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PERCEPTION OF THE ADOPTION DETERMINANTS OF RICE HUSK STOVES BY WOMEN OF THE REGIONAL UNION OF WOMEN RICE PARBOILERS OF THE HILLS (URFER-C) IN BENIN

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ABSTRACT

Rice currently represents the second cereal in production in Benin, after maize. This study aims to understand better the perceptions of women rice parboilers regarding the use of rice husk stoves and to analyze the socio-economic determinants affecting its adoption. To carry out this study, 105 women rice parboilers were sampled and submitted to individual interviews and focus group discussions realization, using an interview guide and a survey questionnaire. From the results obtained, it appears that at the level of the parboiling centers, 74.29% of the parboilers adopted the rice husk stoves but used them combined with traditional stoves (three-stone firewood system). As economic favorable determinants of the adoption of rice husk stoves, they raised, among others, a reduction in the cost of parboiling and losses in quantities of parboiled rice, a decrease in cooking time, an increase of the amount of parboiled rice per unit of time, and obtaining a better quality of parboiled rice. They also mentioned some favorable social determinants such as: the preservation of the environment and the women's health, the reduction of the risk of burning their loincloths, and the reduction of the arduousness of the work. Even though rice husk stoves present several advantages, many factors limit their adoption, notably their purchasing cost, which looks pretty high; their height, which is unsuitable for the average height of women; and the high weight of the stoves, which makes them not easy to move by them. Faced with these shortcomings, research and extension structures must work to make it affordable to women and introduce modifications in the design of the stoves to adapt them to their physical conditions better.

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INTRODUCTION

Rice (*Oryza sativa*) constitutes a strategic and priority product for food security in developing countries (Seck et al., 2013). In the economies of West African countries, rice plays a significant role in the consumption of urban and rural households (Fall, 2018). Formerly considered a luxury food mainly consumed on holidays, rice occupies an increasingly important place in the daily lives of populations in both urban and rural areas (Tondel et al., 2020). Ranked the third (3rd) most consumed food cereal with a global production of nearly 758.9 million tons in 2017 for 503.8 million tons milled (FAO, 2017b), the increase in rice production represents a significant challenge for food security in developing countries (MAEP, 2019). In Benin, rice is one of the priority agricultural development sub-sectors as per the National Strategy for the Development of Agricultural Sectors (MAEP, 2017). In the country, rice is one of the

most abundantly consumed cereals (Konnon et al., 2014), with an increase in annual consumption of 10% between 2013 and 2017 (Tondel et al., 2020). However, despite this remarkable progress in its production, i.e. 519,000 tons of paddy in 2021 compared to 80,000 tons of paddy in 2008 (MAEP, 2022), the challenges of feeding the growing population (increase in consumption needs per capita /year) and harmonizing the interests of rural farmers with those of consumers remain enormous. Furthermore, in the globalization of trade marked by regulatory and normative contingencies regarding product quality, mastery of rice processing constitutes one of the sine qua non-conditions for satisfying market requirements and developing a label for rice from Benin (MAEP, 2017). However, it is noted that the Beninese prefer imported white rice because they consider it "inferior" to the quality of local white rice (Kinkpe et al., 2016). Indeed, several authors have shown that poorly recommended or inappropriate post-harvest practices are the cause of the lower quality of local white rice and that parboiling can largely contribute to its improvement (Zossou et al., 2012; Todomé et al., 2018; Zoundji et al., 2022).

In Benin, parboiled rice processing activities are the prerogative of women with the support of children for collecting water and washing the paddy (Hinnou et al., 2015). Traditional rice parboiling is still widely practiced by rice processors, which negatively impacts the quality of the finished product (Zoundji et al., 2022). Furthermore, the increase in processing volume leads to a chain of constraints linked to the needs for water, wood energy, and time and the rise in by-products and processing waste (Yo et al., 2020). Most parboiling centers in Benin use wood as a source of energy to process rice. Wood fuels (firewood and charcoal) represent 59.4% of national fuel consumption (MEE, 2010). This situation poses ecological problems linked to deforestation and water and sanitation problems due to the piling up of rice husks (Yo et al., 2020).

Furthermore, using of firewood as a source of energy causes quantitative and qualitative losses in the final product (parboiled rice). To remedy this, new technologies have been introduced in paddy processing in parboiling centers, notably rice husk furnaces (Ouédraogo, 2016). Indeed, in the dynamic of continuously improving the quality of local parboiled rice, Africa Rice Center (AfricaRice) and its partners developed a technological innovation called "improved rice parboiling system" (GEM). This technology aims to contribute to changing practices among women parboilers and to qualitatively and quantitatively improve local paddy rice (Zoundji et al., 2022). Within this framework, rice husk stoves were introduced into the parboiling centers of the Regional Union of Women Rice Parboilers of Hills in 2018. Arouna et al. (2023) carried out a study on adopting the improved parboiling technology for rice value chain upgrading in Benin. Still, this study was more focused on the impacts of this adoption on the women rice parboilers' livelihood. Significantly, the current study aimed to raise the intrinsic and the extrinsic determinants of the GEM that enable or limit its adoption as perceived by the women rice parboilers members of URFER-C in the Hills department in Benin.

METHODOLOGY

This section describes and justifies the choice of the study area and then addresses sampling and data collection, processing, analysis appraisals, methods, and tools.

Choice of the study area and the Regional Union of Women Rice Parboilers of the Hills (URFER-C)

The choice of the department of Hills and the URFER-C for this study is oriented by multiple reasons. The first reason is that the Hills department is one of the most important in rice parboiling in Benin (Houssou, 2003). The second one is that 85% of the local parboiled rice present on the markets in Benin comes from department of Hills where the URFER-C headquarter is located. This result can be explained by the fact that parboiling is an activity in a very old economy in this area and by the numerous technical and/or material support that have benefited the parboilers since the rice crisis of 2008 (donations from organizations such as SNV, VECO WA, AfricaRice) (Todomè et al., 2018). Third, URFER-C is the first departmental union of women rice parboilers created in Benin. URFER-C was registered in 2016 in the register of cooperative societies under No. 06- 11-03-2016-230-Im. Today, it has 1076 women, including 342 young women (age ≤ 35 years). The headquarters of URFER-C is located in the Municipality of Glazoué. The URFER-C brings together six (6) Communal Cooperatives Unions of Rice Parboilers of Hills (UCCER) located in the Municipalities of Bantè, Savalou, Savè, Dassa-Zounmè, Glazoué and Ouèssè of the Hills

department (see figure 1). It comprises 83 Village Cooperatives of Rice Parboilers, of which 66 are registered and 64 are already registered in the Official Journal of the Republic of Benin. The URFER-C and each UCCER are administered by a Board of Directors (7 members) and an Executive Office (3 members). Finally, URFER-C has a Final Processing and Distribution Center (CTFD), while each UCCER has a collective rice parboiling center that supplies the CTFD for sorting, packaging, and marketing. However, in addition to collective activities, most women rice parboiling members do rice parboiling individually at home.

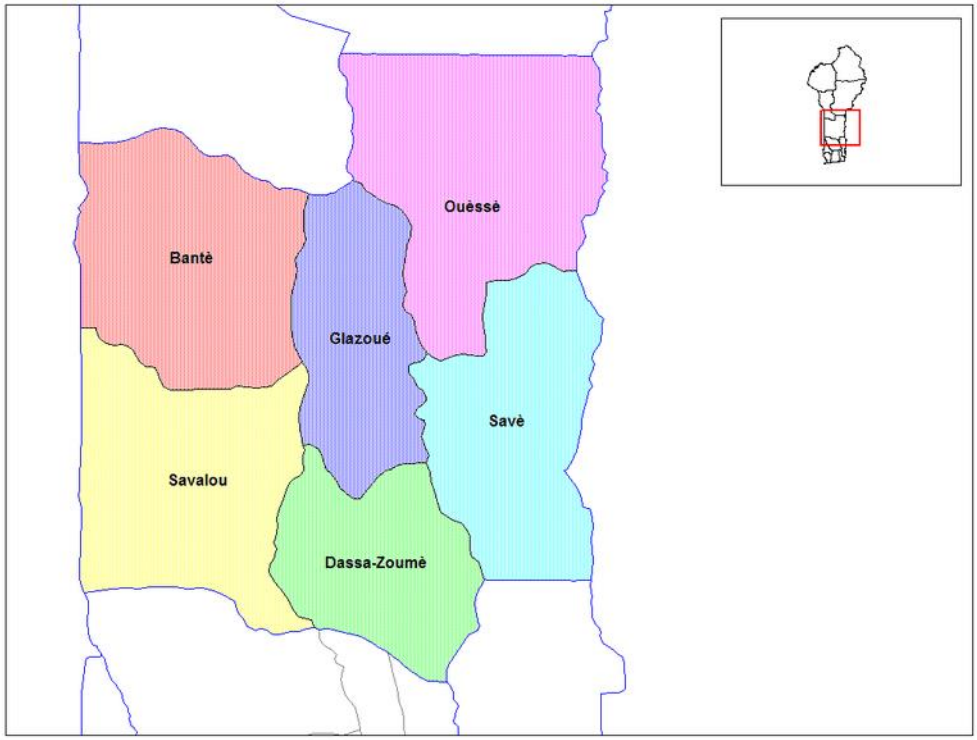

Figure 1. Hills department map. Source: INStaD, 2023

Theoretical Framework of the study

Several theories have been developed to understand factors influencing the adoption and diffusion of technological packages developed for stakeholders in the agricultural world (Yo et al., 2020). As part of this study, we referred to the most relevant ones as described below. The first theory is known as "the diffusion of innovations" and the best-known author on this paradigm is Everett Rogers (1983 and 1995). According to Rogers (1995), the adoption of an innovation is linked to certain factors intrinsic to the innovation itself. For him, adopting an innovation depends on its advantages, compatibility with beliefs and norms, level of complexity, possibility of being tested, and a high degree of observability of its benefits. Davis (1989), through the technology acceptance model, emphasizes the individual factors of potential adopters of an innovation to influence the decision to adopt or not an innovation by studying the perception and beliefs of potential adopters: the perceived usefulness and ease of innovation. These two theories explain users' attitudes and intentions towards adopting or not adopting new technologies and innovations. However, Rogers (1995) and Davis (1989) agree on the level of complexity, which refers to ease of use, and the level of advantage and utility seem to be critical factors for these two authors. These two theories helped guide the data collection and analysis in this study. Indeed, this study highlighted the intrinsic factors of the improved rice parboiling device (GEM), the socio-economic factors linked to the living and working environment of the women rice parboilers that affect the adoption of the GEM and the perceptions (in terms of norms and beliefs) of women parboilers on the use of this device in their parboiling activities and which would affect the adoption or not of this technology.

Selection of respondents

The sampling unit comprises women rice parboilers who are members of the Regional Union of Women Rice Parboilers of Hills (URFER-C) composed of 6 Communal cooperatives in the Hills department in Benin. These are the Unions of Communal Cooperatives of Rice Parboilers (UCCER) of the Communes of Bantè, Dassa-Zoumè, Glazoué, Savalou, Savè and Ouèssè). As part of this study, a sample of 86 women parboilers members of URFER-C was selected for individual surveys and 19 women for the realization of 02 focus groups to measure the level of adoption of rice husk stoves as well as the perceptions of women parboilers on the use and benefits of the GEM. Sampling was done through the snowball method and based on the availability of rice parboilers and active participation in parboiling activities. Indeed, we proceeded with the systematic choice of 03 members among the leaders of the steering committees (president, secretary, and treasurer) of each UCCER and the President of URFER-C for selecting 19 women parboilers for the focus group realization. For individual surveys, we first identified the UCCERs in which at least one session of parboiling activities is scheduled in the UCCER parboiling center during the survey period. The selection criterion was to retain the women we saw in total activity during a rice parboiling session. To this end, all women involved in a parboiling activity at the UCCER parboiling centre were systematically selected onsite. At the end of this process, we noted that only the UCCERs of Glazoué, Ouèssè, and Savè had scheduled at least one parboiling activity in which we were able to participate, which was not the case for the UCCERs of Savalou, Dassa-Zounmè and Bantè. For these last UCCERs, we invited 05 members, including 03 responsible for their steering administrative board and 02 members who also carry out parboiling activities at home. Thus, 105 members were surveyed during this study (Table 1).

Table 1. Distribution of the number of women parboilers surveyed by UCCER.

UCCER	Total members	Number of respondents		Percentage of total respondents
		Individual	Individual and in focus group	
UCCER-Glazoué	142	36	4	38.10%
UCCER-Ouèssè	173	29	3	30.48%
UCCER-Savè	156	15	3	17.14%
UCCER-Savalou	193	2	3	4.76%
UCCER-Dassa	260	2	3	4.76%
UCCER-Bantè	152	2	3	4.76%
	1076	86	19	100%
Total		105		

Data Collection

As part of this study, we conducted non-structured individual and focus group interviews and then carried out participant observations. As mentioned above, individual interviews were carried out with 105 women rice parboilers who were members of URFER-C. Subsequently, two focus group interviews were carried out with 19 elected parboilers from the UCCER and the president of URFER-C. The data collected during individual interviews were related to the socio-demographic profile of the parboilers; the factors affecting the success of parboiling activities, the norms and socio-economic barriers linked to the parboiling activity. In addition, the perceptions of parboilers on the operation and the use of the improved parboiling device (GEM) have been collected. During the first group discussion, data collected were related to the strengths, weaknesses, opportunities, and threats (SWOT) of the URFER-C and the perceptions of the parboilers linked to the use of the GEM. The second group interview validated and classified the identified constraints that affect the adoption of GEMs in order of importance. Finally, specific data were collected based on participant observation through participation in parboiling sessions in the UCCER parboiling centers of Glazoué, Savè, and Ouèssè. This approach was practical to ensure the reliability of the data collected through the interviews.

Data analysis

The method used for data analysis is essentially qualitative. It mobilized several tools and approaches, including the Strengths, Weaknesses, Opportunities, and

Threats (SWOT) analysis matrix, the content-based analysis approach and the grid for prioritizing constraints. Analyzing the matrix of Strengths, Weaknesses, Opportunities and Threats (SWOT) made it possible to identify and analyze the internal and external factors of adopting the rice husk stoves within the UCCER and the 'URFER-C. It also made it possible to identify all the positive and negative aspects of using rice husk stoves to turn this into advantages (strengths) and disadvantages (weaknesses). The content-based analysis approach was used to extract, analyze and interpret the data from the individual open-ended interviews according to meaningful categories. In this context, the different types of favorable or unfavorable socio-economic factors linked to the adoption of GEMs, the perceptions of women relating to them, and the various testimonies, were extracted and analyzed. These data were combined with information extracted from group interviews to ensure their relevance and reliability. Subsequently, each category of factors affecting the adoption or not of GEMs served as a variable to which we assigned the numbers of respondents for calculating averages and percentages. These data, thus stripped and processed, were used to produce tables and figures, which were subsequently analyzed and discussed. Finally, the constraints prioritization grid was used to rank the important factors affecting the adoption of GEMs identified during the data collection phase in order of importance.

Ethical consideration

As part of the ethical consideration, at the beginning of the study, a meeting was held to inform the URFER-C administrative board members clearly about the study's objectives and how the data will be processed and published and request their approval before the data collection started. In addition, a consent form was designed, and all the respondents were informed about its content and gave their consent forms for each interview. Finally, it was clearly stated during the interviews that all the data collected would be processed anonymously.

RESULTS

The origin of the use of rice husk stove technology by URFER-C parboilers

In Benin, parboiling is an important income-generating activity for women (Adégbola, 2010). To this end, improved systems have been introduced in the country to enhance the quality of local rice. According to Zossou and Wanvoekè (2010), the first one is a 25kg and 45 kg parboiling capacity device and was composed of a cast aluminum pot and a frustoconical steaming tank made of galvanized metal sheet which is a bucket-shaped container whose bottom and lower 1/3 perimeter is perforated. The pot is adapted to the steaming tank so that the perforated lower part of the tank is well inserted into it. Although it has contributed to improving the quality of local rice, this device does not resist heat and rust easily (Houssou et al., 2015; Zoundji et al., 2022). Based on this observation, another more improved and rust-resistant parboiling device was developed by research (Houssou et al., 2015). However, this new device does not allow daily parboiling of a large quantity of paddy rice. Next, from 2010 to 2013, to respond to new needs expressed by rice parboilers, the National Agricultural Research Institute of Benin (Institut National de Recherches Agricoles du Bénin [INRAB]) increased the size of the system by introducing new high-capacity treatment components. These higher-sized devices could treat 180kg, 270kg, and 300kg of paddy rice in two (02) hours. They were equipped with improved hearths to reduce smoke and save firewood. Some shortcomings were identified by the rice parboilers after the use of medium-capacity (180kg) and large-capacity (300kg) parboilers. In 2015, the AfricaRice research centre and its partners developed the "Grain quality-enhancer, Energy efficient and Durable Material (GEM)" as an advanced rice-parboiling device. The integrated multifunctionality of this device made people consider it as a system. The initial GEM, which was launched in 2015, is immobile and expensive to install (around 2,000,000 fcfa or about 4,000 USD).

In contrast, women rice-parboilers used to spend about 55,000 fcfa (i.e. about 110 USD) to access the 45 kg mentioned above device. This technology aims to contribute to changing practices among women parboilers and to qualitatively and quantitatively improve local paddy rice (Zoundji et al., 2022). According to Maougbe et al. (2023), the improved parboiling device called “Grain quality enhancer, Energy efficient and sustainable Material” (GEM) produces quality rice. The construction quality characterises it, consumes little energy, and processes large quantities of rice. In Innovations Platforms, GEM is intended for processors, women traders, and young people.

Processors in Glazoué, Benin, evaluated the GEM in March 2015. They "loved" it but recommended various modifications, particularly on the system's capacity. AfricaRice subsequently installed and tested the technology in Glazoué, facilitating further training in using the modified GEM, which helps processors embark on the rice parboiling business. Subsequently, Glazoué processors saw their rice price increase by 25%.

In 2018, following research work on improved stove solutions, the Women's Entrepreneurship Support Project in the Rice Sector (PAEFFR) technical and financial partner at URFER-C, funded by a Canadian NGO, donated several rice husks stoves to URFER-C to allow the use of rice husks instead of fire woods. Thus, the general objective of the initiative is to replace firewood with rice husks to parboil rice to valorize these husks which are stored in rice mills without being used, reduce the cost of parboiling continued to the high cost of wood and thus preserve the forests. Therefore, 4 stoves were distributed in each of the parboiling centers of the 6 Communal cooperative members of URFER-C, and some training sessions were organized for the benefit of parboilers on the use of rice husk stoves at the CTFD of the URFER-C. The rice husk stove uses rice husk from the hulling of paddy rice as fuel. This fireplace is powered by a blower, which ensures the entry of air (Figure 2).

Figure 2. Rice husk stove. Source: Field data, 2023

Sociodemographic profile of the parboilers surveyed

The women parboilers have an average age of 51 years (±9.86) with a seniority of 12 years (±4.76) in the parboiling activity. In addition, most of them are married (88.57%) and have a low level of education (36.19%). Furthermore, all of them belong to a cooperative, and 71.43% carry out rice parboiling as their primary activity. Farming remains the secondary activity for 43.81%) of these parboilers (Table 2).

Level of use of rice husk stoves in parboiling centers and at home

The results showed that the parboilers use rice husk stoves and traditional firewood stoves in the different parboiling centres. 78 parboilers of the 105 surveyed said they use rice husk stoves in the parboiling centers, and 27 said they do not use these stoves (non-adopters) during activities in the parboiling centers. Apart from the parboiling sessions at the parboiling centers, the parboilers practice parboiling at home, but none of them (100%) use the rice husk stoves during their parboiling activities at home.

Favorable perceptions of parboilers regarding the adoption of rice husk stoves

Perceptions of parboilers related to the use of rice husks as an energy source

As mentioned above, parboilers do not use rice husk stoves during their home activities. According to them, the non-use of rice husk stoves at home is explained by the fact that this technology has been tested and popularized within parboiling centers and that they find it too expensive. The results also showed that 52% of parboilers using rice husk stoves found that cooking the contents of the pot was faster and reduced cooking time by at least 30 minutes compared to using rice husk stove with traditional wood-burning. However, 16.19% of the

women surveyed using this technology find that the heat released by the combustion of rice husks is more intense than that of firewood and 8% think that the clear smoke from this biomass remains more bearable than that of wood. On the other hand, 11.14% find that rice husk is more accessible in terms of availability than firewood, and only 4% find that its combustion is slow. However, they praise the availability of rice husk as a source of energy in their environment. Finally, 8.67% of users find it less tiring to handle rice husks than firewood. This is explained by the low weight of the balls compared to firewood (Figure 3).

Table 2. Socio-demographic profile of the women rice parboilers.

Variable	Average	Standard deviation	Minimum	Maximum
Age	51.43	9.86	25	72
Number of parboiling years of experience	12.76	4.76	5	25
Variable			**Absolute frequency**	**Relative frequency (%)**
Education Level	Non-scholarized		67	63.81
	Scholarized at the Primary level		26	24.76
	Scholarized at the secondary level		12	11.43
Marital status	Married		93	88.57
	Widows		12	11.43
Main activity	Agriculture		22	20.95
	Rice parboiling		75	71.43
	Trade		08	07.62
Secondary activity	Agriculture		46	43.81
	Rice Parboiling		32	30.48
	Trade		09	08.57
	Sewing		10	09.52
	Hairdresser		08	07.62

Source: Field data, 2023

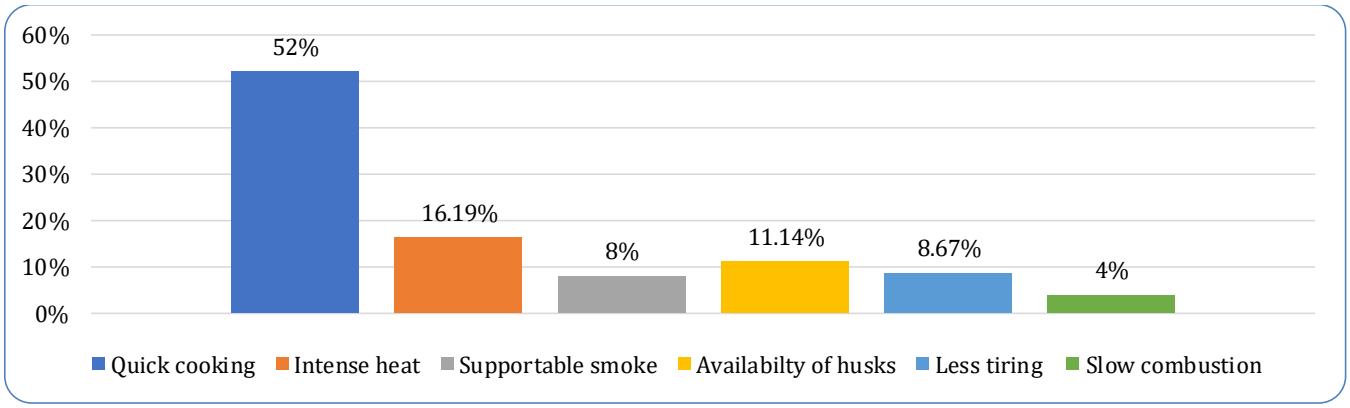

Figure 3. Perceptions on the use of rice husks as an energy source. Source: Field data, 2023

Perceptions of parboilers on the quality of parboiled rice with rice husk cookers

According to the results, 66.67% find that the rice parboiled with rice husk stoves is of excellent quality compared to that of firewood stoves; 23.81% think of an average quality, while 9.52% did not give their opinion. According to 90.48% of adopters, rice parboiled with rice husks as an energy source after drying and hulling is more attractive and of higher quality than rice parboiled with wood. In addition, the latter believe that the

improvement in the quality of parboiled rice resulting from the use of rice husk stoves is because, during cooking, the steam is distributed proportionally over the surfaces of the pot, and this causes the steam to rise quickly above the paddy, which accelerates its cooking and the grains at the bottom of the pot have neither time to open nor turn black; which is not the case with firewood (Figure 4).

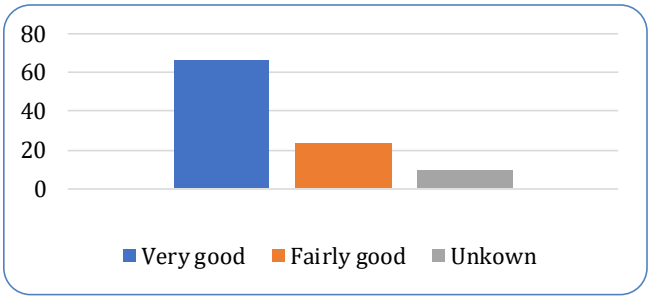

Figure 4. Perception on the use of rice husk stove and the quality of the rice obtained. Source**:** Field data, 2023

Perceptions of parboilers on socio-economic factors influencing the adoption of rice husk stoves

According to most parboilers, introducing rice husk stoves made it possible to understand the usefulness of rice husks, which were previously considered agricultural waste from paddy husking. Thus, for 100% of parboilers using the technology, the availability of rice husks in quantity in the parboiling centers constitutes a motivation for adopting rice husk stoves. According to them, introducing this technology made it possible to reduce the cost of parboiling and save money thanks to the reduction in the costs of purchasing firewood. Indeed, according to them, before introducing this technology and with the high cost of firewood, for a parboiling activity, they spent around 5000 CFA francs to purchase wood for a ton of parboiled rice. But, using rice husk stoves, they spend less than half (less than 2500 CFA francs per ton). In addition, 81.16% of adopters declared that using rice husks as an energy source made it possible to increase by 2 tons the quantity of rice they parboiled per week with firewood alone. In addition, 64.09% of adopters sometimes notice that when they steam the rice with wood, the rice grains at the bottom of the parboiling boat open up and form a soft paste or get burned. This creates a loss, which is not true when using rice husks. As a result, they believe there are more gains than losses when using rice husk stoves. However, for parboiling activities at the household level, 100% of parboilers are not satisfied and affirm that given their low purchasing power, the rice husk stove is considered too expensive a technology. Indeed, the parboilers surveyed estimate that the rice husk stove device (hearth + blower) would cost 280,000 FCFA, unlike firewood where they use the three-stone device, which is inexpensive or even free. Thus, they believe that the rice husk stove's purchase price limits individual parboilers' adoption of their home activities. According to them, this also explains that these devices are only available in the UCCER parboiling centers, which have benefited from them thanks to the financial support of the PAEFFR as mentioned above (Figure 5). In addition to the determinants mentioned above by the parboilers, they also noted that the use of rice husk stoves benefits them greatly in terms of health and the environment. Indeed, according to them, the adoption of the rice husk stove makes it possible to avoid bending to extract the pre-cooked rice and therefore reduces physical pain, unlike the traditional system for which they are required to bend each time to reposition the firewood at the level of the three-stone hearth to prevent the fire from going out. The parboilers noted that parboiling with rice husk stoves reduces the risk of burning their loincloths and the arduousness of the work. They also affirmed that the combustion of rice husks in the hearth does not release black smoke, which reduces air pollution, and the blackening of containers and protects their eyes, thus protecting them from respiratory diseases linked to the combustion of firewood. The women surveyed highlighted an advantage of firewood the fact that it generates charcoal residue which some of them said they use as fuel for other uses such as heating water, cooking meals, etc. According to some non-adopting parboilers, this would be a source of motivation, which explains why they continue to adopt traditional stoves using firewood.

Perceptions of parboilers on technical characteristics limiting the use of rice husk stove

Although using rice husk stoves is beneficial for parboilers, the latter have raised certain constraints and inadequacies about this technology. First, 36.19% of steamers say the hearth height is a limit. Indeed, they believe that the fact that the bins are a little high and mounted on the hearths makes the size of the entire device challenging to handle when the paddy is pre-cooked and must be removed. Women use stools to

stand higher when removing their products to compensate for this insufficiency. Thus, the height of the rice husk hearths is a significant constraint limiting its adoption depending on the parboilers. According to them, during pre-cooking, they are required at one point to lower the parboiling tank and its contents from the hearth to be able to collect the burnt husks from the hearth and add others for combustion. They mentioned that these fire pits are made with iron causes them to heat a lot, which they say sometimes leads to physical injuries when picking up balls from the fire pit while cooking. They also claim that the weight of the fireplace (37kg) does not make it easy to move. Finally, for 4.77% of the parboilers surveyed, the fact that rice husk stoves require regular maintenance to function correctly constitutes a constraint limiting their adoption. Indeed, the latter mentioned that after each use, they must empty the hearth of the charred balls each time, unclog the burner holes, and maintain the blower delicately, which, according to steamers, is tedious and takes time.

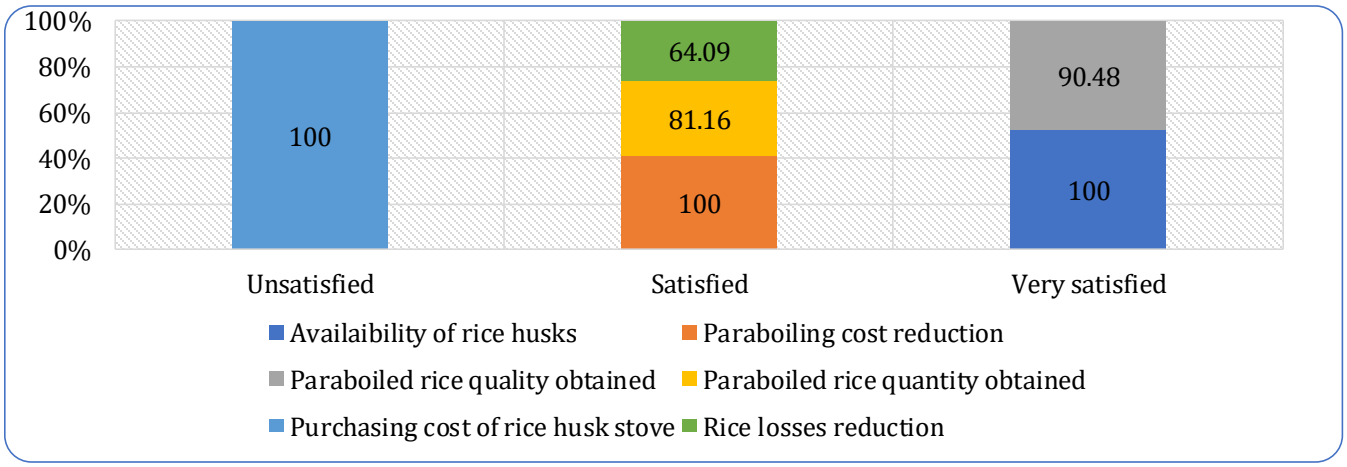

Figure 5. Perceptions on the level of satisfaction of the determinants of the use of rice husk stoves.
Source: Field data, 2023

Hierarchization of the constraints linked to the adoption of rice husk stoves

The results in Figure 6 below present the hierarchy of the constraints linked to using the rice husk stoves. From the analysis of Figure 6, we see that 100% of the parboilers raised the constraint of the cost of purchasing the rice husk stove (around 2,000,000 Fcfa or about 4,000 USD), 36.19% of the parboilers perceived the height of the furnace too high; 29.52%; 16.19%; 13.33%, and 4.77% of parboilers respectively mentioned the problem of the weight of the stove, intense heat, physical injuries, and regular maintenance as constraints limiting its adoption. Whereas, the primary constraints steamers face are the cost of the technology, the hearth's height, and the hearth's weight as reported by the study respondents.

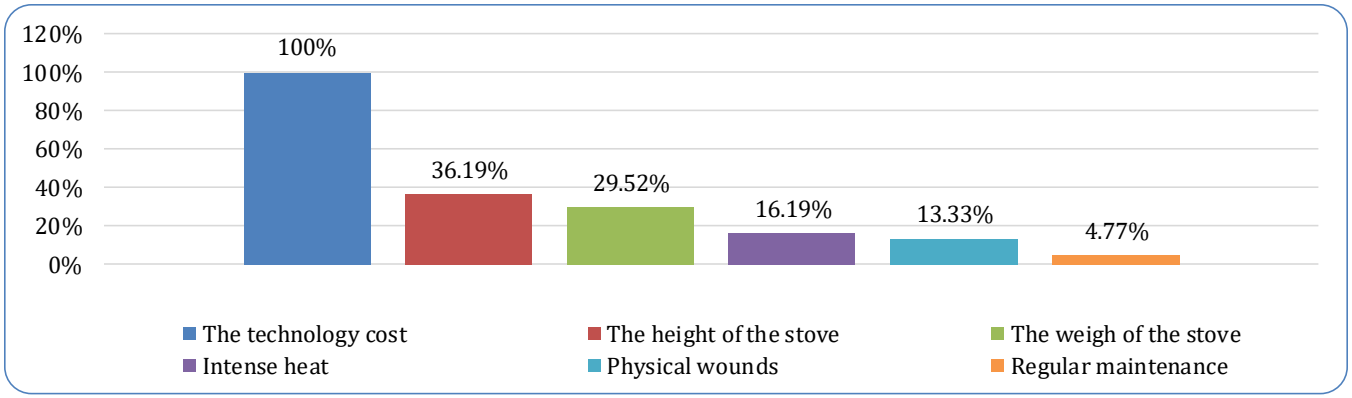

Figure 6. Hierarchization of the constraints linked to using the rice husk stoves. Source: Field data, 2023

DISCUSSION

This study's results revealed several favourable determinants, some favorable and others unfavorable to the adoption of rice husk stoves by women rice parboilers in the Hills department. These determinants are technical, socio-economic, and environmental. Overall, it should be noted that adopting rice husk stoves has several advantages, including its contribution to preserving the health of parboilers and the environment. These results are similar to those of Yo et al. (2020) who highlighted that rice parboiling harms the environment through pressure on forests due to the increasing use of firewood on the one hand and the production of liquid and solid waste on the other hand, but that the production of rice husks as biomass is recyclable and constitutes an economic opportunity that the use of rice husk stoves could help capture and thus reduce the harmful effects of parboiling activity on the environment. As far as health preservation of women parboiled testified is concerned, it is understandable as Parmagini et al. (2014), who reported that indoor smoke from cooking with biomass, is associated with many diseases and that it is estimated that household air pollution from solid fuels accounted for nearly 3.5 million deaths in 2010. In contrast, the rice husk stove positively impacts this indoor smokes' reduction. In addition, these results are well aligned with those of Ndindeng et al. (2019), who mentioned that:

"*Some 5 million tons of rice husk are produced annually in SSA and mostly disposed by burning in open fields or abandoned behind rice milling facilities. With appropriate technologies and knowledge, converting rice husk into high-quality energy is possible. It offsets other unsustainable energy sources, be it wood, charcoal, or petroleum products. This can lead to financial, environmental, and social benefits while building greater resilience in the rice sector, thereby increasing food security and the incomes of rice value chain actors*".

The favorable determinants are also linked, among other things, to saving time, reducing parboiling costs, improving the quality of parboiled rice, and increasing the quantity of parboiled rice per unit of time. According to Sabiyo et al. (2020), rice husks are cost-efficient compared to firewood. Zossou and Wanvoeke (2010) also stated that the improved hearths were designed to save energy, protect the environment, and improve thermal efficiency (Kouévi et al., 2023). It was also mentioned by Zoundji et al. (2022) who showed that the saving of time has a positive effect on the change in rice parboiling practice. According to these same authors, this fact could be explained by the fact that saving time stimulates the motivation of women to use improved practices to reduce parboiling work time and to engage in other income-generating activities. Regarding the improvement of the quality of parboiled rice, Meougbe et al. (2023) showed through the results of a study on women parboilers in the Ivory Coast, that the transfer of parboiling technology GEM among women parboilers improved the quality of parboiled rice and increased their income. In addition, these results are corroborated by those of an evaluation conducted by AfricaRice in 2015 on the effect of the adoption of the adoption of the rice husk stove (GEM) by rice parboilers in Glazoué in Benin in 2015 (AfricaRice, 2017). Indeed, through this evaluation, they showed that average monthly production increased by 188%, translating into an income increase of 123%. They, therefore, estimated that these increases are attributable to the improvement in the quality of parboiled rice.

Furthermore, heat-related damage would have fallen from 23.9% of grains to almost 2%; the quantity of rice processed has increased from 60% to 91%; the undesirable chalky appearance of the medium has decreased from more than 20% to zero; and impurities decreased from more than 5% to zero. In addition, according to a study carried out by the Technical Coordination Office of TAAT (2021) of the International Institute for Tropical Agriculture (IITA), the parboiling technology called Grain Quality Improver, efficient in Energy and Sustainable Material (GEM) combines better soaking, parboiling and drying to improve grain quality, reduce energy consumption and exertion for the benefit of women who dominate the parboiling industry in Africa. Given these numerous advantages, highlighted by several authors, Zoundji et al. (2022) suggest that the government and partners popularize the modern parboiling device (GEM) in rural areas in Benin and promote its exclusive use for the transformation of paddy locally parboiled rice to ensure their competitiveness in the market. In the same vein, Meougbe et al. (2023) propose, taking into account this new technology's potential and women's enthusiasm for its use, that the State should intensify its transfer actions in all areas producing rice in Ivory Coast. Finally, the constraint related to the frequent maintenance of the rice stove husk (GEM) use as raised by the women has

also been corroborated by those of Kouévi et al. (2023) who also reported testimony of some of their respondents in the frame of a study carried out on the rice parboiling innovations in Glazoué Commune, who highlighted that rice husk stoves' metal hearths are usually very dirty after parboiling activities and so require regular maintenance of the device.

However, the evaluation of AfricaRice (2017), did not reveal any constraints linked to the cost of the device itself, which is not affordable for individual parboilers. In contrast, as mentioned above, most of the devices identified in the UCCER parboiling centers were financed by the PAEFFR project, which may raise the question of whether the UCCERs themselves could easily afford it. There are also constraints linked to the handling of the device due to its high height compared to the average size of parboilers. Its high weight, which has not been mentioned in the AfricaRice (2017) evaluation, and requires to be taken by the research centers to work on all the constraints to come up with further innovations to make them more affordable and accessible for women rice parboilers.

CONCLUSION

This study, based on the analysis of the socio-economic determinants of the adoption of rice husk stoves, allowed us to learn about this technology's adoption level and the factors that influence its adoption by parboilers of URFER-C. The use of rice husk stoves as a technology was more motivated by stakeholders' awareness regarding the preservation of forests, which have deteriorated over the years due to firewood cutting. The results showed that using rice husk stoves reduces the cost of parboiling, limits losses in quantities of parboiled rice, speeds up the cooking time of the paddy, and produces a quality final product. However, although it is effective in the parboiling centers, no women parboilers use it for home parboiling activities. They prefer the old device that uses firewood and three (03) stones. The purchasing price of the rice husk stove, its weight, its height, and the regular maintenance its usage requires are constraints of its adoption. The intensity of the heat of its combustion also limits the adoption of the technology. All these shortcomings require additional research and extension to make it affordable to women and introduce modifications in the design of the stoves to better adapt them to the women parboilers' physical conditions.

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