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TECHNICAL AND ECONOMIC PERFORMANCE OF WOMEN FISH PROCESSORS IN SOUTHERN BENIN FISH BASIN

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ABSTRACT

Processing by hot smoking is a technique commonly used by women in the lagoon areas of Benin to preserve fish. The objective of this research was to assess the technical and economic efficiency of women fish processors in order to identify options for improving their income. Guided by the approach of stochastic production and cost frontiers, the results showed that the least technically efficient processor could reduce the amount of resources she used by 42.3 % in maintaining the same level of production. Also, the least economically efficient processor could save 73.7 % of its processing cost while maintaining the same level of production. Economically efficient processors spent less on variable inputs and financial services and sold smoked fish at a competitive price. The economic efficiency indices were significantly and positively correlated with net income. A processor could improve her net income by at least 23% by moving from her economic efficiency class to a higher class. The processors' efficiency levels were determined by their status in the household, their experience and the type of ovens used. It is recommended that more efficient processors share smoked fish production practices with fewer resources to less efficient processors.

Keywords : Fish processing, efficiency, profitability, fishery, food security

PERFORMANCE TECHNICO-ÉCONOMIQUE DES TRANSFORMATRICES DE POISSONS DU BASSIN PISCICOLE DU SUD DU BÉNIN

RÉSUMÉ

La transformation par fumage à chaud est une technique couramment utilisée par les femmes dans les zones lagunaires du Bénin pour conserver le poisson. L'objectif de la présente recherche est d'évaluer l'efficacité technico-économique des transformatrices de poissons pour identifier des options d'amélioration de leur revenu. En se basant sur l'approche stochastique de frontière de production et de coût, les résultats ont montré que la transformatrice la moins techniquement efficace pouvait réduire la quantité de ressources qu'elle utilisait de 42,3 % pour maintenir le même niveau de production. De plus, la transformatrice la moins économiquement efficace pourrait économiser 73,7 % de son coût de transformation tout en maintenant le même niveau de production. Les transformatrices économiquement efficaces dépensaient moins en intrants et en services financiers et vendaient du poisson fumé à un prix compétitif. Les indices d'efficacité économique étaient significativement et positivement corrélés avec le revenu net. Une transformatrice pourrait améliorer son revenu net d'au moins 23 % en passant de sa classe d'efficacité économique à une classe supérieure. Les niveaux d'efficacité des transformatrices étaient déterminés par leur position dans le ménage, leur expérience et le type de fours utilisés. Il est recommandé que les transformatrices plus efficaces avec moins de ressources partagent leurs pratiques de production de poisson fumé avec des transformatrices moins efficaces.

Mots clés : Transformation du poisson, efficacité, rentabilité, pêcherie, sécurité alimentaire.

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INTRODUCTION

Women are very active in fish processing and millions of them derive their income from it in Africa. Food security of children and other vulnerable groups depends on the fact that women obtain fish through their involvement in processing and marketing (Béné & Heck, 2005). Fish processing activities are viewed as key drivers of livelihoods, social and economic development, particularly in the coastal region of Africa (Béné & Heck, 2005 ; Raemaekers & Sunde, 2015).

In Benin, fish occupies an important place in the diet. The proportion of animal protein from fish varies between 47 % and 63 % (MAEP, 2017). The extremely perishable nature of fish induces high losses and reduces the availability of fish for consumers (Anihouvi *et al.*, 2005). To reduce these losses, several traditional methods of fish processing are used: salted-fermented, salted-dried, smoked-dried and braised-salted-dried. There are two types of fish smoking: cold smoking and hot smoking. Hot smoking is one of the main methods of preserving fish in Benin (Degnon *et al.*, 2013). The processing of fish by hot smoking is carried out by women in the lagoon and lake areas and constitutes an important source of income for their households. Yet, the efficiency of this fish processing activity remained a concern for researchers and policymakers (Teutscher *et al.*, 1995 ; Akitipka *et al.*, 2016 ; Adéoti *et al.*, 2018). However, this efficiency question in fish processing has so far been poorly documented. This research aims to address the knowledge gap and assess the technical and economic efficiency of women fish processors, its determinants and the profitability of smoked fish production.

The paper is structured in five sections. After the introduction in section 1, section 2 details the methodology used in the research encompassing the data sources and models used. Section 3 presents the results of levels and determinants of efficiency, the profitability and its correlation with the economic efficiency. Section 4 discusses the findings and compare with the scientific literature. Section 5 concludes and formulates perspectives.

RESEARCH METHODOLOGY

Theoretical models of efficiency measurements

Economic efficiency is determined by the combination of technical and allocative efficiencies (Coelli *et al.*, 1998). A farm is technically efficient when it achieves the potential level of production given the amount of inputs and the technology it uses (Alvarez & Arias, 2004). In other words, technical efficiency is the ability to achieve maximum production with a given amount of inputs. The consequence of technical inefficiency comes down to the increase in production costs and the low competitiveness of farms (Kumbhakar *et al.*, 1989 ; Yi & Reardon, 2015). Allocative inefficiency results from the use of inputs in a wrong proportion given their prices (Schmidt & Lovell, 1979). Allocative efficiency refers to the ability of a farm to choose its inputs taking into account their prices in order to minimize production costs (Chavas & Aliber, 1993). Thus, a farm is allocatively efficient when it produces at the lowest possible cost for a given level of production. Economically efficient farms are more likely to minimize production costs, generate higher incomes and therefore have better chances of survival and prosperity (Bravo-Ureta & Rieger, 1991). Furthermore, this theoretical conception highlights a positive link between the concepts of efficiency and profitability.

Several efficiency measurement approaches have been developed and used for different business sectors. The most appropriate approach for farms is the stochastic frontier of production function (Aigner *et al.*, 1977; Meeusen & van den Broeck, 1977). The stochastic frontier function of production has two error components. The first component is a residual term capturing the effect of random factors which are not under the control of the producer (for example climatic hazards, price fluctuations, shortages of inputs, etc.), measurement errors and any other statistical error (Kpenavoun *et al.*, 2017). The second component is associated with inefficient producers. The stochastic frontier of production is as follows:

$$Y_i = f(X_i, \beta) + \varepsilon_i \tag{1}$$

where Y_i is the output of the i^{th} producer, X_i indicates the quantities of inputs used by the i^{th} producer, β is a vector of parameters and ε_i the error terms.

$$\varepsilon_i = v_i - \mu_i \tag{2}$$

where v_i is the residual term and μ_i the technical inefficiency of producer i ($\mu_i > 0$). The residual term v_i gives a stochastic interpretation of the production frontier. The values of v_i are assumed to follow a normal distribution with mean 0 and variance σ_v^2. They are independent of μ_i which are assumed to follow a half-normal distribution with mean μ and variance σ_μ^2. Equations (1) and (2) can be rewritten as follows:

$$\widetilde{Y_i} = Y_i - v_i = f(X_i, \beta) - \mu_i \tag{3}$$

where $\widetilde{Y_i}$ indicates the observed output of the i^{th} producer, corrected with the random effects captured by v_i (Sharma *et al.*, 1999). The resolution of equation (3) is the basis for the estimation of the technical efficiency indices (TE_i). Coelli *et al.* (1998) defined a simplified formula as follows:

$$TE_i = exp(-\mu_i) \tag{4}$$

Allocative efficiency is generally estimated from the stochastic cost frontier which is derived from the stochastic production frontier (Sharma *et al.*, 1999). The stochastic cost frontier is specified as follows:

$$C_i = g(Y_i, P_i\,; \alpha) + w_i \tag{5}$$

$$w_i = v_i + \mu_i \tag{6}$$

where C_i represents the total cost of production of the i^{th} producer, Y_i is the output, P_i is the unit cost of each input, α is a vector of parameters and w_i the error term composed of two elements (v_i and μ_i). Since inefficiency is expected to increase costs, these error components should show positive signs. The μ_i provides information on the level of allocative efficiency (AE_i) of producer i. This level of efficiency is calculated by the ratio between the minimum cost at the frontier and the observed cost (Coelli *et al.*, 1998). After simplification, we obtain:

$$AE_i = exp(\mu_i) \tag{7}$$

Economic efficiency (EE_i) is decomposed into technical and allocative components (Coelli *et al.*, 1998) and is estimated using the following formula:

$$EE_i = AE_i \times TE_i \tag{8}$$

The efficiency indices are between 0 and 1. The maximum likelihood method has been used to estimate the stochastic frontiers (Coelli *et al.*, 1998). The validity of stochastic frontier models is given by the variance of the residual term (v_i) and the inefficiency term (μ_i). The following parameters are considered:

$$\sigma^2 = \sigma_v^2 + \sigma_\mu^2 \tag{9}$$

$$\gamma = \sigma_\mu^2 / \sigma^2 \tag{10}$$

$$\lambda = \sigma_\mu / \sigma_v \tag{11}$$

where σ^2 represents the total variation in output due to random factors and inefficient producers, γ measures the share of the variation in output due to producer inefficiencies or to random factors $(1 - \gamma)$ and λ measures the relative importance of the inefficiency errors of producers. $\gamma = 0$ indicates that the total change in production (σ^2) is due to random factors; and thus, we deduce that the estimation of stochastic frontiers by the Ordinary Least Square method is preferable. $\gamma = 1$ indicates that the total variation (σ^2) is due to the inefficiency of the producers. In this case, the deterministic frontier which supposes that the error term is linked only to inefficiency would be better at the stochastic frontier. We conclude that there is an inefficiency effect when $\gamma > 0$.

There are two methods of analyzing the determinants of efficiency levels. The first method suggested by Ray (1988) and Kalirajan (1991) uses a two-step procedure. It consists, firstly, in estimating the efficiency indices from stochastic frontiers and, secondly, in performing a regression of these indices depending on the factors specific to the farms. The second method proposed by Battese & Coelli (1993) consists in directly introducing the determining factors in the functions of the stochastic frontiers to analyze their direct effect on the levels of efficiency. The first method was used in this study.

Data sources

This research was carried out in the fish basin regions of Southern Benin: the lagoon of *Cotonou* (*Littoral* department) and the lake of *Aguégués* (*Ouémé* department). The choice of these regions is due to the fact that they have a large number of fishing communities (Sonneveld *et al.*, 2018). The fish processors were randomly selected. A total of 88 fish processors were surveyed, 52 in the *Cotonou* lagoon region and 36 in the *Aguégués* lake region. The data collected concerned the socio-economic and demographic characteristics of processors, the quantities of inputs and outputs, the labor force, the equipment used, the prices of inputs and outputs, the places of supply and sale.

Empirical model of the production function

The production frontier was specified using the Cobb-Douglas functional form.

$$LnQpfu_i = LnA + \beta_1 LnQpfr_i + \beta_2 LnQwood_i + \beta_3 LnQlabor_i + \beta_4 Region_i + v_i - \mu_i \quad (12)$$

where i represents the processors (i = 1, 2, 3, ... 88), Ln is the natural logarithm. The lagoon region was introduced to neutralize potential estimation biases due to the environment (Sherlund *et al.*, 2002). Fish processors smoked an average of 19.38 kg of fresh fish and obtain 10.91 kg of smoked fish per day (Table 1). The processing yield is overall 56%, 58% in the *Cotonou* lagoon and 53% in the *Aguégués* Lake. Besides the fresh fish, wood is the second main input used by the processors. The average amount of wood used is 0.59 m^3 per day. Processors used family and casual labor. They employed on average 2.40 man-days.

Table 1. Descriptive statistics of the variables used in the models

Variable definition	Mean	Std. Dev.
Qpfu: quantity of smoked fish (kg/day)	10.91	5.51
Qpfr: amount of fresh fish used (kg/day)	19.38	9.50
Qwood: amount of wood used (m^3/day)	0.59	0.55
Qlabor: Total amount of labor employed (Man-day)	2.40	1.05
Ppfr: Prices of fresh fish (XOF/kg)	1219.21	214.58
Pwood: Average wood price (XOF/m^3)	2668.24	609.30
Plabor: Average labor price (XOF/Man-day)	509.42	574.73
Exper: Number of years of experience in fish processing	23.58	11.94
CT: Total cost of daily processing (XOF)	31037.56	13964.03
Region (1= Cotonou lagoon, 0= otherwise)	0.59	0.49
Instr (1= the processor reached the primary school, 0= otherwise)	0.08	0.27
Credit (1= access to credit for fish processing, 0= otherwise)	0.27	0.45
Hhead (1= married and non-household head, 0= otherwise)	0.86	0.35
Oven (1= the processor used a barrel oven, 0= otherwise)	0.86	0.35

Empirical model of the cost function

The cost frontier was specified using also the Cobb-Douglas functional form.

$$LnCT_i = LnA + \beta_1 LnPpfr_i + \beta_2 LnPlabor_i + \beta_3 LnQpfu_i + \beta_4 Region_i + v_i + \mu_i \quad (13)$$

where i represents the processors ($i = 1, 2, 3, \dots 88$), Ln is the natural logarithm. In this model, the wood price variable was not considered for reasons of multicollinearity. Processors spent an average of XOF 31037.56 to smoke 10.91 kg of fresh fish (Table 1). During the study period, the average purchase price of fresh fish was XOF 1219.21 per kg. The processors obtain fresh fish from fishermen and fishmongers. The average cost of labor has been estimated at XOF 509.42 per man-day.

Determinants of efficiency levels

To analyze the determinants of the efficiency levels of fish processors, linear regression models were applied considering the distribution of the estimated efficiency indices. These models have been specified as follows:

$$TAEE_i = \alpha_0 + \alpha_1 Exper_i + \alpha_2 Instr_i + \alpha_3 Credit_i + \alpha_4 Hhead_i + \alpha_5 Oven_i + \omega_i \quad (14)$$

where $TAEE_i$ represents the indices of technical, or allocative or economic efficiency of fish processors. The definition of the explanatory variables introduced in the linear regression models is presented in Table 2. All the fish processors surveyed carried out processing as their main activity. Fish processors were mainly married women, wives of household heads (86 %). The average number of years of experience in processing activities was 24 years. The majority of processors were illiterate; only 8 % of them had primary education. A significant proportion of processors (27 %) used loans to fund their activity. In general, fish processors used two types of ovens: barrel ovens and traditional clay ovens. Barrel ovens were used by 86 % of the processors surveyed.

Financial profitability indicator

The method used to analyze the financial profitability of fish processing is based on the calculation of the net income (NI) broken down as follows:

$$NI = GP - (VI + L + FC + T + MT + ED) \quad (15)$$

where GP is the gross product, VI is the value of the variable inputs used in the processing (fresh fish, wood, chips, hulls, oil, baskets and packaging), L is the remuneration of the labor, FC the financial costs, T the cost of transporting the smoked fish from the place of production to the place of sale, MT the taxes linked to the location of the processors in the market and ED the depreciation of the equipment (ovens, basins , plastic containers, knives and wire mesh).

The links between cost and financial profitability indicators and levels of economic efficiency were analyzed using the Pearson correlation test. Stata 13.0 was used to analyze the data and to estimate the models.

RESULTS

Technical efficiency of fish processors

The estimated production frontier model was globally significant at the 1 % level. The parameter γ was highly significant, revealing that the stochastic frontier approach used in this research was more appropriate than the Ordinary Least Square method. The value of γ revealed that 82 % of the variations in the quantity of smoked fish were due to the technical inefficiency of the processors (Table 2). The rest of the difference from the production frontier, representing 18 %, was due to random factors.

Table 2. Estimated results of the production frontier function

Variables	Coefficients	Std. Err.
LnQpfr: quantity of fresh fish (kg/day)	0.917***	0.033
LnQwood : amount of wood used (m³/day)	0.004	0.031
LnQlabor: total amount of labor (Man-day)	0.031	0.031
Region (1= Cotonou lagoon, 0= otherwise)	0.149***	0.054
Constant	-0.339	0.085
Nb. of obs.	82	
Log likelihood	67.42	
Prob. > Chi2	<0.001	
Log likelihood	67.42	
σ_μ	0.14***	
σ_v	0.069	
σ_μ^2	0.020	
σ_v^2	0.005	
$\sigma^2 = \sigma_v^2 + \sigma_\mu^2$	0.024	
$\gamma = \sigma_\mu^2/\sigma^2$	0.82	
$\lambda = \sigma_\mu/\sigma_v$	2.03	

Note: ***, ** significant at 1%, 5%.

The estimated coefficients, representing the elasticity of production, were positive for all factors of production. Only the fresh fish input was significant at the 1% level. Fresh fish was indeed the most important factor of production in the activity of processing fish by smoking. The coefficient associated with fresh fish was 0.92, indicating that an increase of 1% in the quantity of fresh fish would increase the production of smoked fish by 0.92%. The coefficient of Region was positive and significant at the 1% level, indicating that processors of *Cotonou* lagoon were technically more efficient than processors of *Aguégués* lake. The estimated technical efficiency indices ranged from 0.59 to 0.97. Therefore, potential productivity gains remained to be realized. The least technically efficient processor could reduce the amount of resources she used by $\left[\frac{(1-0,59)}{0,97} \times 100\right]$, 42.3 % while maintaining the same level of production.

Allocative and economic efficiency of fish processors

The cost frontier model was globally significant at the 1 % level.

The estimated γ parameter was significant at the 1 % level. (Table 3).

The value of γ was 0.97, indicating that 97 % of the variation in the total processing cost was due to the allocative inefficiency of the processors. All input price coefficients were positive and significant at the 1 % level. This means that increasing the price of each input significantly increases the total cost of processing. The estimated allocative efficiency indices ranged from 0.43 to 0.98. The coefficient of Region was negative and significant, indicating that processors of *Aguégués* lake were allocatively more efficient than processors of Cotonou lagoon.

Table 3. Estimated results of the cost frontier function

Variables	Coefficients	Std. Err.
LnPpfr : Price of fresh fish (XOF/kg)	1.032***	0.089
LnPlabor : Average labor price (XOF/Man-day)	0.129***	0.024
LnQpfr: Quantity of smoked fish (kg/day)	0.944***	0.041
Region (1= Cotonou lagoon, 0= otherwise)	-0.405***	0.035
Constant	0.036	0.659
Nb. of obs.	85	
Prob. > Chi2	<0.001	
Log likelihood	33.55	
σ_μ	0.287***	
σ_v	0.048	
σ_μ^2	0.082	
σ_v^2	0.0023	
$\sigma^2 = \sigma_v^2 + \sigma_\mu^2$	0.084	
$\gamma = \sigma_\mu^2/\sigma^2$	0.976	
$\lambda = \sigma_\mu/\sigma_v$	6.0	

Note: ***, ** significant at 1%, 5%.

The economic efficiency indices estimated from the technical and allocative efficiency indices varied between 0.3 and 0.95. To achieve the optimal level of economic efficiency, the least economically efficient processor would have to save up to $\left[\frac{(1-0,3)}{0,95} \times 100\right]$, 73.7 % of its current processing costs while maintaining the same level of production.

Distribution of efficiency indices

The distribution of technical, allocative and economic efficiency indices is presented in Figure 1. The proportion of processors with a technical efficiency index greater than or equal to 0.8 was 98 %. This shows that most processors were close to the production frontier. Around 67 % of processors had an allocative efficiency index greater than or equal to 0.8. With regard to economic efficiency, 41 % were in the class of indices ranging from 0.8 to 1; 19% of processors had an index less than 0.6 while 40 % were in the class of indices ranged from 0.6 to 0.8. Thus, more than half of the processors had an economic efficiency index lower than 0.80.

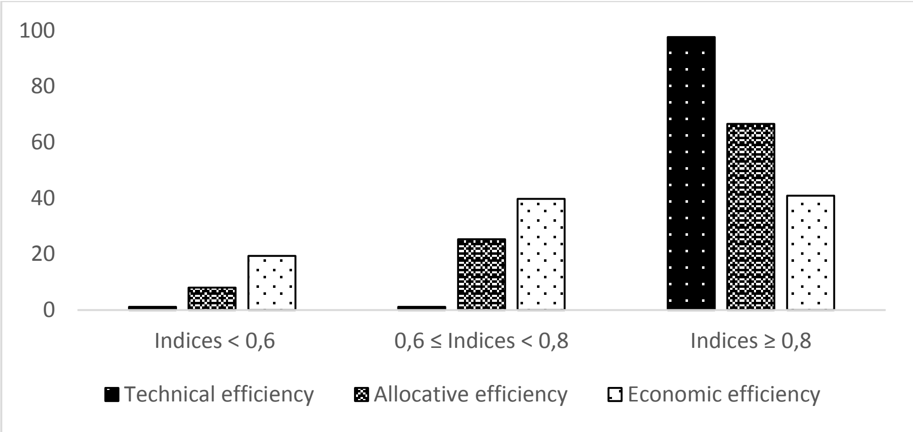

Figure 1. Distribution of efficiency indices for fish processors

Determinants of efficiency levels

Whatever the type of efficiency considered, the regression model was globally significant at the 1 % level (Table 4). The results showed that the number of years of experience in the production of smoked fish, the status of the processors in their household and the type of oven influenced positively and significantly the levels of technical, allocative and economic efficiencies. We deduce that the efficiency levels of the processors were determined by their status in the household, their experience, and the type of ovens they used. Those who used barrel ovens were more efficient. The credit coefficient was negative but not significant.

Table 4. Factors determining the efficiency levels of fish processors

Variables	Technical efficiency		Allocative efficiency		Economic efficiency	
	Coeff.	Std. Dev.	Coeff.	Std. Dev.	Coeff.	Std. Dev.
Exper	0.008***	0.002	0.007***	0.002	0.006***	0.002
Instr	0.120	0.085	0.039	0.098	0.041	0.092
Credit	-0.016	0.060	-0.023	0.067	-0.016	0.065
Hhead	0.386***	0.052	0.370***	0.059	0.319***	0.056
Oven	0.369***	0.058	0.326***	0.065	0.325***	0.062
Nb. of obs.	82		85		82	
F (5, 77)	272.51***		171.94***		152.54***	
Adj-R^2	0.943		0.909		0.902	

Note: ***, ** significant at 1%, 5 %.

Input costs in the production of smoked fish

The distribution of the efficiency indices shows that most processors were technically efficient. Therefore, the level of economic efficiency indices was mostly due to the allocative inefficiency of processors. All the input price coefficients introduced into the cost frontier model were significant and positive. In the Cotonou lagoon region, the costs of purchasing fresh fish (79 %) mainly weighed on the total costs of producing smoked fish, while in Aguégués the average cost of purchasing fresh fish was 45% and financial costs 33 % (Table 5). In fact, the financial costs paid on borrowed capital at Aguégués were three times those paid by the processors of Cotonou. A significant proportion of processors (27%) used loans to fund their activity. They borrowed an average of XOF 48750 with an average interest rate of 19%. These credits were granted by individuals, women's groups and microfinance institutions such as the Association for the Promotion of Development Initiatives (ALIDé) and the Local Fund Union for Agricultural Credit (CLCAM). Some processors (9 %) have benefited from credits granted by the Municipal Approach Program for the Agricultural Market (ACMA) piloted by the International Center for Fertilizer Development (IFDC).

Table 5. Proportion of each input cost in the total cost of producing smoked fish

Inputs used	*Cotonou* Lagoon		*Aguégués* Lake	
	Average cost (XOF)	Proportion (%)	Average cost (XOF)	Proportion (%)
Fresh fish	28423.08	78.70	16384.81	45.06
Financial costs	3833.33	10.62	11977.78	32.94
Casual labor	787.50	2.18	3892.86	10.70
Family labor	809.38	2.24	635.53	1.75
Fire wood	800.45	2.22	2168.57	5.96
Wood shavings	333.13	0.92	-	-
Oil	656.67	1.82	-	-
Other costs	464.00	1.28	1301.39	3.58
Equip. depreciation	6.04	0.02	3.95	0.01
Average total costs	36113.58	100	36364.89	100

Links between cost and profitability indicators and levels of economic efficiency

The economic efficiency indices were significantly and negatively correlated with the value of variable inputs, financial costs and equipment depreciation (Table 6). This means that economically efficient processors spent less on purchasing variable inputs and financial services. They sold smoked fish at a relatively low price. Therefore, economically efficient processors had a better price competitiveness than less efficient ones. Moreover, the results showed that the economic efficiency indices were significantly and positively correlated with the net income. This proves that the more economically efficient the processors, the more profit they make. A processor could improve her net income by at least 23 % by moving from her economic efficiency class to a higher level class (Table 6).

Table 6. Cost and profitability indicators and correlation with economic efficiency

Cost and profitability Indicators	Unit	Classes of economic efficiency						Correlation with Economic efficiency (n=88)
		Indices < 0.6 (n=17)		0.6 ≤ Indices < 0.8 (n=35)		Indices ≥ 0.8 (n=36)		
		Mean	S D	Mean	SD	Mean	SD	
Selling price	XOF/kg	4243	1289	3607	1368	3401	1187	-0.255**
Variable inputs	XOF/kg	3015	705	2568	687	2285	550	-0.51***
Labor	XOF/kg	185	170	130	173	130	189	-0.07
Financial costs	XOF/kg	2173	984	699	452	278	286	-0.81***
Transportation	XOF/kg	155	112	89	96	101	92	-0.28**
Market tax	XOF/kg	4	2	3	2	3	2	-0.35***
Depreciation	XOF/kg	0,91	0,58	0,46	0,30	0,31	0,21	-0.59***
Net income	XOF/kg	-524	1373	681	872	844	796	0.45***

Note: ***, ** significant at 1 %, 5 %.

Fish processing income in the household food security

Income from fish processing is allocated in various ways to household spending. In Aguégués Lake, women processors mainly spend this income on food security for their household members (52 %) (Figure 2). In Cotonou Lagoon region, a good part of the income is used for other expenses (28 %) mainly for reinvestment in the fish processing activity and in the constitution of tontines. Overall, fish processing contributes to food security and improved living conditions for women and their households.

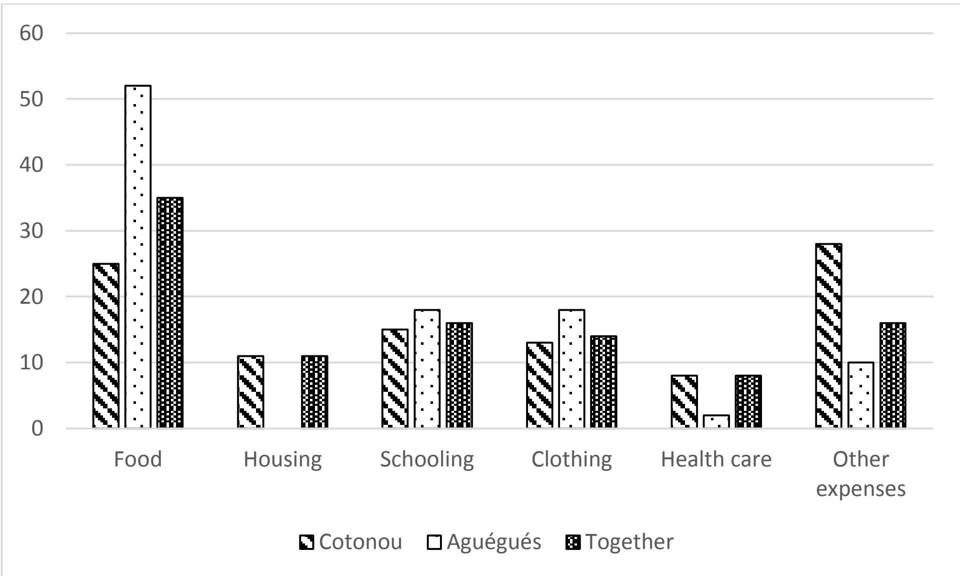

Figure 2. Fish processing income in household welfare

DISCUSSION

Technically, most fish processors were close to the production frontier. This could be explained by their experience in the processing of smoked fish. In fact, processors have on average 24 years of experience in the production of smoked fish. The majority learned the activity through their mothers during childhood. As pointed out by Anihouvi *et al.* (2005), the fish processing is transmitted from generation to generation in the lagoon and lake areas. The analysis of average economic efficiency indices has shown that processors had not reached the stage of optimal allocation of their production resources. There are still potential productivity and cost savings to be realized.

The research has shown that processors who are not household heads are more efficient than those who are heads of households. This may be due in part to the sources of funding to which they have access. Indeed, the main sources of funding for women processors are women's groups, where they are subject to an average half-yearly interest rate of 21 %. However, on top of that, non-households heads have the possibility, through their husbands, to borrow from individuals and social networks at very low interest rates (4 % on average over six months); justifying their improved efficiency. Furthermore, the most economically efficient processors spent less to access financial services. This could be due to their status in households - wide lending opportunities for non-household heads - and the subsequent interest rates charged by the sources of finance to which they have access. This situation is worrisome and calls into question the funding of income-generating activities such as fish processing in the fish basin of South Benin.

Moreover, fish processors who used barrel ovens were more efficient than those who used traditional clay ovens. According to the processors surveyed, barrel ovens require little firewood, reduce smoking time and make it possible to obtain the quality of smoked fish preferred by consumers. Processors, therefore, believe that barrel ovens allow them to be more productive and more competitive on the market compared to traditional ovens. This perception was supported by Chabi *et al.* (2014) in Benin and Kabré *et al.* (2003) in Burkina-Faso who found that the quantity of wood used to smoke fish and the quality of smoking depend on the type of oven used. Next, the barrel oven is preferred by processors for two reasons: its low-cost accessibility and easy transportation from one fishery to another.

Finally, the research also revealed that there was a correlation between the economic efficiency of processors and the financial profitability of fish processing. This correlation was confirmed by Kpenavoun *et al.* (2018) who demonstrated that farmers improve their gross margins by better combining their production factors. Thus, by moving from their current economic efficiency class to a higher class, processors are likely to reduce their expenditures on variable inputs and equipment. Therefore, improving the economic efficiency levels of women processors will plausibly lead to an increase in their income ; justifying the need to strengthen processors' capacity for efficient management of fish processing. Such capacity building could be done by a judicious choice of processors having the best levels of efficiency and who will be responsible for peer training : sharing efficient fish smoking practices to less efficient processors.

CONCLUSION

The research confirms the existence of technical, allocative and economic inefficiencies in the processing of smoked fish in the lagoon and lake areas of Benin. It revealed that the processors had not yet achieved the optimal level of resources allocation. Thus, potential gains in productivity and costs remained to be realized in fish processing. In addition, the processors' experience, their position in the households and the type of oven used influenced their efficiency levels. The research also showed how beneficial it is for processors to better combine their production factors, confirming that the improvement in the economic efficiency of processors is positively correlated to an increase in their net income. Hence, a nice option to improve the income of processors would be to help them better manage their processing units and have access to low interest rate loans. To this end, it is necessary to strengthen the efficient management capacities of processors by encouraging more efficient processors to share smoked fish production practices with fewer resources to less efficient processors.

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