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Full Length Research Paper

Cassava production and processing characteristics in southern Cameroon: An analysis of factors causing variations in practices between farmers using Principal Component Analysis (PCA)

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A questionnaire-based survey study was carried out during a 3 month period, from January to April 1998, in 45 villages belonging to three locations (Yaoundé, Mbalmayo, and Ebolowa) of southern Cameroon. The survey was aimed at collecting constraints and processing practices related information from farmers growing cassava and transforming it into chips. Information in the questionnaire contained some characteristics associated with cassava chips production (processing methods, forms of chips produced, their end uses, drying and storage facilities used, the major problems associated with their production) and cassava cultivation (cassava varieties, harvesting periods of these varieties, and their preferred attributes). A total of 225 farmers were interviewed and the results obtained showed that farmers in Yaoundé and Mbalmayo processed and stored chips in similar ways. Similarly, harvesting periods after planting also differed between Ebolowa and both Yaoundé and Mbalmayo. Storage methods and storage facilities were mainly related to the different forms of chips produced. Chips' discoloration frequently reported by the majority of farmers (87%) was as a result of their insufficient drying. Principal component analysis was implemented to determine those factors accounting for differences observed in farmers' practices. Eleven principal components were derived from the variables used in analysis. Five principal components accounting for 72.75% of the total variations were associated with the data set collected in Yaoundé and Mbalmayo. An equal number expressing 78.2% of the overall variance was likewise obtained at Ebolowa. For a number of reasons such as traditional patterns of nutrition, market purposes, the relative proximity with the nearest city, these components suggested that storage methods, end uses, and production constraints were differently perceived by the respondents. They also showed that the different forms of chips produced were more market oriented, and that a number of constraints experienced by farmers were closely related to the way they managed their fields, or market outlets.

Key words: Cassava; Cameroon; PCA; Survey; variations.

INTRODUCTION

Due to its bulkiness and perishability, cassava (Manihot esculenta Crantz, Euphorbiaceae) is preferably consumed in its growing communities in processed forms. Only within the sub-Saharan area of Africa, about 80 different transformed cassava products have been identified (Anonymous, 1992). Increasing evidence has been raised to

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suggest that from one product to another, differences exist in technologies used in cassava transformation between farmers and between similar or different ecological zones. While this trend is not unprecedented in the history of food transformation, it remains necessary to understand farmers' perceptions of technologies implemented in food processing so as to explain farmer's behaviours. Such an understanding is central in both cassava production and processing for providing critical inputs that could be helpful to assist farmers, especially in the formulation of practical recommendations on cassava cultivation and its further processing.

In almost all the cassava growing communities of sub-Sahara Africa, cassava chips rank first in prevalence among transformed cassava products (Hahn, 1989). These are the dried products of fresh roots of cassava obtained following their fermentation, drying, and subsequent storage. Past and current studies suggest that several forms of cassava chips exist. The existing forms are mainly related to feeding preferences of the local population, their visual appearance, and their potential end uses (Essono, unpublished data). These forms may also be related to particular factors such as traditional patterns of nutrition, market purposes and cooking characteristics of the cassava varieties grown by the farmers in a given setting (Nweke, 1998). Accordingly, it is hypothesised that the preferred criteria adopted by farmers both in cassava chips production and cassava cultivation can strongly vary in a given community as local environments and socio economic parameters change, and as they do, the forms of chips produced may become more or less valued from one cassava growing community to another. Likewise, the resulting constraints are also likely to shift due to the above-mentioned parameters and also the way the farmers manage their actual agro-ecosystems.

Several studies on farmers' practices and handling strategies in production and processing related aspects of cassava have been carried out. The earlier work by Hahn (1989) which underscored the potential of cassava as animal and human foods mainly focused on processing methods. By shedding light on varietal preferences associated with farmers in cassava-based systems of Tanzania, Kapinga et al. (1997) highlighted the increasing importance of bitter varieties in that coun-try and elucidated the related farmers' perceptions. These two studies made only tangential references on practices implemented by the farmers in both the cultiva-tion (varieties used, harvesting periods) and processing methods (technologies used). However, they did not address the related constraints, nor did they attempt to explain the determinants of farmers' practices or options in cassava as grown or processed in the areas investigated. Ignoring these determinants as well as the constraints facing farmers could limit the usefulness of results from farmers' perception studies for orienting cassava production and processing research to better target agronomic related aspects as well as the production of safe cassava products for local and international uses. Several analytical tools have been developed to explain the determinants of farmers' perceptions in agricultural research. Most of the literature available on the topic involves econometric aspects and the computation of percentage of occurrence of practices implemented by the farmers. An example of this is Adesina et al. (1993) who referenced factors affecting fertilizer use decisions in rice fields from a probit model. However, the weakness of this analytical tool is that it treated the decision of using fertilizer as a dichotomous choice: that is, either the farmer adopted or not the fertilizer in his field. Accordingly, this model hardly works in case where more than two alternatives have to be investigated.

Although the multinomial logit model is commonly used in the analysis of individual choice behaviour when two or more mutually exclusive alternatives are to be considered (Mc Fadden, 1978), its main disadvantage lays upon the fact that it is mainly based upon several assumptions which tend to limit its ability to represent the true structure of the choice process (Horowitz, 1981). In practical situations, an appropriate disaggregated choice model while dealing with farmers' behaviour in agricultural research should ideally be the one which relaxes the numerous assumptions connected with the multinomial logit models. In this respect, principal component analysis (PCA), a technique that has been used mainly in numerical classification to explain relationships between experimental variables (Mardia et al., 1995), and which does not require any concrete assumption could be considered as an example to these alternative model structures.

According to current literature, very few applications of this analytical tool have been made in an attempt to explain variations occurring in farmers' behaviours during perception studies. This paper describes the application of principal component analysis in the extraction of factors causing variations in farmers' practices in the production and transformation related aspects of cassava in southern Cameroon. It helps to understand the rationale of producing cassava chips (end uses) in the investigated areas and to determine the level of perception of farmers with respect to the relevance of technologies used in their production (processing methods), the handling practices (drying and storage facilities) and the related constraints; to assess the main factors included in the preference of the different forms of chips as produced by individual farmers; to ascertain the level of awareness of safety and hygiene of the resulting chips once stored by farmers; to derive possible relationships between the above mentioned factors.

MATERIALS AND METHODS

Data for this study were collected from farmers in 45 villages located in the southern area of Cameroon (Central Africa). These villages were chosen based on a detailed macro-level characterization of the zone mentioned above and which led to the delimitation

Table 1. Major characteristics of the 3 blocks of the benchmark area.

Characteristics	YAO	MBA	EBO
Average fallow period (years)	3.9	5.4	7.5
Land sales (% of villages)	67	27	7
Villages on paved roads (% of villages)	20	13	11
Distance to market (km)	17	20	21
Market cost transport (fcfa)	292	493	503
Hunting revenue (% of villages)	0	27	53
Wage employment (% of villages)	33	13	7
Highest rural population density (hab/km^2)	88	41	15
Lowest rural population density (hab/km^2)	14	10	2

YAO: Yaoundé; MBA: Mbalmayo; EBO: Ebolowa Reference: Anonymous (1996).

of a benchmark area. The concept of the benchmark is linked to the idea that there is a range of geographical and socio- economic characteristics which can affect the habits and behavior of people in a given setting. The most important criteria used to construct a framework for site selection in the benchmark area of southern-Cameroon included: geographical distribution of main local crops, human population densities, and infrastructural development with emphasis on accessibility to major or nearest cities (Anonymous, 1996).

Following the above-mentioned criteria of selection, the zone was divided into three blocks consisting of Yaoundé (Yao), Mbalmayo (Mba), Ebolowa (Ebo), with 15 villages per block. These three blocks are included in an area which covers 15400 km^2, and comprise key sites stretching from latitudes 2°20'N to 4°30'N, where socio-economic (e.g., resource management, wage employment, income formation, market opportunities, population density) and biophysical (e.g., fallow periods, cropping systems, pests and diseases) characterizations have been carried out by scientists of the International Institute of Tropical Agriculture (IITA), (Table 1).

In each of the 45 villages, five households were identified along a transect cutting across the village. Eligible households were those hosting people who had been residing in the village for the past two years with farming activities. Surveys were undertaken at household levels from January to April 1998 during the dry season, to collect production practices and constraints related information from farmers producing cassava chips in southern Cameroon. Questionnaires were drawn up based on the previous COSCA (Collaborative Study on Cassava in Africa) and ESCAPP (Ecologically Sustainable Cassava Plant Protection) projects' recommendations (Anonymous, 1989; 1994; 1995). These were administered to only one farmer within each of the above mentioned households. Hence, a total of 225 farmers being simple residents (82% of respondents), village leaders (7%) or marketing agents (11% of respondents) were interviewed in local languages (Bassa, Bulu, Eton, Ewondo, Ntoumou), using local interpreters where needed.

Information on the questionnaires included: processing experience and processing methods, form of chips produced as well as the handling techniques used by processors. After this basic information was obtained, farmers were questioned on the end use of chips (family consumption, marketing, and other uses), their awareness of stored chips' contamination as well as means used to avoid it. The major problems associated with chips production, the varieties of cassava used, harvesting periods of these varieties, and their preferred attributes were also addressed.

Data analysis

Two types of questions were included in the questionnaire. Fixed choice questions were those, for which the informants had to choose one item among many alternatives, or questions for which the expected response was "YES" or "NO". Open-ended questions were those which allowed the informants to express their opinion. Answers resulting from both types of questions were coded numerically. Positive and negative answers in fixed choice questions were coded "1" and "0", respectively. Responses from open-ended questions were recorded, checked, and grouped into similar categories, then given additional code numbers. Codified data were processed using a spread sheet program (Excel 5.1/97). Results were expressed as percentage of responses obtained from farmers.

In order to understand the causes of variation in farmers' responses, a principal component analysis (PCA) was performed. The PCA technique is often used in the selection of the first few components accounting for most of the variation in the original data. It helps to understand the data pattern, particularly if some of the original variables are highly correlated. For example, given a data set of p variables, some of which may be correlated, PCA transforms them to a new set of p uncorrelated variables called principal components (Mardia et al., 1995).

Each principal component is a linear combination of the original variables, whose coefficients are equal to the eigenvectors of the correlation matrix. These eigenvectors are obtained by the spectral decomposition of the data matrix and arranged in decreasing order of the corresponding eigenvalues, which equal the variances of the components.

Variables employed for PCA in this study included, processing practice related variables (methods of chips processing and types of chips produced, reasons for producing chips, and drying facilities used in chips production), storage practice related variables (storage duration, storage facilities, and causes associated with the occurrence of dark spots on chips while in storage), and variables related to constraints in cassava chips production and varietal attribute (tedious nature of processing, lack of market outlets, pest problems, preferred varieties and their maturity periods) (Table 2)

Data processing and all the computations were carried out with the PRINCOMP procedure of Statistical Analysis System software (SAS Institute Inc., Cary, USA, 2000).

RESULTS AND DISCUSSIONS

Characteristics associated with cassava chips production

Prior to implementing PCA, the distribution pattern of the data set was examined for the variables associated with cassava chips production. In relation to these variables, preliminary data suggest that Yaoundé and Mbalmayo

Table 2. Description of variables used in principal components analysis.

Processing practices variables
Proc1= Processing by peeling, cutting, washing before drying
Proc2= Processing by peeling, soaking in water with ferments for two days before drying
Proc3= Processing by peeling, washing, soaking in water for four days before drying
Form1= Pellets as form of chips produced
Form2 = Dried broken pulp as form of chips produced
Form3 = Balls as form of chips produced
Dry1= Drying on roof tops
Dry2 = Drying on raised platforms
Dry3 = Drying over the fireplace
Dry4 = Drying on concrete floors
Dry5 = Drying on rocks in the farm
Repro1= Local sales and home consumption
Repro2 = Sale in market places of nearest cities or export
Repro3 = Production of beer and dough
Storage practices variables
TSTORE1= Storing cassava chips for 1 to 14 days
TSTORE2= Storing cassava chips for 15 to 30 days
TSTORE3= Storing cassava chips for 31 to 45 days
TSTORE4= Storing cassava chips for 46 to 60 days
MSTORE1= Storage of cassava chips in plastic bags incorporated inside jute bags
MSTORE2 = Storage of cassava chips in jute bags
MSTORE3 = Storage of cassava chips over the fire place
MSTORE4 = Storage of cassava chips in closed containers
MSTORE5 = Storage of cassava chips in open containers
MSTORE6 = Storage in baskets
CAUS1 = Insufficient drying as cause of dark spots
CAUS2 = Use of infected tubers from fields as cause of dark spots
CAUS3 = Too long storage of fresh tubers before processing as cause of dark spots
CAUS4 = Presence of insects and mites as cause of dark spots
Production constraints and varietal attributes related variables
PCONST3= Lack of the market
PCONST4= Pests and diseases problems
PCONST5= Tedious nature of chips processing
VAR1 = Use of high yielding cassava varieties in chips production
VAR2 = Use of early maturing cassava varieties in chips production
VAR3 = Use of specific (bitter) cassava varieties in chips production
VAR4 = Use of available varieties in chips production
MATUR1 = 6-9 months harvest after planting
MATUR2 = 10-15 months harvest after planting
MATUR3 = 15-24 months harvest after planting

processed cassava for chips production in the same way, contrary to farmers of Ebolowa. Figure 1 and 2 show the histograms of data distribution of cassava chips production characteristics in Yaoundé and Mbalmayo, and in Ebolowa. As shown in these figures, cassava chips were produced at Mbalmayo, and Yaoundé by 50% of farmers mainly to be sold in nearest cities, whereas the production of local beverages and doughnuts was the main reason for chips production for 56% of Ebolowa farmers. One of the driving forces behind this differential behaveour between farmers in their motivations for producing cassava chips, could be related to the fact that, compared to Ebolowa, the majority of villages surrounding both Yaoundé and Mbalmayo locations have good access to rapidly expanding urban markets. As a result, transportation costs were observed to be relatively higher for Ebolowa farmers compared to those from both Mbalmayo and Yaoundé. This remark, highlighted by data in Table 1, confirms further observations by Gockowski and Ndoumbé (1999) who identified significant relationships between

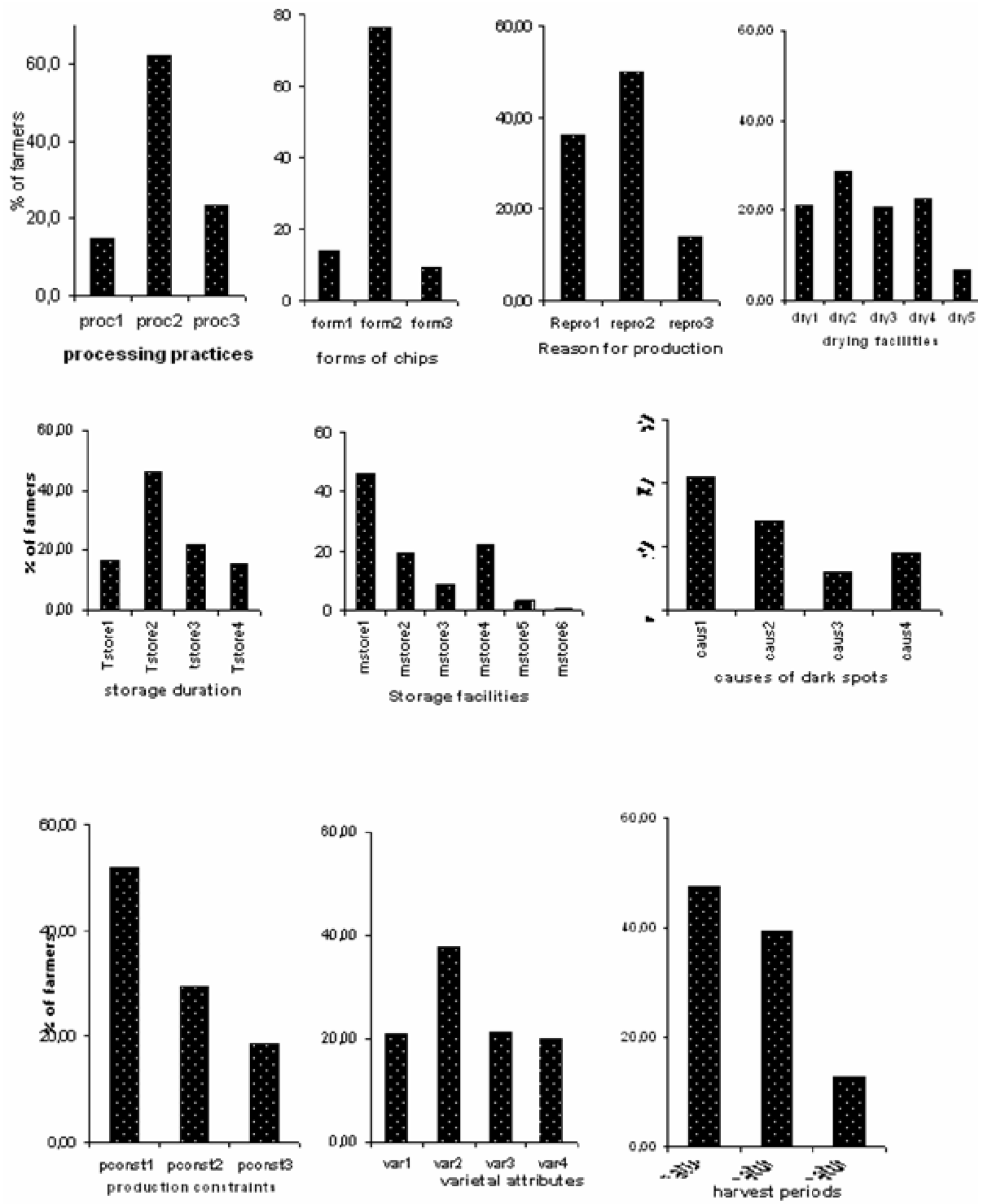

Figure 1. Distribution pattern of casava chips production characteristics in Yaounde and Mbalmayo.

transportation costs and both distance and road quality in the investigated areas.

In Mbalmayo and Yaoundé, the processing practices of chips production involved the use of starters. These were aimed at speeding up the softening process of cassava tubers. At Ebolowa, ferments were not often used by 72% of farmers. In both cases, the resulting products consisted of small crumbs of cassava of 1 to 2 cm diameter and referred to as dried and broken pulp which were preferably dried on raised platforms in the village as was the

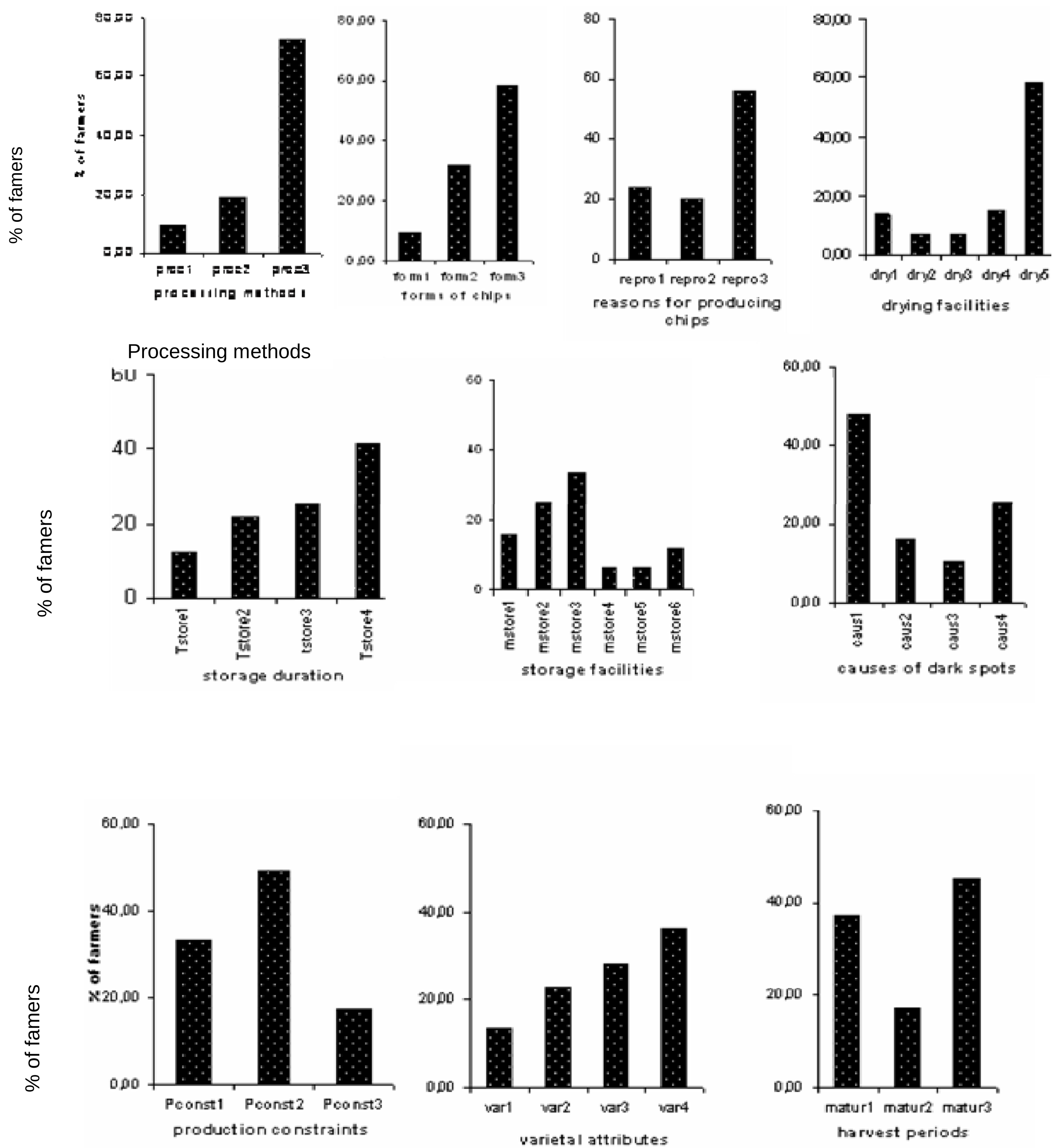

Figure 2. Distribution pattern of cassava chips production characteristics in Ebolowa.

case for almost 29% of farmers in Mbalmayo, and Yaoundé locations, or circular cassava balls with a diameter more often greater than 10 cm, which were dried above the fireplace by over 58% of Ebolowa farmers.

Considering storage related aspects, data obtained in Mbalmayo and Yaoundé show that 46% of farmers in these two locations mainly stored their chips in jute bags for a duration comprised between 15 and 30 days. In

Table 3. Matrix of correlation coefficients between variables used in principal component analysis in Yaoundé and Mbalmayo locations.

	Proc2	Form2	Dry2	Tstore2	Mstore1	Repro2	Caus1	Pconst1	Var2	Matur1
Proc2	-									
Form2	0.178	-								
Dry2	0.049	0.245	-							
Tstore2	-0.036	0.035	-0.023	-						
Mstore1	-0.008	0.035	-0.023	0.114	-					
Repro2	0.465	-0.047	0.162	-0.094	-0.174	-				
Caus1	0.111	0.175	0.067	-0.150	-0.096	0.298	-			
Pconst1	0.224	0.038	0.078	-0.050	-0.104	0.534	0.102	-		
Var2	0.329	-0.005	0.115	-0.114	-0.114	0.679	0.268	0.283	-	
Matur1	0.171	0.061	0.12	-0.004	-0.069	0.467	0.212	0.669	0.330	-

Table 4. Matrix of correlation coefficients between variables used in principal component analysis in Ebolowa.

	Proc3	Form3	Dry5	Tstore4	Mstore3	Repro3	Caus1	Pconst2	Var4	Matur3
Proc3	-									
Form3	-0.015	-								
Dry5	-0.015	0.835	-							
Tstore4	-0.055	0.155	0.010	-						
Mstore3	-0.121	0.479	0.536	0.153	-					
Repro3	-0.127	0.783	0.674	0.144	0.342	-				
Caus1	0.018	-0.061	-0.061	0.061	0.000	0.099	-			
Pconst2	0.143	-0.201	-0.255	-0.016	-0.075	-0.254	-0.041	-		
Var4	0.140	0.235	0.235	0.16	0.059	0.168	0.113	-0.129	-	
Matur3	0.182	0.057	-0.052	-0.003	0.265	0.052	-0.017	0.441	-0.134	-

Ebolowa, chips were preferably kept stored on devices hanging above the fireplace, used as storage facilities for periods comprised between 45 and 60 days. The relative long storage duration associated with cassava balls strengthens the view of the multi purpose uses associated with this form of chips that could be used in the manufacture of local alcoholic drinks, doughnuts and other cassava- based dishes. It may also imply that balls forms of chips could be considered as an important food reserve for the local farmers, especially as cassava serves as the main source of dietary carbohydrate for populations of this location, with only limited quantities being sold out of their respective villages. In all locations, spots or discolorations often observed to occur on cassava chips in storage were believed to be due mainly to their insufficient drying. This suggests that farmers are well aware of the most important factors that could account for the quality of their produce once stored.

In relation to constraints and attributes of cassava varieties used in chips production, data obtained from the locations surveyed show that, the main constraints connected with the production of this food commodity varied. In Mbalmayo and Yaoundé market related aspects were the main constraints highlighted by 52% of farmers, whereas pests and diseases were the most important problem facing almost 50% of Ebolowa farmers. In the latter location, there were no special attributes associated with cassava varieties employed in chips production. Consequently, chips could be produced from any available cassava variety, and these were preferably harvested 15 to 24 months after planting by over 45% of farmers. In Mbalmayo and Yaoundé, the preferred attributes of cassava varieties used in chips production were mostly connected with their early maturing. Accordingly, the greatest proportion of farmers (47.6%) used to harvest the cassava varieties they grew 6 to 9 months after planting.

Assessment of factors causing variations in farmers practices during cassava processing

In order to understand the main factors accounting for differences observed in farmers responses during surveys, we applied the Principal Component Analysis (PCA) technique. Variables used in PCA were selected among those showing highest percentages on histograms describing cassava chips production characteristics presented in Figure 1 and 2. Hence, PROC2, FORM2, REPRO2, DRY2, TSTORE2, MSTORE1, CAUS1, PCONST1, VAR2, and MATUR1 were selected for Mbalmayo and Yaoundé sites, whereas PROC3, FORM3, REPRO3, DRY5 TSTORE4, MSTORE3, CAUS1, PCON-ST2, VAR4, and MATUR3 were chosen for PCA in the location of Ebolowa.

Table 3 and 4 show the matrix of correlation coefficient

Table 5. Factor patterns, eigen-values and cumulative percentages for the five first principal components in Yaoundé and Mbalmayo locations.

	PC1	PC2	PC3	PC4	PC5
PROC2	0.310	0.157	0.052	0.588	-0.127
FORM2	0.065	0.744	-0.030	-0.068	0.093
DRY2	0.139	0.530	-0.051	-0.263	-0.41
TSTORE2	-0.104	0.126	0.615	0.144	-0.378
MSTORE1	-0.130	0.207	0.432	0.373	0.618
REPRO2	0.511	-0.118	0.002	0.189	-0.139
CAUS1	0.251	0.195	-0.438	0.015	0.416
PCONST1	0.418	-0.116	0.356	-0.556	0.133
VAR2	0.424	-0.123	-0.129	0.321	-0.133
MATUR1	0.417	-0.047	0.307	-0.394	0.237
Eigen-values	2.91	1.28	1.16	1.02	0.903
Cumulative %	29.13	41.91	53.49	63.73	72.75

associated with variables used in PCA. In Mbalmayo and Yaoundé, data obtained from farmers' responses indicated proc2-Repro2, Repro2- Pconst1, Repro2-Var2, Repro 2-Matur1, and Var2-Matur2 to be highly correlated. Apparent high correlation coefficients were likewise obtained for the pairs Form3-Dry5, Form3-Repro3, Dry5-Mstore3, and Repro3-Dry5 in Ebolowa sites.

The PCA yielded cumulative percentages and eigen-values for each principal component axis. These axes were chosen on the basis of magnitudes of eigen-values greater than, equal, or close to one rule.

On the basis of these criteria, Table 5 shows the first five principal components associated with cassava chips processing in Yaoundé and Mbalmayo locations. These components have eigen-values ranging from 2.91- 0.902, and explain together 73% of the overall variance. The remaining components were less meaningful, and were not taken into consideration in data interpretation. The first principal component was highly related to REPRO2, and moderately to VAR2, MATUR1, and PCONST1. This shows that an important proportion of farmers produced chips mainly for being sold in nearest cities (REPRO2). Among these, some faced market constraints (PCONST1) . In the course of this survey, market constraints were related to the absence of market places around the villages where farmers could sell their produce, or the absence of good road infrastructures. Since accessibility to some villages was not always easy because of the state of roads, this could be explained by the absence of good road infrastructures, with subsequent high costs of transportation of their produce from villages to cities, and poor return on sales. The lack of utilization of agricultural inputs such as pesticides and fertilizers in cassava fields was noted as an important feature for almost all farmers in the whole benchmark. In
this respect, and from the soil fertility viewpoint, fallow periods which are the main way of providing critical nutrients (N-P-K) to soils in the investigated area (Westphal, 1981; Manyong et al., 1996) ranged between 3.9 and 5.4 years on the average in Yaoundé and Mbalmayo (Anonymous, 1996). These two locations were also associated with the highest population densities in the whole benchmark (Table 1). Consequently, it could be hypothesized that, as fallow periods shorten due to excessive pressure exerted on lands by the actual increasing population, soil fertility likewise declines, farmers reply to these hardships by targeting improved cassava varieties that can overcome soil fertility problems. In this respect, the tendency of some farmers for preference of early maturing cassava varieties (VAR2) that could be harvested within a short period of time and also highlighted in this first principal component is in line with both production constraints and markets outlets. In practical situations, this would imply that, as market opportunities grow and albeit scarcity of fertile soils, cassava chips could be made available in the market places whatever the season provided that early maturing varieties are made available to farmers. Accordingly, this component can be characterized as "rationale for production" factor.

For the second principal component PC2, high positive coefficients were associated with FORM2, and DRY2. This component suggests that the majority of chips produced as dried and broken pulp forms (FORM2) were preferably dried on raised platforms in the villages (DRY2). Raised platforms according to some farmers were essential in preventing chips from being spoiled by dust, and cattle excrements during the drying process. Given the importance attached to chips' appearance in relation to consumers' preferences, this component could be viewed as mainly related to the different activities performed by farmers, and aimed at making their produce attractive before it is being sold. Hence this component can be considered as the "final quality product" factor.

Data obtained from the third principal component show that this axis was strongly related to TSTORE2, and moderately to MSTORE1, and CAUS1. This component

Table 6. Factor patterns, eigen-values and cumulative percentages for the five first principal components in Ebolowa.

	PC1	PC2	PC3	PC4	PC5
PROC3	-0.061	0.316	0.503	-0.501	-0.127
FORM3	0.525	0.072	-0.038	-0.139	-0.032
DRY5	0.515	0.045	-0.249	-0.185	-0.029
TSTORE4	0.142	0.031	0.227	0.749	-0.436
MSTORE3	0.36	0.254	-0.213	0.194	0.129
REPRO3	0.48	-0.009	-0.013	-0.024	0.191
CAUS1	0.008	-0.235	-0.075	0.279	0.765
PCONST2	-0.201	0.584	-0.542	0.107	-0.048
VAR4	0.185	-0.012	0.586	-0.052	-0.378
MATUR3	0.010	0.698	-0.065	0.057	0.0949
Eigen-values	3.069	1.55	1.25	1.02	0.93
Cumulative %	30.67	46.22	58.65	68.94	78.19

shows that the largest proportion of farmers who used to store their produce for a maximum period of 30 days (TSTORE2) also had a tendency to use jute bags as storage facilities (MSTORE1). Some among these, tended not to consider insufficient drying as causes of chips deterioration (CAUS1). However, attention is to be given to the signs of the coefficients of MSTORE1 and CAUS1. They are opposite to each other, but are quite similar in terms of absolute values. During surveys, some farmers justified storage of chips in jute bags by the fact that this storage facility brought about some ventilation of their chips. It is likely that cassava chips stored this way could be associated with lower moisture contents which are often negatively related to insufficient drying, and leading to chips discoloration. In this respect, this component could also be identified as “final quality product” factor.

With respect to the fourth principal component PC4, high coefficients positive or negative were given to PROC2 and PCONST1. The factor patterns associated with those variables are quite identical, implying that almost an equal proportion of farmers who used ferments or starters while producing chips (PROC2) did not experience market constraints (PCONST1). It is possible that cassava chips produced by those farmers were used mainly for family consumption, or to be locally sold in the villages. Another possible explanation accounting for such behaviour could be found in the relative distances between villages where chips were produced and the nearest cities where chips had to be sold. In this respect, it could be hypothesized that farmers whose villages were not so far from cities did not complain of market out-lets. In addition, most of those farmers who did not view market aspects as a constraint also had a tendency not to mind about harvest periods. A practical implication connected to this observation could be because probably those farmers are always aware of market related information due to the relative proximity of their respective villages to nearest cities. Consequently, the cassava varieties they grow could be harvested earlier or latter on, according to the actual market situation. This component could be characterized as “market opportunity” factor.

The fifth principal component could also be characterized as “storage” factor due to the value associated with the coefficient of Mstore1. This component underscores the importance attached to storage facilities used in chips production and shows that only a limited number of farmers did not use jute bags as a storage facility.

Table 6 shows the first five principal components associated with cassava chips production characteristics in Ebolowa. The corresponding eigen-values varied between 3.069 and 0.93, and explained 78.19% of the total variation.

In this location, the first principal component was associated with high coefficients for FORM3, and DRY5. In addition, it was moderately related to REPRO3. This component indicates that the production of cassava balls by farmers as form of chips (FORM3) was positively related with its drying in kitchens on devices hanging above the fireplace (DRY5). In this respect, most of these farmers had a tendency to use this food commodity as a raw material to produce local beverages, and doughnuts (REPRO3). This component could be considered as “processing practices” factor because all the variables associated with processing parameters are present in this component with relatively higher coefficients.

In the second principal component PC2, high and positive coefficients were given to MATUR3, and PCONST2. These two variables which are positively related to each other clearly indicated that the majority of farmers who harvested the cassava varieties they grow 15 to 24 months after planting (MATUR3) experienced pests and diseases as the most important constraints (PCONST2) in cassava chips production. This could be because; no chips can be produced if the cassava crop cannot yield usable tubers as a result of pests and diseases attacks. Accordingly, it could be postulated that although cassava is often regarded as a disease-tolerant crop, it is possible that the fact of keeping the tuberous roots for a long time underground could have given rise to the development of pests and diseases on the crop, with subsequent harmful effects on the end product and yields. This component can be qualified as “production constraints and maturity period” factor.

For the third principal component, high and positive coefficients were given to VAR4, PCONST2, and PRO-C3, indicating that a non negligible proportion of Ebolowa farmers who produced chips from any available cassava varieties (VAR4), did not use starters during the proces-sing process (PROC3), and did not experience pests and diseases problems. To this effect, it is possible that the cassava varieties grown by these farmers were not har-vested 15 to 24 months after planting, but much more earlier, as was the case for the greatest proportion of farmers in this location. It is also possible that, either the varieties grown by those farmers were disease-resistant, or disease- tolerant. This could be so because the largest majority of varieties grown by farmers in the research sites are provided to them free of charge by extension services agents, and a greatest proportion among these are either disease-resistant, or disease-tolerant. Accord-ingly, this component could be characterized as “varietal attribute” factor.

The fourth principal component is connected with high negative coefficients, associated with variables TSTO-RE4 and PROC3. This suggests that the majority of far-mers who did not store their chips for up to a period of two months (TSTORE4), employed starters or ferments during the processing process (PROC3) (because of the negative sign associated with PROC3). Accordingly, and given the role of starters in speeding up the softening process of cassava tubers while immersed in water, it could be hypothesized that most of these farmers produ-ced their chips either for consumption purposes, or to be sold either locally, or in nearest cities. A close look at the raw data set used to construct histograms of cassava chips production characteristics supports this conclusion.

The fifth principal component is apparently the “storage factor” because the variable CAUS1 related to “insuffi-cient drying” was associated with the highest correlation coefficient. In addition, this variable was more or less significantly related in a negative way to storage of chips for a period comprised between 46 and 60 days (TSTO-RE4). This shows that an important proportion of farmers who viewed insufficient drying as cause of dark spots on cassava chips in storage also had a tendency not to store the produce for prolonged periods of time. In this respect, it can be inferred that an adequate drying of chips as well as other food commodities could be considered as an important prerequisite that conditions their quality and appearance in storage. Since this variable was the most important related in the three surveyed sites to chips dis-coloration, it could consequently be hypothesised that far-mers were well aware of the relevant parameters accoun-ting for cassava chips damage in storage.

Conclusion

In this study, the activity of production of cassava chips was categorized into several factors each of which was interpreted under the conditions of the sites surveyed. Preliminary data obtained from all locations showed that the farmers in Yaoundé and Mbalmayo processed and stored cassava chips in similar ways although slight differences were sometimes observed. In Ebolowa, balls were the form of chips predominantly encountered and these were stored more often over the fireplace for per-iods comprised between 1.5 and 2 months.

Soaking of entire roots of cassava in water for 5 to 6 days before they are being washed, pounded, transfor-med into balls and dried over the fireplace has always been the main way of producing chips in almost all the villages of the benchmark since the introduction of cassa-va. Almost all the respondents among the aged ones (more than 50 years) indicated that the advent of market economy coupled with the migration phenomena brought about all the modifications currently associated with the existing forms of chips. In this respect, the connexion of cassava balls with the manufacture of doughnuts, alcoho-lic beverages, and other cassava based-foods can be viewed as related to ancient practices for which the majo-rity of farmers belonging to the Ebolowa block are still strongly attached.

On the other hand, the use of ferments or starters in cassava chips producing methods can be viewed as a way of addressing temporal constraints aimed at speed-ing up the softening process of soaked cassava roots. This practice, mainly implemented by the majority of farmers in villages surrounding the Yaoundé block, and to some extent by a non negligible portion of Mbalmayo far-mers, could be considered as related to make cassava based-products available to consumers at any time in the expanding urban markets of these two blocks. Conside-ring this it can be postulated that farmers from Yaoundé and Mbalmayo were more commercially oriented and more subject to profit motivations due to the relative pro-ximity of their respective villages with market places.

We were unable, using PCA to explain the differences accounting for these discrepancies among the locations. Nonetheless, it could be hypothesized that several proba-ble factors including traditional patterns of nutrition, mar-ket related aspects, the influence of external exchanges due to migration phenomena and others might be the dominant criteria explaining these deviations in results. Previous studies carried out by the Ecoregional Program for the Humid and sub-humid Tropics of sub-Saharan Africa (EPHTA), (Anonymous, 1996) indicated that Yao-undé and Mbalmayo shared the same socio-economic characteristics.

The differences observed in the processing and stora-ge practices, as well as constraints and varietal attributes in the different principal component scores, allowed clear identification of variables that can be used in quantifying variations in the different parameters assessed, and variables that brought little information about the underlying relationships, and if deleted from the overall data could result in a more simplified data set without loss of significant information.

An important observation that can be drawn from results of PCA is that this analytical technique was able to explain at the level of the locations surveyed the differential behaviour of interviewed farmers with respect to processing, storage practices, as well as constraints and varietal attributes associated with the whole process. For instance, according to information presented in Tables 4 and 5, PCA was able to highlight that dried and broken pulp form of cassava chips were produced mainly to be sold in nearest cities. In addition, it was also observed that the majority of farmers who viewed pests and diseases as a constraint in cassava chips production used to harvest their cassava 15 to 24 months after planting. Otherwise stated, from PCA, it could be hypothesized that early harvesting of cassava could prevent farmers from experiencing pests and diseases problems on cassava in their fields.

The rationale behind using Principal Component Analysis (PCA) in this study was mainly to assess the interrelationships of variations occurring in the practices and constraints of production of cassava chips among farmers. Accordingly, it was ascertained from the present work that the PCA confirmed the wisdom of interviewed farmers' choice in discriminating important aspects in cassava chips production practices on the basis of routine behaviours and experience acquired in the long run during the process of production of cassava chips.

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