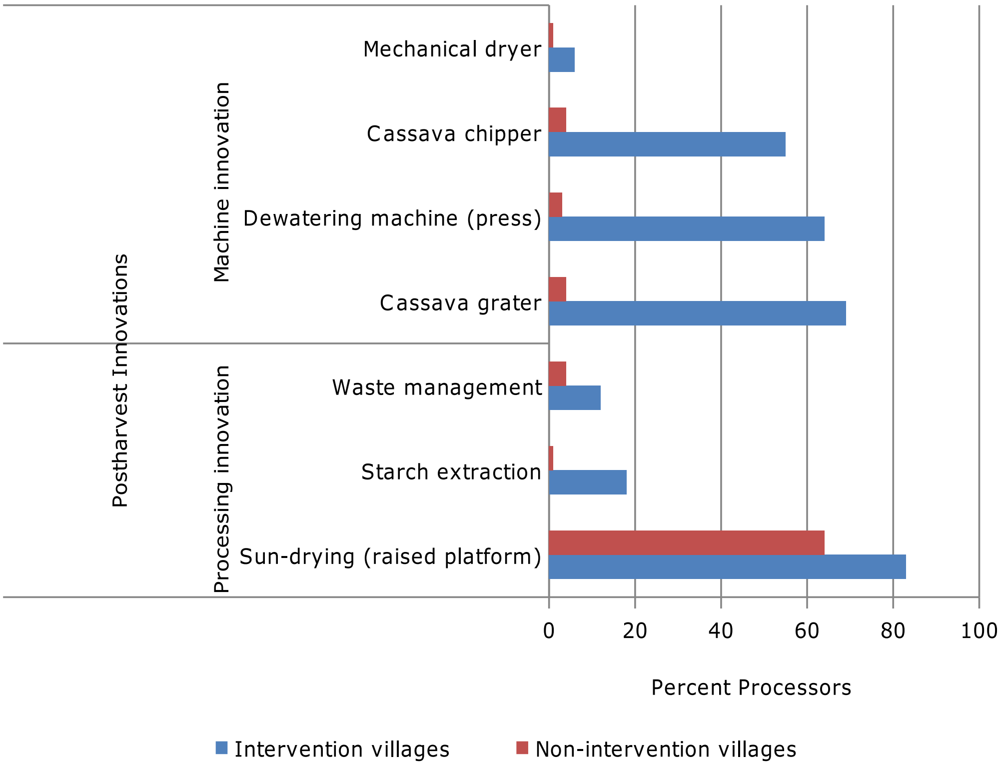

Figure 3: Adoption of cassava processing technologies in the intervention and non-intervention villages.

intervention villages respectively. Graters are largely used for processing high quality cassava flour. Meanwhile, 64% and 3% of processors in the intervention and non-intervention villages respectively, said they had adopted a cassava pressing machine to mechanically reduce the water content of the cassava roots before drying (Figure 3).

On the other hand, 55% and 4% of processors in the intervention and non-intervention villages respectively said they had adopted cassava chippers to reduce the size of the cassava roots before drying. Finally, the adoption of cassava starch technology, waste management processes and mechanical driers was found to be less than 20% in the intervention villages, and less than 5% in the non-intervention villages.

Determinants of the adoption of mechanized technologies for processing cassava into a value-added high quality cassava flour (HQCF)

This section examines those key determinants influencing the adoption of mechanised technologies for processing cassava into value-added HQCF.

Table 3 shows those determinants for the adoption of mechanized cassava flour processing. The first step model estimates (i.e. estimates of the logistic regression model) shows that the decision to adopt HQCF processing technology is influenced by the gender of the processor, the distance of a processing site to the nearest tarmac road, and the cost of capital to measure what will be the interest (or opportunity forgone) if money is invested in processing HQCF.

The coefficient given for the gender variable was found to be statistically significant ($\rho \leq 0.05$) and showed a positive relationship with the decision to adopt HQCF. This result shows that male processors are also more likely to adopt the HQCF technology when compared to their female counterparts.

Because gender is a dummy variable, its coefficient of 0.488 implies that, all other factors being equal, the probability of male processors adopting is autonomously higher than that of the female-processors, by 0.488.

The distance of processing sites to the nearest tarmac road was found to be significant in terms of influencing the adoption of HQCF among cassava processors in Tanzania ($\rho \leq 0.10$).

Table 3

Estimates of double-hurdle model.

Variables	First-Hurdle		Second-Hurdle	
	Coefficient	Std. Error	Coefficient	Std. Error
Number of adult male in the household	0.00005	0.01012	-0.01127	0.02303
Number of adult female in the household	-0.00148	0.00988	-0.03689*	0.02103
Gender	0.48768**	0.21670	-0.55810	0.45324
Age	-0.00380	0.00887	0.02186	0.01653
Highest educational qualification	-0.10892	0.30347	1.12080**	0.56462
Farming experience	-0.01125	0.01276	-0.05008*	0.02876
Distance of processing site to the nearest tarmac road	-0.00726*	0.00391	0.00411	0.00915
Revenue	0.00283	0.00550	-0.00984	0.01231
Availability of supply/contract farmers	0.66147	0.67840	-0.93686	1.62457
Number of new farmers that planted cassava in the last 12-24 months	-0.00116	0.00618	-0.00352	0.011509
Number of farmers that supply cassava to the processing plant every year	0.00365	0.00280	0.002931	0.007659
Distance from the processing plant to the nearest product market	-0.00036	0.00372	0.01269*	0.007397
Cost of Capital	0.10342***	0.02646	-0.04951	0.069866
_cons	-2.30181	1.79980	10.62961**	4.358825
sigma				
_cons	2.02154	0.132270		
Log Likelihood	-368.55			
Number of observation	200			
Wald chi2 (13)	27.65			
prob> chi2	0.0101			

*** Significant at 0.01 level; ** at 0.05 level and * and 0.1 level

Source: Authors' estimates

The sign of the coefficient of this variable was negative, implying that the processors with processing sites nearer to tarmac roads have a greater likelihood of adopting cassava flour technologies when compared to those processors located further away. Apparently, it is easier and cheaper for processing sites closer to tarmac roads to get their supply of raw materials than it is for processing sites located further away. These processing sites that are closer to tarmac roads can also easily convey their finished products to consumers. Being located close to a tarmac road also gives them some cost advantages over those sites located further away, particularly in relation to infrastructure costs, which includes roads, a key factor in agricultural development. This implies that lower transportation costs help reduce the cost per kilometre of both raw materials and finished products. Good roads are needed to convey raw materials to processing industries, as well to transport processed products to consumers.

The cost of capital was found to be positive and significant (ρ≤0.01) in influencing the decision to process fresh cassava roots into HQCF. This is consistent with the expectation, since individuals may decide to process cassava into another product or even not to process at all if the cost of capital is relatively high.

The second step estimates (i.e. the truncated regression model estimates) suggest that household decisions with regards to the amount of investment needed to process HQCF are determined by four significant factors, namely the number of adult females in a household, the education level of the processors, the farming experience of the processors, and the distance of the processing plant to the nearest product market. The number of adult females in a household was also significant (ρ ≤ 0.1) in influencing the adoption of HQCF production technology.

The variable also had a negative sign. This suggests that households with fewer adult females have a higher likelihood of adopting the HQCF technology when compared to households with a larger number of adult females. The likely reason for this is that making cassava flour is a labour-intensive activity mainly carried out by females in small-holder agriculture.

The availability of adult females at the household level means having labour for that kind of activity. Hence, where such labour is not available, the next option is to look at labour-saving methods.

Adopting HQCF processing technology is one way of producing HQCF while using less labour. Processing cassava into HQCF using small-scale, mechanized grating method requires a different type of labour from the traditional method carried out by women. This factor; therefore, tends to influence the adoption of HQCF technology. The use of machinery to process a crop reduces significantly the need for adult females to be involved in a process, as in the case of mechanical cassava processing.

This result suggests that when cassava processing practices become increasingly mechanized, there is a shift in gender roles. A shift in roles may not necessarily be synonymous with the 'displacement' of a specific gender from a typically assigned task, but rather represent an 'alignment' of tasks based on new labour requirements under mechanized operations when compared with non-mechanized operations. For example, as men may be more inclined to operate the mechanized grating or pressing machines during HQCF processing, larger number of women are required in the subsequent drying of the cassava on raised platforms than needed for non-mechanized operations.

The educational level of the processors was found to be significant (ρ ≤0.05) in influencing the adoption of HQCF technology. The sign of the coefficient for education was positive, implying that individuals who had been in formal education longer had a higher likelihood of adopting the mechanized cassava flour processing technology than those who had spent less time in formal education.

Education increases the ability of a person to assess, interpret and process information about a new technology, in the case of farmers enhancing their managerial skills such as the adoption and efficient use of agricultural technologies (14, 15). It can; therefore, be expected to have a positive impact on the decision to adopt and use a technology.

Farming experience was also significant (ρ ≤ 0.10) in influencing the adoption of cassava flour technology in the study area. The sign of the coefficient for farming experience was negative. The implication of the negative sign is that individuals who had recently started cassava farming had a greater likelihood of adopting the cassava flour technology than those who had been involved in cassava farming for a longer period. Implicitly, cassava processors who have been involved in cassava production for a long time operate at the subsistence or food security level, while new processors seem to have a more commercial orientation. This suggests new entrants see the processing of cassava as a business rather than as a means of achieving food security alone. Even though new entrants are likely to have fewer years of farming experience, their commercial orientation makes them more likely to adopt improved technologies when compared to long-term subsistence farmers. This finding is consistent with 'Promoting Sustainable Agriculture in Borno State (PROSAB) Project (12), who reported that farmers who participated in the PROSAB project in Nigeria adopted improved soybean seeds as a production technology.

Distance from the processing plant to the nearest product market was positive and significant in terms of influencing the quantity of HQCF processed ($\rho \leq 0.10$). Normally, the coefficient of distance to the nearest product market can be expected to be negative in terms of influencing the adoption of technologies among farmers and processors, implying that proximity to the source of fresh cassava is more critical than to a market for it. This result is logical, considering the bulkiness of the fresh cassava, as this makes it more expensive to transport (by almost 200-400%) than processed products such as HQCF.

The combined results of the four adoption parameters outlined above are significant, as they partly explain why several mechanized cassava processing plants with a large fresh cassava intake capacity, and located close to major cities, have been unsuccessful in Nigeria, Ghana and other African countries (2, 3, 16). Poor road infrastructure and suboptimal raw material supply arrangements are the major contributors to these failures. This is a significant pointer for policy interventions and for the decision-making processes of prospective entrepreneurs who have an interest in managing mechanized processing enterprises in Africa.

Furthermore, the major buyers of HQCF are supermarkets and food industries often located further away from the processing centres. The supermarkets sell the cassava flour to household consumers; while the food industries use cassava flour to process a range of food products, such as biscuits, bread and other baked products (16). The supply of HQCF to these market outlets is mainly carried out based on contractual agreements. Thus, these outlets' proximity to cassava processors does not necessarily influence the processing of HQCF. In the intervention villages, fresh raw cassava roots are mostly sourced from the processors' own production farms (80%), while 20% of raw cassava roots are purchased from other cassava farmers within the intervention communities.

Evidence in the literature on adoption suggests that membership of farmer groups or organizations, early experience and peer-group learning, as well as participation in technology development or testing, and the opportunity to observe fellow farmers using an agricultural innovation, all positively influence adoption levels (17, 18, and 19). During the process of developing or testing a technology with a potential user, most performance issues encountered can be resolved and solutions clarified. Participation in the testing of a given technology may also give processors some form of commitment to its use. All these factors increase the likelihood of a technology being adopted among processors who participate in its testing, when compared to those who do not.

Previous studies have shown that awareness and technology-try out are necessary steps toward adoption (20).

While awareness may be determined by the education level and social capital status of the farmer, try-out is positively influenced by extension interventions. On the other hand, adoption is mostly influenced by the availability of capital needed to acquire the technology. If capital constraints exist, extension interventions may not be adequate to support continued adoption (17, 20).

The results of this study tend to support these observations.

Focus group discussions with the manufacturers of the cassava flour equipment revealed that the research-for-development institutions that implemented the projects on small-scale cassava processing, including district governments and NGOs, made significant contributions to the adoption process. These contributions included making the design or prototypes of machines for mechanized processing available to the equipment manufacturers, making the cassava processing machines available and transferring the knowledge on cassava flour processing to the farmers and processors during the try-out stage. Such intervention was necessary to ensure adoption, as most farmers were unable to make the required investments needed to acquire the machines.

Conclusions

There exists a positive correlation between the level of awareness of cassava processing technologies and their adoption. This positive correlation confirms the significance that the awareness of a technology has for its adoption.

Those factors which significantly influence the adoption of HQCF are the education level of the cassava processors, their farming experience, the cost of capital, distance of the processing plant to the nearest tarmac road, and distance of the processing sites to the nearest product market. The adoption of HQCF processing technologies in the rural areas of Tanzania led to the emergence of cassava farmers who cultivate in close proximity to those villages using mechanized cassava processing technology.

Although this may enhance the availability of processed cassava flour at the household level, to maintain food security during lean periods, there still are some challenges to address if cassava is to be upgraded from its status as a food security crop, to that of a commercial crop. First, the cassava processing technologies need to be promoted in the major cassava producing areas – beyond just the intervention villages – to further enhance their adoption. Second, increasing access among smallholders to credit services, and also improving rural roads, are both required to help boost the commercial production and processing of cassava. Third, a system that allows greater contact between farmers/processors and extension or technology experts will expose the processors to information regarding the use of such technologies. However, targeted policies such as access to credit and improved rural infrastructures, especially roads are necessary to facilitate increased adoption of HQCF processing in Tanzania.

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