

Full Length Research Paper

No appropriate technology so far for *Ricinodendron heudelotii* (Baill. Pierre ex Pax) processing in Cameroon: Performance of mechanized kernel extraction

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Accepted 4 June, 2013

Ricinodendron heudelotii kernels are an important source of income for rural women in the humid tropics of Africa. Manual kernel extraction is time consuming and efforts have been made to mechanize the process. However, mechanical damage to kernels remains an issue. Within the socio-economic and resource ecology context in the central region of Cameroon, a prototype machine for extracting njansang kernels was developed and has been tested since 2007, then evaluated using a learning selection model. Surveys with users and non-users suggested a shift towards male and younger users. The advantages of rapid kernel extraction are partly offset by the requirement to sort out broken kernels, leading to a total time requirement of 60.87 min for manual processing and 2.08 + 39.56 min for mechanical extraction + manual sorting. The technology needs further improvement to deliver the expected increase in labour efficiency and economic advantages for rural women.

Key words: Cameroon, adoption, agroforestry, NTFPs, smallholder producers.

INTRODUCTION

Increased labour efficiency through an appropriate levels of mechanization is an important enabling factor for smallholder economic development, provided the additional benefits are greater than the additional costs and the equipment is easy to use, faster and more flexible, as well as acceptable and accessible to the poorer segments of society (Czech, 2003; Lara et al., 2011). African farmers have benefited less from

appropriate technology development than their colleagues in Asia, where for example mechanical rice hulling became mainstreamed and considerably improved labour efficiency in rural areas (Alizadeh, 2011). Farmers spend considerable time on processing of agricultural and forest products, and this negatively affects the economic value of these products (Héran, 1979).

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Mechanization of processing can therefore lead to higher returns to labour for the processors, lower consumer prices and/or increased demand for the processed products. Nevertheless, to be adopted, such technology must simultaneously meet a number of criteria, including:

- (i) Effective access for community members
- (ii) Feasibility and actual use across age and gender categories of current users
- (iii) Technical performance in terms of quality of the product
- (iv) Labour saving and profitability
- (v) Overall appreciation by local stakeholders as basis of spontaneous adoption
- (vi) Distributional and gender equity effects of adoption and re-allocation along the total value chain,
- (vii) Opportunities for further improvement
- (viii) Sustainability, that is, community members must be able to maintain the equipment and acquire spare parts (Van Noordwijk, 2011).

Mechanisation can play an important role in the process of adding value to Non-Timber Forest Products, in particular when quantities processed increase because producers start planting them on-farm, as is the case of *Ricinodendron heudelotii*. In Cameroon, farmers ranked *R. heudelotii* as the fourth most important species in terms of uses, management and economic value, after *Irvingia gabonensis*, *Baillonella toxisperma* and *Dacryodes edulis* (Ayuk et al., 1999). Kernels of *R. heudelotii* fruits, also called njansang, constitute an important ingredient in many local dishes and have a strong local and urban demand (Manirakiza, 2007). Moreover, regional commercialization of njansang has increased significantly in recent years (Cosyns et al., 2011; Facheux et al., 2012). *R. heudelotii* farm-gate value for the Central, South and East regions of Cameroon was estimated at US\$ 4,9000,000 (Franzel et al., 2008). Processing and marketing of njansang is mainly harvested from the remaining natural forest and from retained trees on farm, and this is mostly done by women.

Post-harvest processing of njansang fruits involves 1 to 2 months period of rotting, washing away the decayed fruit pulp around the nut, boiling the nuts for 1 to 2 days over a wood fire, manual extraction of the kernel from its very hard shell and drying the kernels. The whole process takes between 2 and 6 months (Mbosso, 2007; Nakuna, 2009). Given the economic importance of the product, both at regional and international levels (Nkwatoh et al., 2011; Nkwatoh and Yinda, 2007), improving labour efficiency in post-harvest processing through mechanization appears to be an attractive option, provided current producers have access to the new technology and can make productive use of the time saved (e.g. by increasing quantities processed).

As part of tree domestication and agroforestry development efforts in Cameroon, a prototype extraction

machine was designed to provide an alternative to the manual extraction of njansang kernels from the nuts (ICRAF, 2009). The single prototype was provided to a producer group in one village in the humid forest zone of Cameroon for testing and pilot use. The theoretical underpinning of this testing process was the learning selection model (Douthwaite, 2006). The author commented that successful technologies are those which manufacturers and users have developed together. This co-development occurs when manufacturers and users believe that the first commercial prototype makes a "plausible promise" of being of benefit to them, thus, motivating them to become co-developers.

In the co-development process, the key stakeholders learn about the equipment and develop their own procedures and protocols that often increase the performance of the equipment in ways that the engineers have not envisaged. This is called increase in fitness for task. The learning selection model is depicted graphically in Figure 1. It shows a technology, shown as a cogwheel, beginning as a "plausible promise" that motivates the key stakeholders to co-develop it. The technology then increases in fitness through the acquisition of knowledge and by becoming "meshed in" to existing systems through the adaptation and learning that takes place. Here, fitness is taken in the sense to mean improvements in the livelihood that will motivate the adoption and promulgation of the technology. The "meshed in" aspect of the technology, or its "social construction" as it might also be termed, is represented by the move from a single cogwheel to three inter-locking ones. The increase in knowledge is represented by the increase in size of the cogwheels.

Learning selection is shown inside the black box in Figure 1 and is responsible for the evolution. Learning selection is a process built on Kolb's 4-stage experiential learning cycle, and is perhaps best explained using an example:

- (a) Experience: Suppose a farmer finds that the rice miller pays her a low price for the grain dried in her dryer because some of it is not properly dried.
- (b) Making sense: She reflects and makes sense of the experience. She realizes that uneven drying is losing her money and that it might be sensible to try and improve the dryer's performance.
- (c) Drawing conclusion: She then develops personal explanations of what happened from her own or others' previous experience or theories. She hypothesises that if she reduces the amount of rice she loads into the dryer the drying will be more uniform.
- (d) Action: She then decides to test her hypothesis, and in so doing generates a novelty.

In addition to the eight criteria for appropriate technology listed above, four simple questions guided the analysis of strengths and weaknesses of the njansang extraction machine:

- (1) Community-based rules for access to the machine



Figure 3. Insertion of the nail in the opened part of the shell (nut with crack) for kernel extraction.

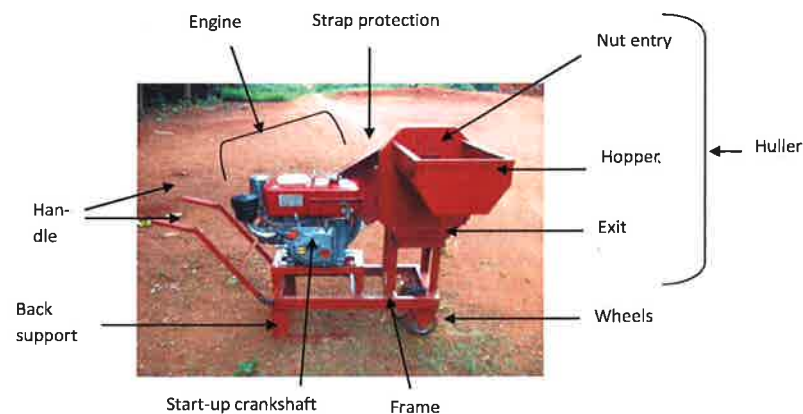


Figure 4. Different parts of the njansang nut cracker.

- (2) Actual use, specified by age and gender of the users
- (3) Technical performance in terms of quality and quantity of the product, as well as labour saving,
- (4) Overall appreciation by local stakeholders.

After a description of the research site, data tools, target population, sample size and a technical description of the manual processing and the njansang extraction machine, we will summarize the findings for each of the above aspects, followed by a discussion of how appropriate the technology is in the context of the local value chain and development imperatives.

MATERIALS AND METHODS

Research site

The study was carried out in the small community of Epkwassong, 42 km from Ayos city, Nyong-et-Mfoumou Division in the Central region of Cameroon (Figure 2). Epkwassong was chosen because njansang is common here and women in the village have a good knowledge of its exploitation. The njansang producer group 'Fa'a Si Obe' is well-organized and has been selling njansang as a group

since 2005 (Facheux et al., 2007). In terms of socio-economic and biophysical characteristics, Epkwassong is in many ways representative of the humid forest zone of Cameroon, and even of the Congo Basin. Epkwassong is located in a forest zone with bimodal rainfall (1500 to 2000 mm per year in average) characterized by a Guinean climate with 4 seasons (main dry season from December to February; main rainy season from March to June; short dry season from July to August; short rainy season from September to November).

The average temperature is 25°C (Ambassa-Kiki, 2000; Tchatchoua, 2007). The main economic activities of the area are agriculture, artisanal fishing in the rivers Nyong-et-Mfoumou and hunting. Commercialisation of njansang is the fourth most important source of income after plantain, cocoa and cocoyam (Plenderleith, 2004). *R. heudelotii* in this zone is typically found in abandoned farmland and is often retained when land is cleared for farming because it improves soil fertility and provides shade required for cocoa cash cropping (Tchoundjeu and Atangana, 2006).

Data collection tools, target population and sample size

Most of the information reported was collected during a period of intensive sociological research in the community of Epkwassong on harvest and post-harvest techniques between 2003 and 2008 by ICRAF. Methods used at that time included direct observation of the people at work, participation in their everyday lives and attending

public events. Then in 2010, a study was carried out to specifically look at recent developments in njansang extraction machine use in Epkwassong. The following actors were interviewed during data collection: the designer (mechanic engineer), executive members of the group "Fa'a Si Obe" (president, secretary, marketing officer, treasurer, etc.), machine operators and producers, members of "Fa'a Si Obe" group (those who used the machine and those who had not used the machine). Information was collected using three types of questionnaires:

(1) Producers' questionnaire asking for information on the use of the machine and its management system, annual njansang extraction calendar, producer's perception in relation to the machine and to products from the machine. From the 88 group members living in the village, 50 were available for interview, representing 56.8% of group members. From the 50 respondents, 22 had used the extraction machine at least once (users), while 28 had never used the machine (non-users).

(2) Machine operators' questionnaire: required information included the selection mechanism of machine operators and their background on mechanics, machine functioning and maintenance, organization of the work at the machine level, perceived qualities of the machine and quality of the product obtained.

(3) Machine designer questionnaire: to find out about the characteristics of the machine in general. We also used a check list for the focus group discussion with members of the group executive. Required information here was related to machine acquisition and the way in which the machine is managed at group level, knowledge of the content of the machine transfer agreement, quantity of njansang the group is able to provide, constraints and advantages of the machine. A detailed record of labour inputs involved in the extraction of njansang kernels was also undertaken for a complete njansang season in 2010.

In general, the research concentrated on evaluating manual and mechanical extraction using parameters such as extraction time, quantity of kernels obtained, quantity of intact and broken kernels. For the tests on manual extraction, 10 women between 39 and 45 years old were chosen because of their knowledge and experience on njansang extraction.

Qualitative data were analyzed using content analysis, then coded and entered into SPSS12.0 for Windows. Quantitative data were entered into Excel 2007 and were analyzed using frequencies, percentages, means, standard deviation, and standard error. To analyze the performance of the extraction machine, quantitative data on the extraction experiments (manual and mechanized) were analyzed comparing means using the student test.

For further analysis, the learning selection model was used by comparing the Kolb's 4 stages experiential learning cycle on the case of the njansang extraction machine.

Description of kernel extraction methods

Njansang manual extraction

In the village of Epkwassong, njansang processing takes place from November to April. For men, it is a particularly busy period because of the cocoa harvesting (November to February). It is also a very busy period for women with crop harvesting and land preparation. This busy period markedly affects njansang activity because it is not a priority activity for both men and women. To process njansang from fruit to kernel, there are six main steps: fruit collection, pulp removal, nut washing, nut boiling, kernel extraction (Figure 3) and drying.

Fruit collection consists of collecting green fruits one by one from under the tree, putting them in piles and covering with banana leaves. Fruits then have between two to five months to

rot. The second step (pulp removal) consists of removing rotten pulp from all fruits. Inside each fruit, there are two nuts with very hard shells that are obtained after washing. Traditionally, njansang nuts are boiled for duration between 180 to 480 minutes (3 to 8 h), generally in hot water that may often reach boiling water temperature (100°C). The heat softens the shell and small cracks are formed. However, offloading boiled njansang nuts from the cooking pot is traditionally done with calabashes. This means that njansang nuts that enter first the pot will be the last to be removed, causing variation in the time different nuts are exposed to the heat from both the wood fire and the heated water. It is expected that this can lead to irregular reaction in terms of forming cracks in the shell. The small opening in the shell now enables the removal of the shell and manual extraction of the kernels one after the other. Kernels obtained are then washed and dried.

In general, manual extraction is done by women using flattened nails or any other sharp metal object such as a knife. As shown in Figure 1, the metal implement is inserted into the small opening to enable the shell to be split into two, freeing the kernel. Manual extraction is mostly done in the evenings after farm activities.

Njansang mechanical extraction

A prototype njansang extraction machine was introduced in 2007 for experimentation with the group "Fa'a Si Obe" in Epkwassong. The machine was designed by a mechanical engineer based in Douala city (society GFTI) with orientation of ICRAF staff. The njansang extraction machine has three principal parts: the engine, the cracker and the frame (Figure 4). The engine which generates the necessary rotative movement to make the machine function is a diesel (6 CV) monocylindric engine with cooling water.

With a maximum rotative speed of 2800 revolutions per minute, the machine has a gaz oil tank (5 L), a water tank (6 L) and an oil tank (1 to 1.2 L). A hole (or opening) helps to fix a crank to start the machine. The rotative movement is transmitted to the huller through a transmission strap protected by a cover. The huller includes the hopper into which nuts to be cracked are placed, and from there they are introduced into the hammer through an entry orifice. The hammer (or robot) is a disk with small openings which, after extraction, projects shells and kernels toward the exit. Both engine and huller are joined on a frame serving as support. The machine can be lifted using both hands and moved with the aid of two wheels. The back supports enable the machine to be positioned stably on the ground.

RESULTS

Community-based rules for access to the machine (Do current njansang processors have effective access?)

"Fa'a Si Obe" group consists of people living in the village of Epkwassong or neighbourhoods, but not necessarily linked by family ties. Executive members have a role to lead the group to achieve its objectives. Capital decisions on group functioning are first discussed among them before sharing with everybody in the group. For security reasons, the njansang extraction machine is located in the house of the group's president. However, the place is accessible to all. Executive group members have overall responsibility for the machine. Two individuals were selected by the group to be trained in the correct operation of the machine and act as machine operators.

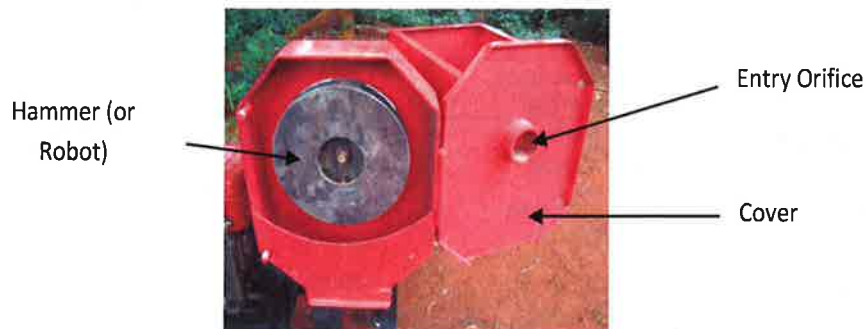


Figure 5. Other parts of the njansang extraction machine

The selection process took into account the candidates' availability and previous knowledge on mechanics. They received training from an ICRAF technician, who had himself been trained by the machine designer. The njansang extraction machine operates Tuesdays from 2 to 6 pm during low production periods and from Monday to Friday, from 2 to 6 pm during high production periods.

Initially, the project provided fuel for the machine. With time however, the group had to take over this responsibility. It was decided that, members willing to extract their product should pay for it in kind or in cash. From the study however, 60% of users did not follow this rule and they cracked their product free of charge. The remaining 40% paid for the use of the extraction machine, but there was high variability in level and type of compensation: for example, 1 or 2 L of fuel, 2 kg of njansang (nuts), and cash payment ranging from 500 to 2000 FCFA according to the quantity the producer brings to the machine.

In terms of the level of utilization, only 22 out of 88 group members (25%) used the machine. This is large because the machine was in an experimental phase and only volunteers brought their product for trials. From these users, more than half (59.1%) used the machine only once, one fifth (27%) twice, 4.5% three times and 9.1% more than four times. The low utilization of the technology can be explained probably by the rate of broken kernels which is higher than with manual extraction.

Most users mentioned curiosity as principal motivation for the utilization of the machine. Nevertheless, 13.6% of producers used the machine on more than three occasions because it is facilitating their work. Other significant reasons as to why respondents were not using the machine were: high rate of broken kernels, long sorting time, distance to the machine and low quantities produced by individuals. At the present stage, taking into account the rapidity of the machine, the possibility of extracting large quantities of kernels and lower risk of accidents, 95.5% of users and 96.4% of non-users said that, they are prepared to use the machine in the next

production season, provided the rate of broken kernels decreases. Broken kernels fetch a lower price at the market and are only used for home consumption.

Actual use, specified by age, gender and education level of the users (Who is actually using it?)

This section deals with three main parameters which, for Rogers (1995), influence the level of adoption of innovations and technologies. Those parameters are sex, age and education level of potential innovation receivers. Respondents included users and non-users of the innovation. The distribution of respondents per sex shows that women represented the majority of producers (72%). Nevertheless, men proportionally (57.1%) used the njansang extraction machine more than women (38.9%). Distribution of respondents by age and category shows that, 34% of respondents were in the 31 to 40 years age group, while the oldest class (60 years and above) constituted 12% of the population. Age analysis of producers per user category shows that most users (70%) were between 41 and 50 years; while most of the non-users (85.7%) were between 21 to 30 years. From the distribution of producers according to education level, 90% of producers have had some formal education with 59% of users having attained secondary education level and 32% primary education level. Those who have not been to school (10%) were producers of more than 60 years old; all 5 in this category were women.

Technical performance in terms of quality of the product (Is the product acceptable for the market?)

To measure the performance of the two extraction methods, the extraction time, the quantity of intact kernels obtained, the quality and the extraction rate of the product were compared (Table 1). Njansang producers do not operate the machine by themselves; this is done by two designated machine operators.

Table 1. Comparison test between two types of extraction for 1000 g of nuts.

Parameter	Extraction method	N	Average	Standard deviation	Difference of average	T	t-probability
Extraction time (in seconds)	Mechanic	4	2523.75	58.071	1128.5	15.82	0.000***
	Manual	4	3652.25	130.311			
Quantity of intact kernels after sorting (in g)	Mechanic	4	251.25	7.500	82.5	18.54	0.000***
	Manual	4	333.75	4.787			
Quantity of kernels divided into 2 (in g)	Mechanic	4	76.25	7.500	65	13.28	0.000***
	Manual	4	11.25	6.292			

$p \leq 0.01$ so p is highly significant to a threshold of 1%.

Table 2. Test of comparison of intact and divided kernels rate according to extraction type.

Parameter	Type of extraction	N	Average	Standard deviation	T	t-probability
Intact kernels' rate	Mechanic	4	76.4	1.84	15.850	0.000***
	Manual	4	96.8	1.73		
Divided kernels' rate	Mechanic	4	23.3	1.84	15.850	0.000***
	Manual	4	3.23	1.73		

$p \leq 0.01$ so p is highly significant to a threshold of 1%.

Extraction time

Results in Table 1 show that, manual extraction time for 1 kg of nuts was 3652.25 s (60 min, 08 s). To extract the same quantity mechanically, it took on average 2523.75 ± 58.07 (42 min, 04s), where the machine running time was 127.75 ± 12.89 seconds (2 min, 08 s) and sorting time 2396 ± 63.72 s (39 min, 56 s). The duration time difference between the two techniques is 18 min 04 s for the extraction of 1 kg of nuts. Comparing the average time needed for the two extraction techniques, results of the student T test indicate that, the mechanical extraction took significantly less time (42 min, 04 s) compared to the manual process (60 min, 08 s). The machine thus, reduces the time spent extracting by 30%. This confirms interviewees' affirmation that the machine is faster than manual extraction.

Quantity of product obtained

Table 1 also presents the quantities obtained for each extraction technique. Mechanical extraction gave significantly ($t = 18.54$, $p = 0.000$) less intact kernels (251.3 ± 7.5 g) than manual extraction (333.8 ± 4.8 g). The difference in broken kernels between mechanical extraction (76.3 ± 7.5 g) and manual extraction (11.3 ± 6.29 g) was also highly significant ($t = 13.28$, $p = 0.000$). These results correspond with producers' perception that the machine breaks more kernels than manual extraction.

Extraction rate

The extraction rate (Table 2) is the quantity of kernels obtained after extraction divided by the quantity of nuts initially used. Intact kernel rate is the quantity of intact kernels obtained divided by the total quantity of kernels obtained. Broken kernel rate is the quantity of broken kernels divided by the total quantity of kernels obtained after extraction. Intact kernel rate of mechanical extraction ($76.4 \pm 1.84\%$) is significantly ($t = 15.85$, $p=0.000$) lower than that of manual extraction ($96.77 \pm 1.73\%$). Consequently, broken kernel rate of mechanical extraction ($23.26 \pm 1.84\%$) is significantly ($t = 15.85$; $p = 0.000$) higher than that of manual extraction ($3.23 \pm 1.73\%$). Hence, mechanical extraction breaks more kernels than manual extraction. This result confirms perception of the producers interviewed. The extraction rate of both techniques is $33.63 \pm 1.3\%$ with standard error 0.46%. So, the kernel quantity which is obtained immediately after extraction is about 1/3 of nuts' quantity for the two techniques. The difference of product obtained in manual and mechanized extraction is due to more broken kernels when using the machine for extraction.

Quality of the product

The quality of njansang in the market is judged from the physical presentation of the kernels as opposed to their flavour. Traders and consumers prefer full bright kernels.

Broken kernels are mostly used for home consumption as they would fetch low prices in the market. From manual extraction, three types of products can be obtained: intact kernels, broken kernels (kernels divided into two) and shells. The kernels obtained during manual extraction are clean because shells are systematically thrown out by the person who is removing the kernels from their shells.

On the other hand, when nuts are cracked mechanically, six types of products are obtained. Adding to the three types from manual extraction, the extraction machine also produces intact kernels in partially cracked shells (remaining inside the shell), broken kernels but remaining inside the shell and full nuts (not extracted). The kernels obtained here are also not clean because of the abrasion resulting from contact between the kernels and shells. This mix of products of different quality constitutes a major disadvantage of the extraction machine.

Overall appreciation by local stakeholders (Will it be adopted based on perceived success?)

Results divide the producers into four opinion groups: 62% of the respondents reported that the machine is a tool to solve extraction problems such as tediousness, risks of accidents and the fact that it is a time consuming task. More than 12% of the respondents said that the machine is a tool to increase quantities exploited. 10% saw it simply as a gift from ICRAF and very few (2%) considered it a loan to the community to conduct extraction trials. Talking about the complexity of the machine, 72.7% of the users interviewed found the machine easy to use, making it very easy to extract large quantities in a very short time. In contrast to this, 27.3% of users thought that the extraction machine results in more work because of the need to sort kernels after extraction.

Perception in relation to the quality of product here concerns the physical presentation of the kernels after extraction and not the biochemical composition and other characteristics. In general, 65% of producers were of the opinion that the quality of njansang kernels obtained from the machine is not as good as the one obtained from manual extraction. The reason for this high percentage is that, the machine breaks kernels into two or more parts. Added to this, is the mixture of kernels and shells which resulted in the adhesion of small shell parts to the kernels, which exit with dirt. 26% of producers however said that the kernel quality obtained from mechanical extraction is as good as that obtained from manual extraction because after the extraction (manual and mechanical), kernels should be first washed before drying.

Producers are aware of the utility of the njansang extraction machine compared to manual extraction. The rapidity of mechanical kernel extraction helps producers

to save time that can be used for other activities. Manual extraction using nails and knives exposes producers to accidents, which is not the case with mechanical extraction. The machine also has some disadvantages. The main disadvantage is the high rate of broken kernels, reported by 68% of the respondents.

DISCUSSION

Co-development process of njansang extraction machine

Researchers involved in the development of the njansang extraction machine include ICRAF staff and the mechanical engineer. From their knowledge, a prototype of the njansang extraction machine was developed, which is a "plausible promise" as described by Douthwaite (2006). The technology is still at the "plausible promise" stage at lower left in Figure 1, but the testing with the njansang producer group has been valuable to help make further improvements. It has also allowed a more effective linking of the engineer's technical skills to local innovation and evaluation. ICRAF staff and the engineer first worked at a conceptual level, but collaboration with the users of the technology allowed the design of different tools and materials to respond to subsequent changes. Building on the prototype received from ICRAF, the machine operators used their knowledge to suggest modifications to the machine. Their motivation to be co-developers came from the fact that the machine is fast and the quality of the product is in some ways as good as that for manual extraction. Changes in the type of extraction will be easily evaluated because stakeholders are 'learning by using'.

The increase in fitness of the njansang extraction machine has been made possible by gaining knowledge through the Kolb's 4 stages experiential learning cycle of the innovation (Douthwaite, 2006).

(i) The experience. Producer's experience here indicates that the njansang extraction machine is a time saving device, but one that breaks a rather high proportion of kernels, discouraging 75% of the population to use it. Broken kernels fetch low prices at the market. It is most likely this reason lies behind the low interest shown by producers in mechanical extraction. These results correspond to findings from Chambers et al. (1994), stating that in general, individuals want to know about advantages and disadvantages of an innovation before taking a decision to adopt or to reject.

(ii) Making sense: One of the reasons behind the high rate of broken kernels is the way in which nuts are preserved and their treatment (nut boiling) before extraction. This obviously needs to be improved.

(iii) Drawing conclusions: From their experimentation, machine operators mentioned that, to avoid the drying of

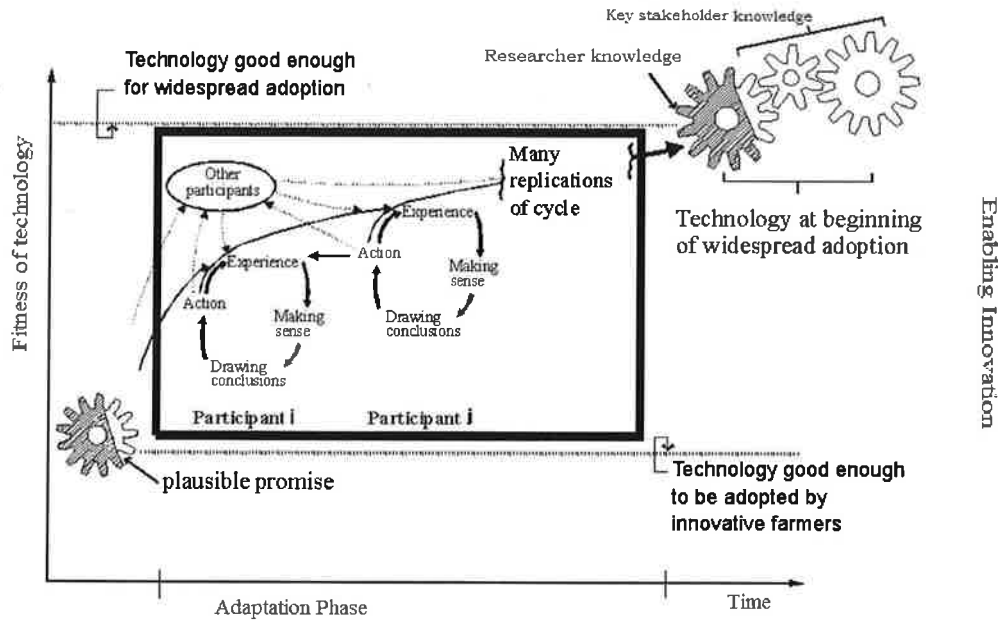


Figure 1. The learning selection model adopted from Douthwaite (2006).

kernels inside their shell, it is important to keep them out of the sun, preferably in a humid place. Added to this, nuts should be soaked in water for at least two days before boiling. This information should be disseminated within the village where the machine is located and more people should be encouraged to experiment with the technology. It is also important that during the boiling of nuts, the temperature of the water is constant and evenly distributed, so that all nuts are equally exposed to the heat that provokes the cracking.

(iv) Action: The action here is to reduce the rate of broken kernels from the mechanical extraction (23.3%) to the level achieved through manual extraction (3.23%). An additional aim would be to eliminate during mechanical extraction three types of product (out of six) which are intact kernels in partially cracked shells (remaining inside the shell), broken kernels but remaining inside the shell and full nuts (not cracked). Later on, the machine utilization rate by njansang producers should be increased.

Success of njansang extraction machine and remaining challenges

Users were happy with the time saved by the njansang extraction machine (difference of 18 min to crack 1 kg of njansang nuts), leading to an increase in the total quantity of kernels that can be extracted. Remaining challenges however are the high rate of broken kernels and associated sorting time. Similarly, to increase the use

of the machine, it should be located within practical proximity of potential users.

Altarelli (1985: 12) concluded from a study on a grinder in Burkina Faso and Mali that women living far from the grinder were not using the machine to grind their cereals. One other factor of an innovation affecting its adoption is testability (Rogers, 1995). Unfortunately, very few producers have been bringing their njansang to the machine during this experimental phase and are therefore not able to evaluate its performance.

The tediousness and complexity of njansang processing, especially nut boiling and kernel extraction, are the main reasons why men are less interested in the activity (Tiki-Manga et al., 2003). Consequently, we expected that, women would be more interested in using the machine than men, but the contrary proved to be the case. It may be that, because the machine utilization is at an early stage, many women do not want to be involved in experimentation or taking any risks with their products. Our data shows that, younger people (below 50 years) made less use of the machine compared to older people (> 60 years). It is likely that, older people are more interested in the technology because their physical energy gradually decreases, encouraging them to opt for less demanding tasks.

Appropriate technology for njansang value chain development

The njansang sub-sector has four main categories of

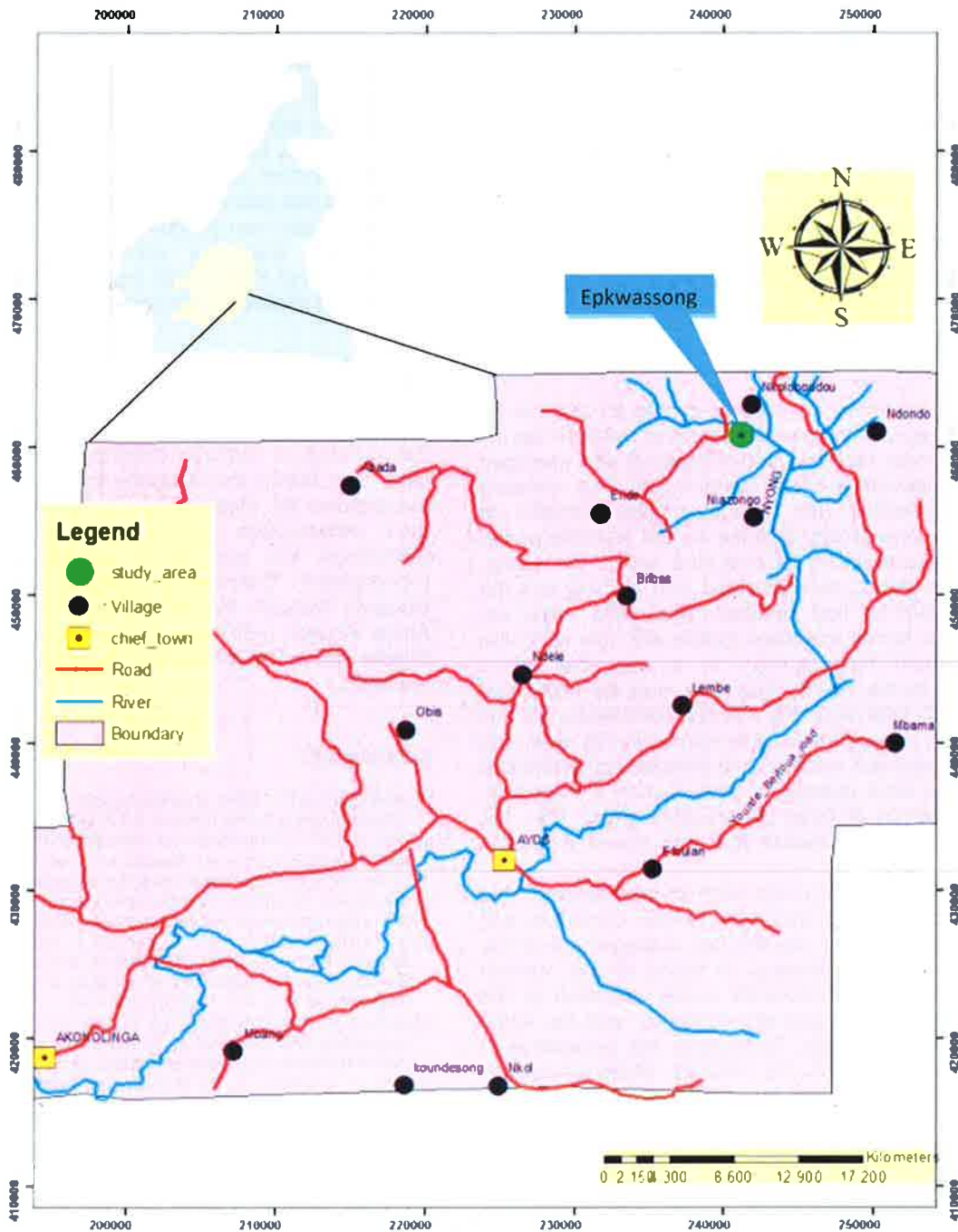


Figure 2. Map of the village Epkwassong.

actors: Producers, processors, traders and consumers. The njansang extraction machine enables producers not only to increase the quantity of the product and its quality, it also provides greater flexibility for choosing the appropriate period to take advantage of favourable

market conditions in terms of price. With sound organizational skills, producers can easily project/estimate available quantities for marketing. Processors also add value to njansang by making powder, paste or oil. The difficulty they face is the

availability of the product during the year.

With the njansang extraction machine, processors can make contacts either with producers or traders to be supplied with a product on a regular basis. Consumers are also able to enjoy supplies of the product avoiding the scarcities of the past. In these conditions traders are able to plan ahead in terms of supply and demand. Moreover, the presence of the machine, with its efficiencies in terms of production, would surely contribute to price regulation at all levels of the commercialization chain, thus, helping to maintain a stable price per kilogram of njansang.

Conclusion

This paper examines an initiative that is an example of introducing agricultural mechanization at the post-harvest level, a process that was conceptualized and managed with the collaboration of all stakeholders. The njansang extraction machine has brought multiple benefits to people who are directly affected by the technology: the machine is accessible to everyone within the group, machine operators were provided with training and the risk of accidents has reduced. Men who were not interested in kernel extraction before are now using the machine more than women. In a way, this brings equilibrium to the activity, but care must be taken that men do not take over the activity completely, as this would mean a loss of income to women in this area. The njansang extraction machine is a time saving device that processes a large quantity of product in a short time. The appreciation of local stakeholders shows that, the machine is a very effective tool that solves extraction problems.

Nevertheless, some points need to be improved, that is, knowledge of nut treatment before extraction and group organization for the efficient management of the njansang extraction machine. In terms of use, women should become more involved in the utilization of the machine even if they are not educated, and the same applies to young people. Technically, the percentage of broken kernels needs to be reduced, which would also shorten the time needed for sorting. If these technical issues are resolved, then adoption of mechanical njansang extraction would be more about changing how people deal with their njansang and make decisions about the production process, and less about the acceptance of a new technology. Nevertheless, a cost-benefit analysis of mechanical extraction is needed to determine what quantities of njansang are required and how much users have to pay to break even.

The results of the study are based on evaluation of one prototype machine for extracting njansang kernels in one community in the Centre of Cameroon. However, the community of Epkwassong can be considered representative of many villages in the forest zone of Cameroon, and even in the Congo Basin where *R.*

heudelotii is present. The main objective of the introduction of the machine in a rural setting was to involve end-users in the process of technology development in an early stage. As mentioned earlier, this participatory evaluation has resulted in adjustments made to the machine, but has also brought out the need to look at nut treatment before introduction into the machine; something that was not thought of before. Nevertheless, after the study was conducted, 6 other machines were constructed and are currently under testing in communities of East, South and Center of Cameroon to continue its evaluation and further increase its relevance.

ACKNOWLEDGMENTS

We wish to thank the population of the village Epkwassong, in particular the group members of "Fa'a Si Obe" who tested the njansang extraction machine and the engineer (M. Mushagalusa Tele) who designed it, for their collaboration during the evaluation of the technology. We are equally grateful to the Belgian Development Cooperation (DGCD) for funding this research through the Agroforestry Tree Products for Africa Project (AFTP4A). We also wish to thank Ms Sheilla Atieno Odhiambo for reading and commenting on the draft.

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