Bottlenecks and Opportunities for Quality Improvement in Fresh Pineapple Supply Chains in Benin

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Abstract

This study mapped and diagnosed the fresh pineapple supply chains in Benin to identify bottlenecks in pineapple quality improvement for different markets. A research framework was defined that comprised all relevant aspects to be researched. After 54 semi-structured interviews with key informants, 173 structured interviews were held with actor groups. The chain diagnosis showed there was no concordance between actor groups in which quality attribute they valued most. Moreover, pineapple quality was found to be highly heterogeneous. Key bottlenecks identified were lack of training of primary producers in production practices, unconditioned transport, and unavailability of boxes for export.

Keywords: *Ananas comosus*, pineapple, quality, outlets, supply chain.

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Introduction

Pineapple [*Ananas comosu*s (L.) Merrill] is a tropical fruit with a large production volume in the world (FAO 2009). In West Africa, it is the second most important tropical fruit after banana (FAO 2009). In Benin, it is one of the main crops in the Atlantic department in the south (Arouna and Afomassè 2005), where it is grown by 70% of the farmers for fresh consumption and processing into juice. Since 2006, pineapple is among the crops selected by the government in Benin to potentially alleviate poverty (Agbo et al. 2008) since Benin is the fourth country in the world delivering the highest pineapple yields (FAO 2012). Different market outlets exist: (1) the local outlet for fresh and processed pineapple, (2) the regional outlet for export to neighboring countries (Nigeria, Ghana) for fresh and processed pineapple, and (3) the European outlet (export to Belgium, the Netherlands, France, etc.) for high-quality fresh pineapple.

The main problem of pineapple in Benin is the fact that the produce often does not meet the standards for any of the outlets and certainly not the European standards (Gbenou et al. 2006). Each time producers want to export fresh pineapple to European countries a huge quantity (more than 50% of what is delivered to be exported) is rejected because it does not meet the European import criteria (Gbenou et al. 2006). Despite frequent attempts, less than two percent of the total production of pineapple is exported to European countries (Agbo et al. 2008; FAO 2011). For example, in 2009, the pineapple production was about 222,223 Mg, but only 74 Mg (0.033 %) was exported (FAO 2009). In 2010, from 220,800 Mg of pineapple produced, only 82 Mg (0.037%) was exported (FAO 2011). The remaining pineapples were delivered to the local and regional markets with lower quality demands and lower prices. Unfortunately, most of these pineapples lose their quality before being consumed (Gbenou et al. 2006) resulting in huge losses.

These problems show that the current pineapple supply chains are not effective in supplying the right quality of pineapple to meet the demands of the present markets. Such problems are also encountered in other countries, e.g. in Thailand (one of the biggest pineapple producers in the world) (Joomwong and Sornsrivichai 2005), and other crops in most Sub-Saharan African countries (Temu and Marwa 2007), e.g. mango in Ethiopia (Joosten 2007) and fresh fruits and vegetables in Kenya (Neven and Reardon 2004). Increased knowledge on how the different supply chains operate, and on existing bottlenecks for improving quality, is important to tackle these problems and establish effective chains. The primary objective of this paper is to describe and analyze the fresh pineapple supply chains in Benin and identify the main constraints for quality improvement to fulfil the requirements for different markets. The secondary objective of this paper is to identify the pineapple quality preferred in the different outlets and compare the quality preferred to the quality supplied. We based our analysis of the pineapple supply chains on a framework of Lambert and Cooper (2000) adapted by Van der Vorst et al. (2005). Preliminary results from semi-structured interviews helped us formulate the appropriate questions within the selected framework and develop a proper sampling strategy for the subsequent in-depth questionnaires with actor groups in the fresh pineapple supply chains. This study is an essential step towards improving the fresh pineapple supply chains in Benin. The approach used in this study can be applied by researchers working on other agri-foods chains, mainly in developing countries where there is a great need to understand why different chains are not effective in achieving their objectives.

The paper is organized as follows: first the research framework is described. Second, the methods used to gather and analyze information in the chains are described. Thereafter, we present results obtained through this framework and discuss how they contribute to meeting the objectives. Answers to the question "why the chains are not effective in supplying the right pineapple quality". Finally, the main findings are summarized followed by suggestions for quality improvements in the supply chains.
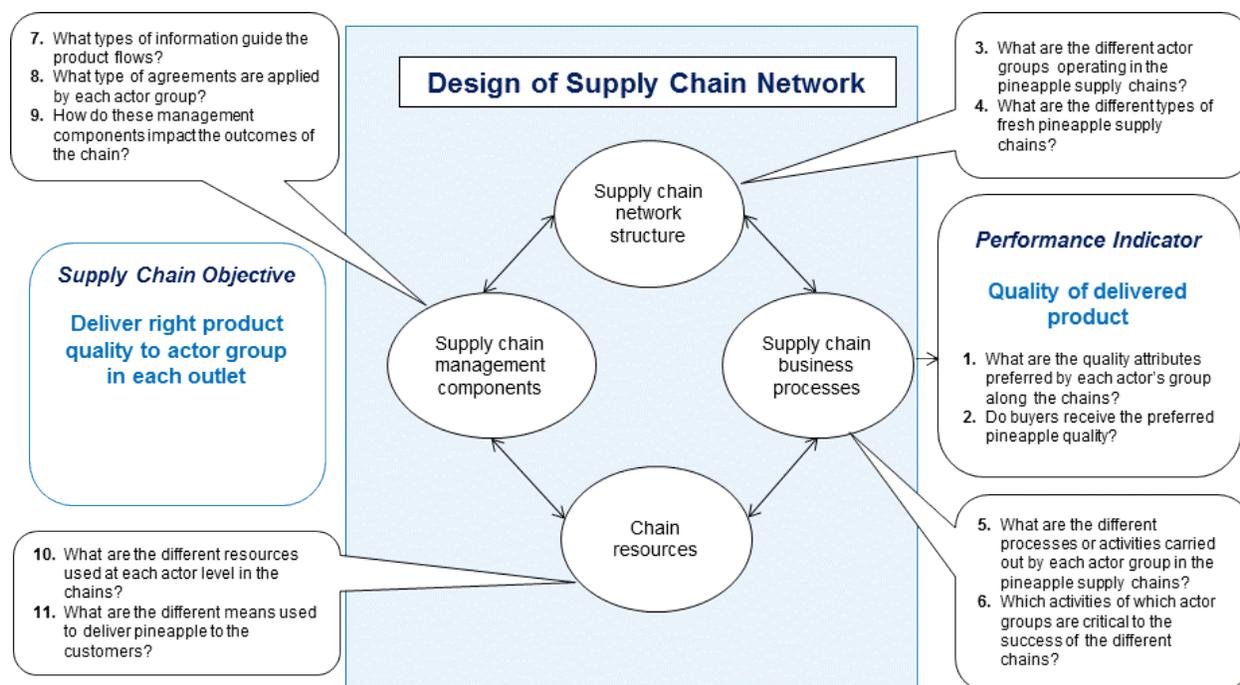
Research Framework

A supply chain (SC) is generally defined as "a network of physical and decision-making activities connected by material and information flows that cross organizational boundaries" (Van der Vorst et al. 2009) and aims to deliver superior consumer value in a sustainable way at low cost. In the present study, a supply chain was regarded as viewed by Bijman (2002) i.e. as an orderly sequence of processes and flows of products and information from primary producers to consumers. This implies that in supply chains studies, actor groups, processes, flows of products and information management should be considered. In the last two decades much research has taken place analyzing supply chains (foremost in the developed world) and identifying major improvement options (see Ebrahimi and Sadeghi 2013; Shukla and Jharkharia 2013 for recent reviews). A framework of Lambert and Cooper (2000), later adapted by Van der Vorst et al. (2005) is often used by scientists to evaluate and analyze logistic and information-management processes in food supply chains (Szymanowski 2007; Van der Vorst et al. 2007; Verdouw et al. 2008).

In line with Van der Vorst et al. (2005) five elements were used to analyze the different fresh pineapple supply chains: (1) chain objectives and performance indicators, (2) the supply chain network structure, (3) supply chain business processes, (4) supply chain management components, and (5) chain resources (Fig. 1). Preliminary results from semi-structured interviews (see Materials and Methods) helped us to phrase appropriate research questions within the framework, taking into account the characteristics of the pineapple chains studied. This resulted in 11 research questions that were projected within the elements of the framework described below (Fig. 1).

Chain Objective and Performance Indicators

The objective of the pineapple supply chain was assumed to be to deliver the right quality of pineapple to the different market outlets. To assess whether an objective is realized or not, specific performance indicators are required. In the present study, the main performance indicator was whether customer expectations regarding the quality of delivered product are met. In order to meet or exceed customer's expectations, it is important to know what quality of pineapple customers prefer (quality preferred) and to ensure that they are supplied with pineapples of that quality (Research questions 1 and 2 in Fig. 1).

Figure 1. Research framework with research questions
Note. The research framework was adapted from Lambert and Cooper (2000) and Van der Vorst et al. (2005).

Supply Chain Network Structure

The network structure is a description of (1) the different groups of actors in the chains, their roles and their experience in performing their activities, and (2) the interrelationships between actor groups in the network, thereby describing the different routes products take from primary producers to consumers (Lambert and Cooper 2000). The aim of describing the network structure was to sort out prevailing chains and to identify and characterize different groups of actors operating in these chains (Research questions 3 and 4 in Fig. 1).

Supply Chain Business Processes

Business processes include all activities designed to produce a specific output for a particular customer or market (Lambert and Cooper 2000; Van der Vorst 2006). In our case, business processes refer to all practices executed to meet the buyer's expectations in terms of pineapple quality. For example, how are pineapples grown and stored and what is done to reduce quality deterioration. The focus was on harvesting and storage practices because information on cultural practices was published by Fassinou Hotegni et al. (2012). The aims were to describe these practices in each actor group and to identify which practices influence product quality (Research questions 5 and 6 in Fig. 1).

Supply Chain Management Components

Lambert and Cooper (2000) defined nine management components in food supply chains needed for successful supply chain management: planning and control; work structure; organization structure; product flow facility structure; information flow facility structure; management methods; power and leadership structure; risk and reward structure; and culture and attitude. In

our case of the fresh pineapple supply chain two management components were considered: the information flow facility (what kind of information is exchanged between actor groups and how) and the management methods (what are the different types of agreements between actor groups and when are agreements made). These management components were identified as relevant from the results of the semi-structured interviews (Research questions 7, 8 and 9 in Fig. 1).

Chain Resources

To ensure product and information flows, resources are needed. Chain resources include facilities, logistics means and information capabilities (Van der Vorst et al. 2005). The aim of integrating chain resources in the framework is to know the resources used by each actor group in the chains and to analyze how these resources could constitute a bottleneck to the success of the supply chains. In the present study, the focus was on the transport means because they were identified as the most used chain resources (Research questions 10 and 11 in Fig. 1).

Methodology

A two-step method (Korneliussen and Gronhaug 2003) was used to collect data on the fresh pineapple supply chain network. First, 54 semi-structured interviews were held with key informants. Then, 173 structured interviews using in-depth questionnaires were held with different supply chain actors.

Semi-Structured Interviews

Semi-structured interviews (Leech 2002) were held with key informants in the fresh pineapple supply chains during September and October 2009 using a semi-structured questionnaire. Key informants comprised 13 primary producers, 1 exporter, 12 wholesalers plus retailers in different markets, 6 processors and 12 pineapple experts from 10 knowledge institutions. The aims of these semi-structured interviews were to obtain an overview of (1) actor groups in the chains (2) the activities carried out by the actor groups in the chains (3) information and product flows between actor groups in the chain and (4) the most important quality attributes for each actor group. This overview helped to select and elaborate proper research questions within the framework. The main themes of the semi-structured interviews were (1) the actor groups in the chain and the pineapple cultivars grown and sold, (2) existing chains (3) product and information flows in the chains (4) activities by each actor group (5) main quality attributes for fresh pineapple, and (6) constraints hampering high quality.

Structured Interviews Using In-Depth Questionnaires

Actor Groups Sampling

Based on the preliminary results of the semi-structured interviews with key informants, in-depth questionnaires were designed and administered face-to-face during May and June 2010, to 100 primary producers, 3 exporters, 50 traders (35 wholesalers and 15 retailers), 10 middlemen and 10 processors. The primary producers were interviewed in the municipalities of the Atlantic department where pineapple was mainly produced (Table 1). These municipalities contributed 99% of the total pineapple production in the Atlantic department (Gbenou et al. 2006). The number of interviewed primary producers per municipality was proportional to its contribution to

the total production in the Atlantic department. A stratified sampling method (Bailey 2008) based on the number of primary producers was used to determine the number of respondents per pineapple growing area within a municipality. Table 1 shows the number of primary producers surveyed per pineapple growing area. The wholesalers and retailers were selected proportionally to their number from the five main markets Sèmè Kraké, Dantokpa, Zè, Sékou and Sèhouè. Wholesalers on Zè, Sékou and Sèhouè sold to local customers only, whereas wholesalers on Sèmè Kraké and Dantokpa might focus on either local or regional customers. The processors and middlemen were randomly selected in the different municipalities. Local consumers, regional customers and importers were not part of this study.

Table 1. Number of primary producers surveyed per pineapple growing area

Municipality	Pineapple growing areas	Number of primary producers
	Fanto	11
	Glo-Centre	10
	Wawata	7
	Zinvié-Zoumè	6
	Kpé	4
	Kpaviédja	2
Zè	Agbondjedo	8
	Tangbo	7
	Anagbo	5
	Adjamè	4
	Houeta	3
	Gandaho	3
Allada	Adimalè	7
	Dodji Aliho	6
	Loto Dénou	4
	Lokoli	3
Tori	Sogbé Hétin	5
Toffo	Agbamè	3
	Ouègbo-Gare	2
TOTAL		**100**

Information Collected

The questionnaires were designed to gather information on the network structure, the business processes at each actor group level, the management components, the resources used, the most important quality attributes and quality criteria per actor group, and constraints experienced by the actor groups operating in the chain for successfully delivering the right quality to the right market. Below the *network structure* respondents were first asked their education level, their experience with pineapple, the contribution of pineapple to their total income and the pineapple cultivars cropped/sold. Next, respondents were asked to name the actor groups from whom they received the pineapple and to whom they delivered the pineapple. Below the *business processes*, primary producers were asked how they cultivated their pineapples, about their harvesting practices, whether they had received any training on the pineapple production practices and whether they belonged to a producer's organization or not. The other actor groups were asked

how and how long they stored their pineapples. Below *management components*, respondents were asked about the different types of agreements they had with other actor groups. Below *resources*, respondents were asked how the pineapple was transported from one actor to another.

Possible constraints on training and resources were identified based on the interviews with the key informants. Questions on these constraints during the in-depth interviews were pre-formulated. Respondents were asked to either agree or disagree using a five-point Likert scale (1 = completely disagree to 5 = completely agree) as suggested by Hensen and Loader (2001) to find the barriers to agricultural exports from developing countries. Later the Likert points were regrouped into three points: agree (combining "completely agree" and "agree"), neither agree nor disagree and disagree (combining "completely disagree" and "disagree") (Allen and Seaman 2007).

Quality Attributes and Criteria Determination Along the Chains

To determine which quality attributes each actor group valued most, the five attributes most frequently mentioned in the semi-structured interviews (weight of the pineapple, skin color, skin damage, firmness and taste of the pineapple flesh) were presented to the respondents; they were asked to rank these five quality attributes for each of the pineapple cultivars grown and traded in Benin from the first to the fifth, with the first being what they valued most and the fifth being what they valued least.

To determine which criteria primary producers, wholesalers, retailers and processors applied to value different quality attributes, actor groups were asked to select the relevant criteria for weight of the pineapple, skin color, skin damage, firmness, taste of the pineapple flesh, translucency of the pineapple flesh and internal browning. To determine the preferred weight of the pineapple, an at-line measurement technique was used (Callis et al. 1987), i.e. three pineapples (fruit including crown) were selected by each respondent and weighted at their selling place. Skin color criteria were determined using different maturity degrees: [0-25]%, [25-50]%, [50-75]% and more than 75%, concerning how many of the eyes of the pineapple were yellow. The criteria regarding skin damage were determined from four modalities: skin free of damage, damage on 1-4% of the area, damage on 4-8% of the skin area and more than 8% of the skin area damaged. The firmness criterion had two modalities: high or low. The taste of the pineapple was determined using sugar and lemon taste (well known by the respondents) as reference in modalities: always a taste like sugar, always a taste in between sugar and lemon, and always the lemon taste. The criteria used for translucency and internal browning were derived from Soler (1992). For translucency three modalities were used: [0-25]%, [25-50]%, and more than 50% of the flesh of the pineapple showing translucency. For internal browning four modalities based on the proportion of the blackheart symptoms were used: [0-25]%, [25-50]%, [50-75]%, and more than 75% of the flesh of the pineapple showing blackheart symptoms. Pictures were taken from Soler (1992) to help respondents indicate their choice. The European market quality attributes and criteria of importers were derived from the Codex standard for pineapple (Codex Alimentarius 2005). The heterogeneity in the pineapple quality supplied, important for exporting pineapple to Europe, was also assessed. Respondents were asked to agree or disagree using a five-point Likert scale (1 = completely disagree to 5 = completely agree) (Hensen and Loader 2001) on whether the lot of the pineapple produced/supplied was highly heterogeneous.

Statistical Analysis

Data were analyzed using SPSS (Statistical Package for Social Science), version 16.0. To describe the supply chain network structure, descriptive statistics such as percentage were used to describe the (1) actor groups in the chain and (2) proportion of actors in a group supplying the next actor group(s) with pineapples. To describe the business processes, the management components and the resources at each actor group level, descriptive statistics such as percentages were used. Practices below the business processes, management components, and resources elements were viewed to be critical for the chain objective when they were demonstrated in literature to negatively affect the quality of the product. To establish differences in the percentage of actors falling in the different Likert-scale classes for the different constraints, non-parametric Chi-square tests were performed (Clason and Dormody 1994; Pallant 2010). For data on quality attributes, non-parametric Kendall coefficient of concordance (W) tests were first performed to test whether there was agreement within groups of actors in ranking different quality attributes from first to fifth (Kendall and Smith 1939; Legendre 2005). To test for differences in quality criteria (quality criteria produced/supplied by primary producers/sellers versus quality criteria preferred by customers), non-parametric Kruskal-Wallis tests were used.

When differences between actor groups were significant, this test was followed by Mann-Whitney U tests (Field 2005) to compare a given actor group against all other groups. A Bonferroni's correction was applied (to control the type I errors), so all differences revealed by the Mann-Whitney U tests were reported at 0.05/10= 0.005 level of significance with 10 being the number of comparisons (Field 2005). To compare the differences in preferred weight among actor groups one way ANOVA was performed. For comparison of means, Gabriels pair-wise test procedure was applied at 0.05 significance level as the numbers of respondents in each actor group were not equal (Field 2005).

Results

The findings are presented as follows: first, the preliminary results of the semi-structured interviews are presented. Second, the structure of the chain network is described. Next, the business processes, the chain management components, and the chain resources are presented. Finally, the quality attributes and criteria preferred by the different actor's groups as well as a comparison between the pineapple quality supplied and the pineapple quality preferred are presented.

Preliminary Results of Semi-Structured Interviews

The fresh pineapple supply chain was composed of primary producers, exporters (i.e. producers selling to the international market), wholesalers[1] (selling at local or regional markets), retailers, processors and so-called "middlemen." The middlemen's role was to look for pineapple fields about to be harvested and connect primary producers to customers. The numbers of pineapple primary producers, fresh pineapple exporters and formal processors in the Atlantic department were estimated to be 3191, 3 and 25, respectively. Primary producers, exporters and middlemen were located in the pineapple growing areas in five municipalities, Abomey Calavi, Zè, Allada,

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[1]wholesalers in local market comprised those selling their pineapple mainly to local customers while wholesalers in regional market comprised those selling mainly to regional customers.

Tori and Toffo, out of the eight municipalities that constitute the Atlantic Department. Wholesalers and retailers were based on five market places Sèmè Kraké (in Sèmè- Kpodji), Dantokpa (in Cotonou), Zè (in Zè), Sékou (in Allada) and Sèhouè (in Toffo). Their number fluctuated in these five markets places. Sèmè Kraké and Dantokpa were the main market places for the regional market since they were visited by both local and regional customers, i.e. customers from neighboring countries, such as Nigeria, Ghana, Burkina Faso, Mali and Ivory Coast. Zè market, Sékou market and Sèhouè market were the main market places considered as local markets where pineapple was sold as the main commodity. Wholesalers and retailers had their base on the five market places considered in the study. Processors were located throughout the Atlantic department but most of them were not located in the pineapple growing areas, but in Littoral department (bordered by Atlantic department in West) close to the regional market places. Two pineapple cultivars were grown and sold: Smooth Cayenne and Sugarloaf.

Different activities took place at each actor group level. At primary producer's/exporter's level, the pineapple fruits were cultivated and harvested. At the wholesaler's/retailer's level, the pineapple fruits were just stored and sold. Wholesalers and retailers had their storage place on the five markets earlier mentioned. At processor's level, the pineapple was stored and processed into juice and dried pineapple. From one actor group to the next, trucks were used to transport the pineapple. Between primary producers and other actor groups in the chains, there were often some agreements made during the pineapple production which lasted 15-18 months. These agreements were often made by phone calls and were mainly based on the quantity, quality and the delivering time.

Wholesalers, retailers and processors affirmed not being supplied with their preferred pineapple quality. The most frequently mentioned quality attributes by actor groups, being the most valued ones, were the weight of the pineapple, skin color, skin damage, firmness and taste of the pineapple flesh.
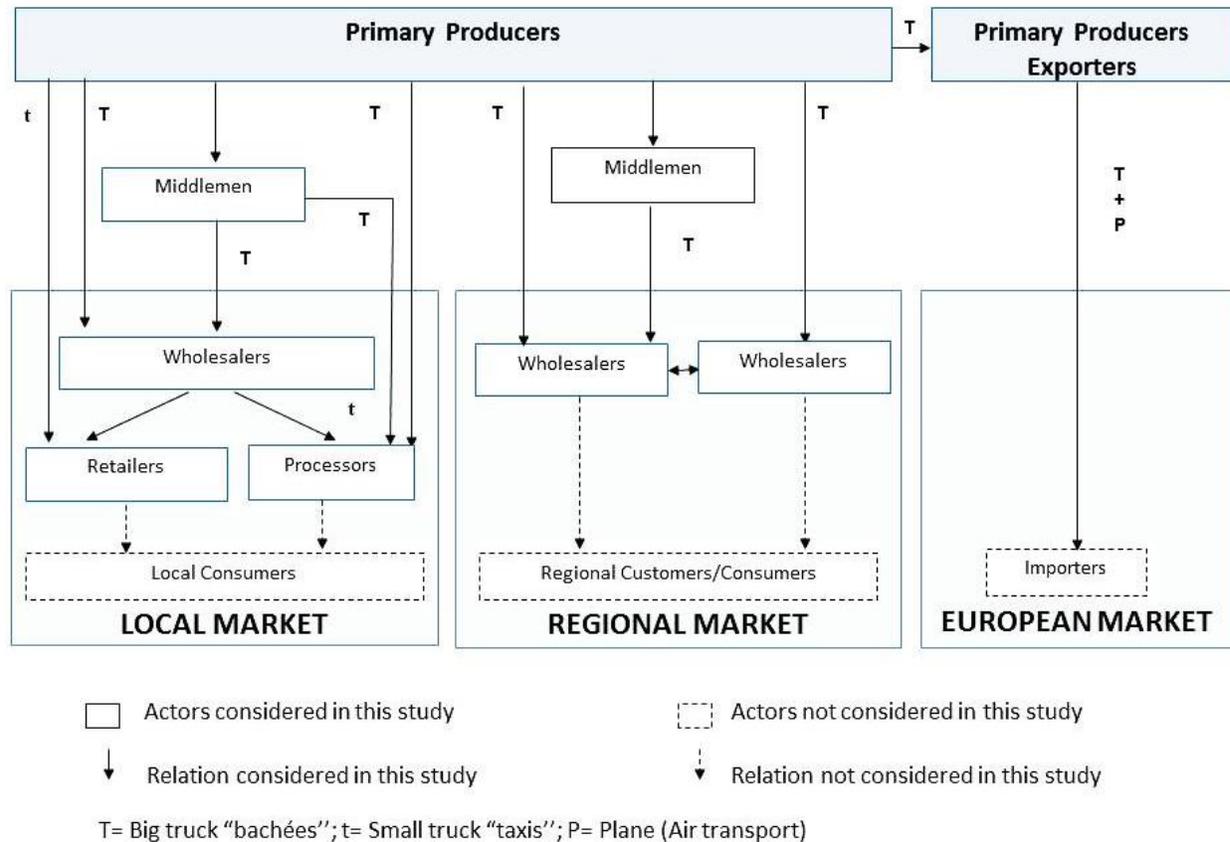
Structure of the Pineapple Chain Network

Actor Groups

Table 2 (See Appendix) summarizes the characteristics of the actor groups in the fresh pineapple chains. Most primary producers, exporters, processors and all middlemen were male; all wholesalers and retailers were female. Producers, and especially middlemen, wholesalers and retailers had less education than exporters and processors. 56% of the producers, all exporters and 63% of the wholesalers had 10 or more years of experience in pineapple cropping or selling, whereas all middlemen, 67% of the retailers and 60% of the processors had less than 10 years of experience in pineapple selling/processing. The contribution of pineapple to the total income was at least 40% for at least 90% of the respondents in each actor group, and at least 80% for the exporters and the majority of the wholesalers and retailers. Sugarloaf was the most cultivated and sold cultivar. Smooth Cayenne was the most exported cultivar.

Chain Structures

Fig. 2 shows the different structures of the fresh pineapple chains. Two types of fresh pineapple supply chains prevailed to reach the local and regional markets: (1) chains where the customers (retailers, wholesalers and processors) reach the consumers after obtaining their pineapples

directly from the primary producers, and (2) chains where customers reach the consumers after obtaining their pineapples through middlemen. In the local markets, seven fresh pineapple supply chains were prevailing: 1) primary producers-retailers-local consumers, 2) primary producers-wholesalers-retailers-local consumers, 3) primary producers-wholesalers-processors, 4) primary producers-middlemen-wholesalers-retailers-local consumers, 5) primary producers-middlemen-wholesalers-processors, 6) primary producers-middlemen-processors and 7) primary producers-processors. Three chains prevailed in the regional markets: 1) primary producers-wholesalers-regional customers, 2) primary producers-middlemen-wholesalers-regional customers, and 3) primary producers-middlemen-wholesalers-wholesalers-regional customers.

Figure 2. Structure of the pineapple chains in Benin including means of transport of pineapple between actor groups

For the European markets, the exporters sent their own pineapples to the importers, but incidentally bought pineapples from other primary producers (non-exporters) to meet the demand.

From Primary Producers to Wholesalers, Retailers, Processors and Exporters

Most of the Sugarloaf and 50% of the Smooth Cayenne wholesalers that obtained their pineapple directly from producers, bought from 6 or more producers (Table 3, see Appendix), while the limited number of retailers buying Sugarloaf directly from primary producers, bought only from

1-5 primary producers. Processors bought Sugarloaf directly from 6 or more primary producers. No retailers bought Smooth Cayenne from primary producers. All exporters obtained their additional pineapples directly from 11 or more primary producers. When middlemen were involved in obtaining pineapples from primary producers, the number of middlemen was no more than 4 for most wholesalers and 5 or more for most processors, for both cultivars (Table 3).

From Wholesalers to Wholesalers, Retailers and Processors

Wholesalers constituted another source of pineapple for the retailers and processors in the local market and for other wholesalers in the regional markets (Fig. 2). The pineapple was delivered to retailers and processors on a first come first served basis by means of small trucks.

Most wholesalers obtaining pineapple from other wholesalers bought from 1-6 wholesalers (Table 3). This was observed at Dantokpa and especially Sèmè Kraké market places where 90% of the wholesalers sold their pineapples to regional customers. To meet those customers' demands, wholesalers were often obliged to turn to other wholesalers at the same market. Most sales to regional customers took place during the evening and night at Sèmè Kraké market place.

Most retailers buying Sugarloaf from wholesalers obtained their pineapples from 4 or more wholesalers whereas retailers buying Smooth Cayenne got their pineapples from fewer than four wholesalers (Table 3). Most retailers bought and sold from the same market.

For both cultivars, most processors buying from wholesalers obtained their pineapples from 4 or more wholesalers.

Business Processes

At Primary Producer's/Exporter's Level

The processes at primary producer's level consisted of cultivating and harvesting pineapple for different outlets. According to Fassinou Hotegni et al. (2012), the production system was either inspired from neighbor producers or inspired from those in use in neighboring countries. Inputs used by producers included planting material (slips, hapas and suckers), fertilizers, and chemical products to induce flowering and to synchronize maturity. The planting materials were derived from plants kept in the field after harvest of the fruits for about 6 months. The primary producers obtained planting material either from their own previous field or from other producers' fields. Shops and CeRPA (Centre Régionale de la Production Agricole) were used to obtain the fertilizer; the chemical products to induce flowering and to synchronize maturity were obtained from shops and CeRPA.

After planting, fertilizers were applied, and carbide of calcium and ethephon were applied to induce flowering and synchronize maturity, respectively. Details on production practices are described by Fassinou Hotegni et al. (2012). Here attention is given to the harvesting practices and the producer's training.

At harvest time, pineapples were harvested by workers (generally women) hired by either the buyers or the primary producers. After harvest, 83% of the primary producers stated that they kept their pineapple fruits on the soil for a period proportional to the size of the field (generally this period ranged from 1 to 6 hours). The pineapple was loaded by two loaders hired by the drivers in unconditioned trucks. At the exporter's level, the pineapple once harvested were first sorted at the production site based on the quality attributes (mainly the external quality attributes, i.e. the skin color, crown height, fruit height and fruit size) and then packed in boxes based on the uniformity in quality attributes before being sent to importers. The boxes were bought from neighboring countries and were often not available leading to reduction or delay in the volume being exported.

There was a significant difference between the number of primary producers agreeing and disagreeing on not having received training to cultivate pineapple for (1) fertilizer application time and rate, (2) flowering synchronization practices, time of application and rate, and on (3) pest and weed management ($P < 0.05$ in all cases) (Table 4).

Table 4. Percentage of primary producers that did not receive training on pineapple production practices since they have been producing pineapple based on the Likert-scale, n=100

Likert-scale[a]	No training on fertilizers application rate	No training on fertilizers application time	No training on flowering induction practices	No training on flowering induction time	No training on pest and weed management
Disagree	37	36	32	31	16
Neither agree nor disagree	4	4	4	4	5
Agree	59	60	64	65	79
χ2(Chi-square)[b]	5.042 *	6.000 *	10.667 *	12.042 *	41.779 *

[a]The five Likert-scale points were regrouped into three points: Agree (combining ''completely agree'' and ''agree''), neither agree nor disagree and disagree (combining ''completely disagree'' and ''disagree'').
[b]Chi square test was performed to compare the number of primary producers who disagree with those who agree. Therefore, the number of primary producers that ''neither agree nor disagree'' with the statements were not considered.
* Significant, $P < 0.05$

The number of primary producers agreeing that they never had received training since they had been cultivating pineapple was higher than the number disagreeing. Fifty eight per cent of the producers were not member of a producer's organization.

At Wholesalers and Retailers and Processors Level

Pineapples delivered to wholesalers, retailers and processors were stored on the ground in a pile and kept in sunlight or shade, covered with bags or not covered. About 43% of the wholesalers stored their pineapples in the shade without covering, 32% in sunlight without covering, whereas 20% and 70% of the processors, respectively, stored their pineapple in these ways. Pineapple stayed in these conditions for 1-3 days. All retailers stored their pineapple in shade without covering them, for a period of 1-7 days.

Chain Resources

From Primary Producers to Wholesalers, Retailers, Processors and Exporters

The pineapples were transported by independent drivers hired by the buyers, from primary producers to wholesalers, processors, retailers or exporters using either big trucks called "bachées'' or small trucks called "taxis" (Fig. 2); "bachées", of which the capacity ranged from 1200 to 1400 pineapples for Smooth Cayenne and from 1440 to 2160 pineapples for Sugarloaf, were used when customers were wholesalers, processors or exporters; "taxis", of which the capacity ranged from 400 – 470 pineapples for Smooth Cayenne and from 480 – 720 pineapples for Sugarloaf, were used for transport to retailers (Fig. 2). In both cases, environmental conditions were not controlled and pineapples were loaded individually next to each other by the loaders.

About 26% of the wholesalers deemed that they did not receive their pineapple on time and this was, next to lack of quality, one of the reasons why they rejected pineapple from the primary producers. However, most of the wholesalers accepted the pineapple even if the quality was not what they expected; but in that case the price was reduced.

From Exporters to Importers

Exporters sent their pineapples to importers in European countries by plane (Fig. 2). The pineapples were transported to the airport by means of either big trucks under uncontrolled conditions (when the volume of pineapple being exported was less than 5 Mg) or very big trucks (when the volume of pineapple being exported was more than 5 Mg) under controlled conditions. Once at the airport, the pineapples were unloaded from the trucks and loaded in the plane. However, it often occurred that the pineapple stayed for some hours or days under uncontrolled conditions at the airport before being loaded in the plane. Generally this situation was due to a lack of synchronization between the pineapple harvest time and the plane (generally Air France) departure to Europe. The importers transported the pineapples to the different European markets (Belgium, the Netherlands, France, etc.).

Management Components

Three types of agreements existed between the primary producers and their customers (Table 5): (1) agreements made before planting time; in that case, producers had fixed customer(s) and the pineapple was delivered to them no matter the harvesting time; (2) agreements made between planting and before harvest; producers delivered all pineapple no matter the harvest time and quantity to a fixed customer(s) and (3) no agreements made before harvest time; primary producers falling in the third type of agreement had no contact with the buyer before the pineapple reached the closest stage to the harvest time.

Table 5. Proportion of primary producers making selling agreements with wholesalers and processors at different pineapple developmental phases for two cultivars

Pineapple cultivar	Type of agreement			χ^2 [a]
	Agreement made before planting	Agreement made between planting time and harvest	No agreement made before harvest	
Sugarloaf (n=97)	41	29	30	1.292 ns
Smooth Cayenne (n=30)	30	37	33	

[a] χ^2-analysis was carried out on numbers
ns: Not significant, $P \geq 0.05$

Sometimes, primary producers making the third type of agreement could not find a buyer until they harvested their pineapple and brought them to the closest market. The proportion of producers making a certain type of agreement was not cultivar dependent (Table 5).

The quantity of pineapple bought by wholesalers, retailers and processors depended on the quantity of pineapple in store and the period of the year. Most wholesalers (71%) bought one or two big trucks of pineapple from the producers when the quantity of pineapple in store was reaching a level of 60-90 pineapples. Retailers who obtained their pineapple from the wholesalers generally bought 40 pineapples (one forty) only when they had no pineapple left to sell. Retailers who obtained their pineapple directly from the primary producers generally bought 320-600 pineapples (8 to 15 forties) when the quantity of pineapple in store was reaching a level of 40-60 pineapples. Processors bought a quantity of pineapple that ranged from one to four trucks for both cultivars when the quantity of pineapple in store was reaching one truck. The quantity of pineapple asked for by regional customers ranged from 120 pineapples to two big trucks loads.

Wholesalers, retailers obtaining their pineapple directly from primary producers, and processors affirmed that their buyer demand for pineapple was lower from mid-March to July and from mid-September to mid-October, while in the other months of the year (Mid-October to Mid-March and Mid-July to Mid-September) the demand was high. However, wholesalers, retailers and processors agreed that they bought their highest volume of pineapple from August to October, coinciding with the Muslim fasting period of the study year.

Generally, exporters received orders from importers in European markets some months before the exporting date. The demand for pineapple by the importers varied between 20-40 Mg (8-16 big trucks) per week. During the long dry season (January, February, March and early April), exporters faced problems to meet this quantity of fresh pineapple; they then collected additional pineapple from 20-40 well-known producers to whom they provided technical assistance in pineapple production. This collection was based on the external quality attributes and the uniformity in quality attributes required by the importers.

Quality Attributes and Criteria along the Chains

Most Important Quality Attributes for Different Actor Groups

Actor groups differed in their ranking of the quality attributes, weight of the pineapples, skin color, skin damage, firmness and taste of the pineapple flesh, from the most valued (first rank, first quality attribute) to the least valued (fifth rank, fifth quality attribute) (Fig. 3).

For Sugarloaf, there was agreement among primary producers in ranking the weight of the pineapple as first quality attribute followed by respectively the taste of the pineapple, the firmness, the skin color and the skin damage (Kendall's W=0.571, $P < 0.001$) (Fig. 3). The same observations were made for the Sugarloaf wholesalers selling at the regional market (Kendall's W=0.524, $P < 0.001$), whereas Sugarloaf wholesalers at the local market agreed on ranking the taste of the pineapple as first followed by skin color (Kendall's W=0.416, $P < 0.001$). Contrary to the wholesalers, Sugarloaf retailers agreed on ranking the skin color as first quality attribute followed by firmness and taste of the pineapple (Kendall's W=0.452, $P < 0.001$). The Sugarloaf processors differed from the other actor groups by agreeing on ranking firmness as first quality attribute followed by skin color and weight of the pineapple (Kendall's W=0.339, $P < 0.01$).

For Smooth Cayenne, primary producers, wholesalers at the local and wholesalers at the regional market agreed on ranking the weight of the pineapple as first quality attribute (Fig. 3). Differences among these actor groups were noticed in ranking the remaining quality attributes. For the primary producers, the second quality attribute was the taste of the pineapple, the skin color being the third (Kendall's W=0.385, $P < 0.001$), whereas for the wholesalers selling Smooth Cayenne at the local market, skin color and taste appeared to be the second and the third quality attributes respectively (Kendall's W=0.539, $P < 0.05$). Wholesalers selling Smooth Cayenne at the regional market agreed on ranking firmness and taste of the pineapple as second and third quality attributes (Kendall's W=0.792, $P < 0.01$). For the processors processing Smooth Cayenne, the five quality attributes were given more or less the same ranking when compared with their ranking for Sugarloaf.

Skin damage was the least valued quality attribute by all actor groups except processors (Fig. 3).

Pineapple Quality Produced/Supplied Versus Pineapple Quality Preferred

For both cultivars, the weight (fruit with crown) preferred by retailers was significantly lower than the weight preferred by wholesalers (Table 6); there was no significant difference in the desired weight between wholesalers at the local or the regional market.

Preferred fruit weights were higher for Smooth Cayenne than for Sugarloaf. Processors were not exigent for fruit weight, so every pineapple size was convenient to them (Table 6). For the European markets, the average weight of the pineapple should be at least 0.80 kg with the crown and 0.664 kg without crown for the lowest weight class and no more than 2.75 kg with crown and 2.28 kg without crown for the highest weight class (Table 7).
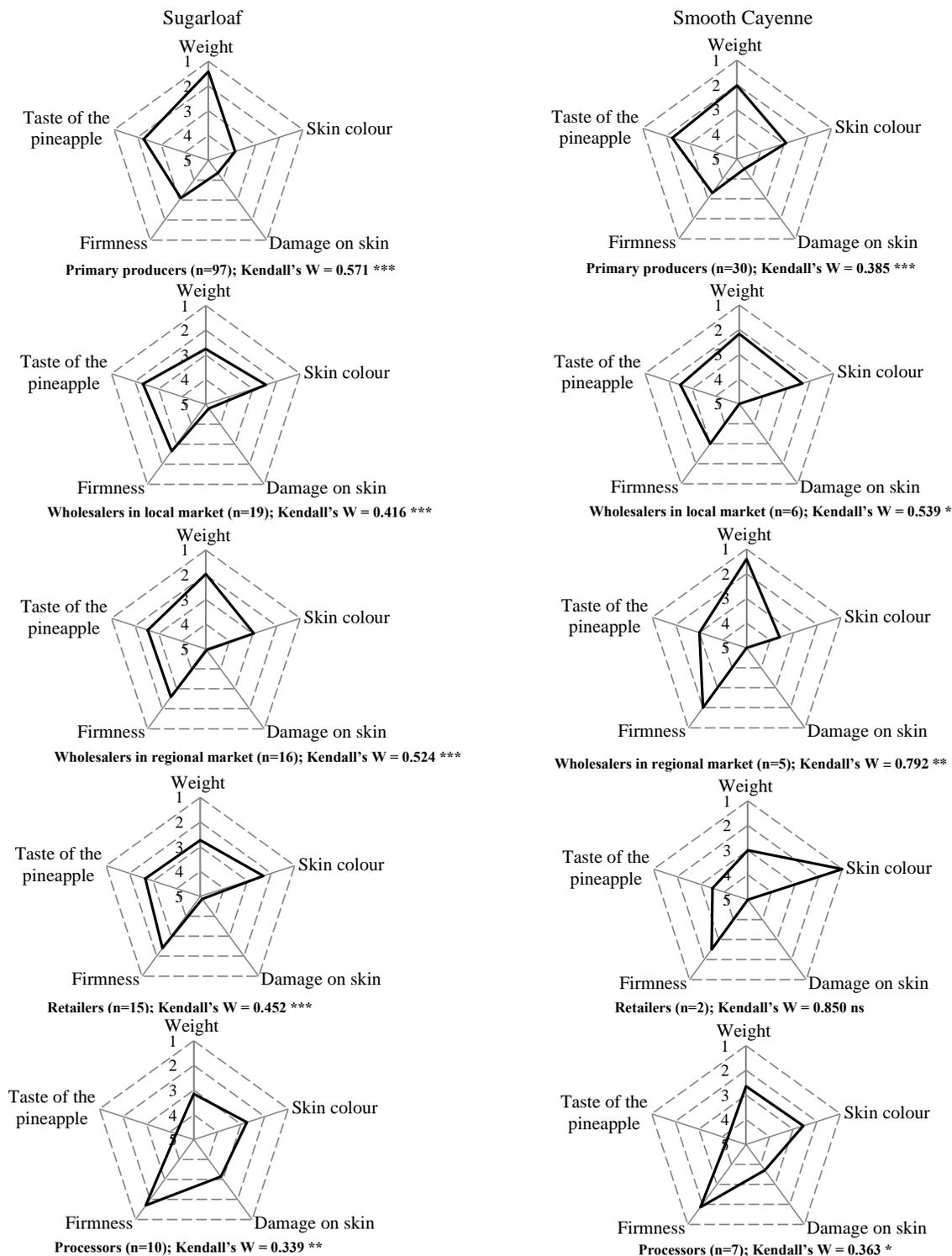
Figure 3. Quality attributes of pineapple as ranked by different actors

Note. Mean rank assigned by different actors to the five most frequently mentioned quality attributes for the pineapple cultivars Sugarloaf (left) and Smooth Cayenne (right). A significant Kendall's coefficient of concordance (Kendall's W) indicates that there was agreement within actors' group on ranking the quality attributes from 1=first (most important) to 5 = fifth (least important).

*** Significant, $P < 0.001$; ** Significant, $P < 0.01$; * Significant, $P < 0.05$; ns: Not significant, $P \geq 0.05$

Table 6. Pineapple fruit weight (kg per fruit) preferred by different actor groups for two cultivar

Cultivar	Actor group				*P*-value[a]
	Wholesalers Local market	Wholesalers Regional market	Retailers	Processors	
Sugarloaf	1.47 ± 0.28 b	1.50 ± 0.27 b	1.08 ± 0.33 a	Every size	0.000
Smooth Cayenne	2.71 ± 0.35 b	2.85 ± 0.52 b	1.53 ± 0.18 a	Every size	0.011

[a] *P*-value from ANOVA test comparing the different groups of actors except processors;
Values followed by the same letter within a row are not significantly different at 0.05 according to the Gabriel pair-wise test.

Table 7. Average pineapple weight (kg ± 12%) with/without crown in different weight classes for pineapple export

Weight class	Weight with crown	Weight without the crown
A	2.75	2.28
B	2.30	1.91
C	1.90	1.58
D	1.60	1.33
E	1.40	1.16
F	1.20	1.00
G	1.00	0.83
H	0.80	0.66

Source. Codex Alimentarius (2005)

For Smooth Cayenne, the weights preferred by wholesalers were the top end of what would be the highest weight class suitable for export.

Kruskal-Wallis tests revealed that there were also significant differences between actor groups in taste (H=20.54, *P* < 0.001), firmness (H=29.66, *P* < 0.001), skin color (H=13.33, *P* < 0.01) and translucency (H=27.84, *P* < 0.001) produced/preferred for Sugarloaf (Table 8, see Appendix) and in taste (H=14.22, *P* < 0.01) and skin color (H=30.56, *P* < 0.001) produced/preferred for Smooth Cayenne (Table 9, see Appendix).

Differences in taste criteria preferred for Sugarloaf were observed between primary producers and processors (U=183.50, *P* < 0.005) and between wholesalers in regional markets and processors (U = 23.00, *P* < 0.005) (Table 10, see Appendix).

Most processors preferred Sugarloaf pineapples with always a taste in between sugar and lemon whereas most wholesalers at the regional market preferred pineapples having always a taste like sugar; most primary producers at the same time produced pineapple having a taste like sugar (Table 8). Differences in firmness and flesh translucency preferred for Sugarloaf existed between primary producers and other actors except processors (Table 10); all wholesalers at local and regional markets and all retailers preferred "always firm pineapple", while only 62% of the primary producers always aimed to produce firm pineapple (Table 8, see Appendix); similarly 70% of the primary producers produced Sugarloaf having 25-50% of the flesh translucent while most wholesalers in local and regional markets as well as retailers preferred pineapple having 0-25% of the flesh translucent (Table 8). For skin color, a difference in quality criteria preferred for

Sugarloaf was only observed between primary producers and wholesalers in the local market (U = 589.00; P < 0.005) (Table 10). Sixty five percent of primary producers produced Sugarloaf pineapple with 25-50% yellow skin, while 68% of the wholesalers at the local market preferred pineapple with 0-25% yellow skin (Table 8).

Difference in taste preferred for Smooth Cayenne was observed between primary producers and processors (U = 32.50; *P* < 0.005) (Table 11, see Appendix).

Most Smooth Cayenne primary producers produced pineapple with a taste like sugar whereas most processors preferred pineapple with a taste between sugar and lemon (Table 9). As to the skin color, difference in quality criteria was observed between primary producers and all other actor groups except retailers (Table 11). Eighty percent of the primary producers produced pineapple with less than 50% of skin yellow, while all wholesalers in local and regional markets as well as most of the processors preferred pineapple with more than 50% of the skin yellow (Table 9).

Wholesalers in both markets as well as retailers and processors preferred pineapple presenting less than 25% of blackheart symptoms and free of skin damage, independent of the cultivar; primary producers responded well to these quality criteria requirements since all of them affirmed producing pineapple fulfilling these criteria (Table 8 and Table 9).

Another aspect of the pineapple quality preferred by actor groups including the importers (affirmed by exporters) along the chain was a very low heterogeneity in the different quality attributes. It was noticed that more than 50% of wholesalers in local and regional markets as well as retailers and processors agreed that there was a large heterogeneity in the pineapple size delivered to them no matter the cultivar (Fig. 4). Likewise, most primary producers also admitted that there was a large heterogeneity in pineapple size at harvest (Fig. 4).
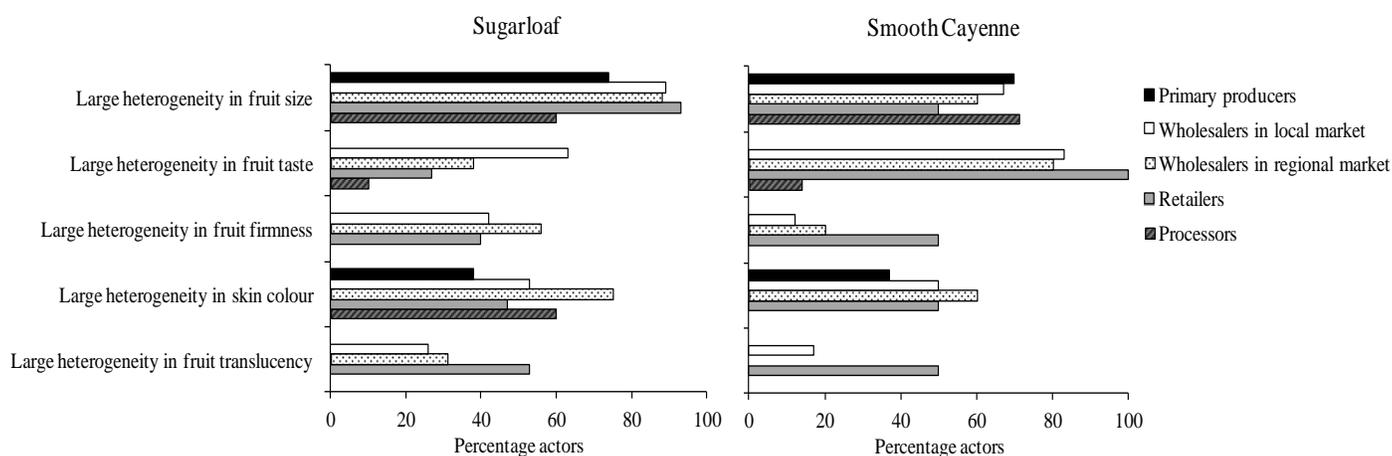
Figure 4. Heterogeneity in quality of pineapple cultivars, as perceived by different actors
Note. The diagrams list the percentage of actors in different groups, agreeing (combining the responses "agree" and "completely agree") with statements on the heterogeneity in quality of pineapple cultivars Sugarloaf (left) and Smooth Cayenne (right) that they produced or received.

Concerning heterogeneity in the taste of the pineapple, most Sugarloaf wholesalers at the local market and most Smooth Cayenne retailers agreed that there was a large heterogeneity in taste; a large heterogeneity in fruit firmness was confirmed to exist by most Sugarloaf wholesalers in regional markets and most Smooth Cayenne retailers. Most Sugarloaf and Smooth Cayenne wholesalers at the regional market agreed on a large heterogeneity existing in the pineapples they received for skin color (Fig. 4). Most Sugarloaf and Smooth Cayenne processors agreed there was a large heterogeneity in pineapple flesh translucency. For the European market, heterogeneity in quality attributes is very important since fruits in the same boxes should be uniform in skin color, weight, etc. (Codex Alimentarius 2005); exporters faced difficulties meeting this quality demand since they often collected pineapple from many primary producers.

Discussion

Fresh Pineapple Supply Chains Structure

The fresh pineapple supply chain network in Benin was composed of six main groups of actors: primary producers, exporters, middlemen, wholesalers, retailers and processors. For all these actor groups, but especially for the exporters, pineapple was very important due to its high contribution to the total income constitution (Table 2). Actor groups were integrated in differently structured chains leading to four outlets: (1) the local outlet for fresh pineapple, (2) the local outlet for processing pineapple, (3) the regional outlet for export to neighboring countries for either fresh or processing pineapple, and (4) the export outlet for import in Europe (Fig. 2). The chains to the local outlets differed in the involvement of wholesalers versus direct delivery by primary producers to retailers and processors and in the involvement of middlemen to search for fields and contact primary producers versus direct contact by wholesalers and processors. Chains to the regional market operated always through wholesalers, who might use middlemen or have direct contact with primary producers. Chains to the European outlet were direct, with exporting farmers contacting neighboring primary producers (Fig. 2). The same situation defined as partial integration between exporting farmers and primary producers was observed in Ghanaian pineapple chains where exporters used purchases from primary producers as buffers to respond to the European Union demand in pineapple (Suzuki et al. 2011). In these conditions, primary producers obtaining advice on cultural practices and assistance in getting inputs to grow their crop from exporters, would tend to produce high-quality pineapple and so meet the demands of exporters for quality as well (Suzuki et al. 2011).

Business Processes and Constraints for the Success of the Chains

Business processes at each actor group level can impact the quality of the pineapple delivered to customers/consumers and affect the success of the pineapple chain. In analyzing the pineapple production systems, Fassinou Hotegni et al. (2012) found that constraints in the pineapple cultivation in Benin were the diverse production systems and a lack of planting material and some fertilizers. In our study, most primary producers agreed on not having received any training on pineapple production practices such as fertilizer application time and rate, flowering synchronization time and rate and pest and weed management since they had started producing pineapple (Table 4). This will also be a bottleneck to high-quality pineapple production since Subramanian and Matthijs (2007) reported the lack of training as one of the critical factors in

high-quality production. The lack of training of primary producers can be viewed as a threat to the success of the pineapple chain since Cetinkaya (2011) argued that training actor groups in their activities constituted a key element in implementing successful supply chains.

It was also noticed that the pineapple was left for hours in sunlight on the soil after harvest before being loaded. This exposure of the fruit to high temperature was reported as one of the causes associated with translucency (Chen et al. 2009). Then, the fruits may become translucent, i.e. the flesh of the fruit will show water soaking, and therefore becomes fragile (Py et al. 1987) and more susceptible to diseases (Gortner et al. 1963).

Results also showed that most primary producers were not a member of a producer's organization. The same findings were reported in Brazil by Brito et al. (2009) and this was argued to be a negative factor contributing to the lack of organization of the chains and therefore to non-successful chains. Belonging to producer's organizations facilitates the organization of the production and the access to credit and other support services (Coulter et al. 1999) and promotes good practices in the chains (UNEP 2012).

Results also indicated the unavailability of boxes for export. The government should either make the boxes needed by exporters available in the country or stimulate the private sector to take this up. This would create opportunities for off-farm employment and incite exporters to continue producing pineapple for European countries.

At wholesaler and processor's level, the storage of pineapples in the sun could also increase fruit translucency as previously stated for the primary producer's level.

Chain Resources and Constraints for the Success of the Chains

From one actor group to another, the pineapple was delivered under non-controlled conditions in "taxis'' or "bachées'' by independent drivers hired by the buyers (Fig. 2). When combining the ways the fruits are treated after harvest, i.e. the exposure of the fruits in sunlight for some hours, the loading in trucks next to each other and the unconditioned transport conditions, the quality of the fruit, especially the firmness, could be reduced (Crisosto et al. 1995) and thus will limit the possibilities to reach higher-valued markets and increase losses. In Benin, there are no cold facilities for pineapple. It is well known that temperature conditions affect the fruit shelf life (Nunes and Edmond 2002). According to Hardenburg et al. (1986) and Cantwell (2002) the optimum storage temperature for a long shelf life for pineapple is 10 °C. In Cotonou, Zè, Allada and Toffo where the Dantokpa, Zè, Sékou and Sehouè markets are located, the mean monthly temperatures range from 27-31 °C; they range from 25-30 °C in Sèmè-Kpodji where the Sèmè Kraké market is located (INSAE 2004). In these conditions of high temperature, the pineapple shelf life will be reduced leading to high degree of rotting when not quickly sold. These high temperature conditions may also play a positive role, since they may be the cause of the absence of blackheart problems (cf. Tables 8 and 9); blackheart symptoms develop when fruits are exposed to temperatures below 10-12 °C (Akanine et al. 1975; Keetch and Balldorf 1979).

In the current situation, the chain resources used do not help in keeping the quality of produced pineapple. The establishment of a cold chain especially in the export chain as is the case in

Ghana (Fassinou Hotegni 2013) is needed for keeping the quality. Cold storage facilities at exporter level and at the airport will reduce rejection of pineapples by importers since the fruits will still be fresh and well-looking. Therefore, actions need to be taken by the government to implement the storage facilities or to stimulate the private sector to take this up.

Management Components and Constraints for the Success of the Chains

Our results indicated that 30% of the primary producers producing Sugarloaf and 33% of the primary producers producing Smooth Cayenne had no selling agreement with their customers at the time of harvest (Table 5). This could be considered as a factor preventing primary producers to meet their customers' quality criteria. In pineapple it takes 15-18 months before the fruit is harvested (Fassinou Hotegni et al. 2012). Having an order before harvesting time would allow primary producers to know the type of pineapple quality they have to produce. This means that information sharing between actor groups in the chains should be more intensive to facilitate the supply of preferred pineapple quality. Cooperation between actor groups within a chain is essential to access high quality export markets as highlighted by Garcia Martinez and Poole (2004) for the Moroccan citrus chain.

Mismatch between Pineapple Quality Supplied and Pineapple Quality Preferred

Primary producers producing Sugarloaf pineapple and wholesalers in the regional market selling Sugarloaf pineapple shared the weight as the "most valued" quality attribute; this was not the case for wholesalers at the local market selling Sugarloaf pineapple, retailers selling Sugarloaf pineapple and processors (Fig. 3). As to the Smooth Cayenne cultivar, actor groups sharing the weight as the "most valued" quality attribute were primary producers, wholesalers in the local market as well as wholesalers in the regional market (Fig. 3). However, retailers desired a lower weight than wholesalers; processors were not exigent in pineapple weight (Table 6). Considering the fact that wholesalers constituted a major source of pineapple for all retailers (Table 3), the observed mismatch in pineapple weight criteria between wholesalers and retailers could be viewed as a constraint for not meeting retailer's quality criteria in pineapple weight. Wholesalers will have the tendency to buy big pineapple from primary producers and will most likely present that big pineapple to the retailers who will be obliged to buy them although their quality criteria are not met. So for the chains where retailers bought their pineapple from wholesalers, wholesalers appeared to be the critical actor group to the success of the chains.

For the other quality attributes criteria, results revealed that there was a mismatch between (1) primary producers and processors for the taste criteria for both cultivars (Tables 10 and 11), (2) primary producers and wholesalers in the local market, primary producers and wholesalers in the regional market and primary producers and retailers for the firmness and translucency criteria for cultivar Sugarloaf, (3) primary producers and wholesalers in local market for the skin color criteria for both cultivars, primary producers and wholesalers in regional market and primary producers and processors for skin color criteria for Smooth Cayenne pineapple (Tables 10 and 11). These mismatches between the quality of pineapple supplied and the quality of pineapple preferred could be considered as a bottleneck to the success of the chains as stated by Fisher (1997), stressing once more the importance of information exchange between actor groups in the chains.

The fact that primary producers were the main pineapple source of wholesalers and processors (processing Sugarloaf) and an additional source for some retailers (Table 4), and the fact that there was a mismatch between the quality of pineapple supplied by primary producers and the quality preferred by processors, wholesalers and retailers show that primary producers are the actors critical to the success of the chains where wholesalers, processors (Sugarloaf processors) and retailers obtained their pineapple from them.

The results also revealed that another problem encountered in the chains was the heterogeneity in pineapple quality, mainly in size (comparable to weight) and skin color (Fig. 4). This was an important point especially for the exporters since they should fit uniform fruits with specific quality criteria in the boxes. So, in addition to the quality criteria that should be met (Codex Alimentarius 2005), a higher uniformity in fruit quality is needed to improve the volume of exported pineapple. According to Luning and Marcelis (2006), the heterogeneity in quality is linked to production practices. Therefore, it is important to fully understand and analyze the pineapple production system so as to implement good production practices yielding more uniform and acceptable pineapple quality. On the other hand, the heterogeneity of the pineapple (mainly the size) could create opportunities for hawker salers[2] and pineapple processors.

Conclusions and Implications

Many actor groups operate in the fresh pineapple supply chains of Benin. The chains were not successful in delivering the right product quality to the markets. First, the research identified a large mismatch in perception of quality between different actor groups. There was a mismatch between wholesalers and retailers for the weight demands of the pineapple fruit; a mismatch for taste, firmness and translucency criteria was identified between primary producers and wholesalers, retailers and processors. These observations make wholesalers and primary producers critical actor groups in the chains. Second, all buyers concluded there was a large heterogeneity in quality delivered by the producers. This could be due to the way the pineapple is produced. Bottlenecks for achieving and keeping a high quality level of the fruits were lack of training of primary producers in production practices, limited organization of farmers, the poor transportation system and the poor storage conditions at wholesaler and processor levels, and also at the airport when the pineapple was intended to be exported. In addition, the lack of transport boxes constituted another constraint for export.

For the establishment of successful fresh pineapple supply chains in Benin, it is important to first tackle the main bottlenecks. Emphasis should be given to solve the problems at primary producers' level so that the chain starts with high-quality produce with low heterogeneity in pineapple quality. This requires not only training of primary producers in best production practices but also research on tools to reduce the heterogeneity in pineapple quality. In addition, the performance of the chains could increase by aligning the quality criteria of actor groups in the chain.

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[2] Hawker salers are people selling pineapple occasionally.

Acknowledgements

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Appendix

Table 2. Classification of the respondents based on different characteristics (%)

Characteristics	Modalities	Primary producers (n=100)	Exporters[a] (n=3)	Middlemen (n=10)	Wholesalers (n=35)	Retailers (n=15)	Processors (n=10)
Sex	Male	93	66	100	0	0	70
	Female	7	34	0	100	100	30
Education level	Non educated	42	0	60	74	86	0
	Literate	8	0	10	3	0	0
	Primary school	28	0	30	17	7	0
	Middle school	21	0	0	3	7	40
	University level	1	100	0	3	0	60
Experience (Exp) in pineapple	< 5 years	13	0	30	11	40	20
	5 ≤ Exp < 10 years	31	0	70	26	27	40
	10 ≤ Exp < 15 years	33	0	0	40	27	40
	≥ 15 years	23	100	0	23	6	0
Contribution of pineapple to total income (Inc)	< 20%	0	0	0	0	0	0
	20 ≤ Inc < 40%	7	0	0	0	0	10
	40 ≤ Inc < 60%	13	0	70	11	0	20
	60 ≤ Inc < 80%	51	0	30	20	33	30
	≥ 80%	29	100	0	69	67	40
Pineapple cultivars cropped/sold	Sugar loaf only	70	0	-	69	87	30
	Smooth Cayenne only	3	0	-	0	0	0
	Both cultivars	27	100	-	31	13	70

[a]: Primary producers who exported to European markets

-: did not crop/sell pineapple

Table 3. Percentage of different customers buying their pineapple from a given number of primary producers (directly or through middlemen) and wholesalers, for pineapple cultivars Sugarloaf and Smooth Cayenne

Pineapple source	Chain type	Number of people	Customers							
			Wholesalers (n=35)		Retailers (n=15)		Processors (n=10)		Exporters (n=3)	
			Sugarloaf	Smooth Cayenne	Sugarloaf	Smooth Cayenne	Sugarloaf	Smooth Cayenne	Sugarloaf	Smooth Cayenne
			(n=35)	(n=11)	(n=15)	(n=2)	(n=10)	(n=7)	(n=3)	(n=3)
Primary producers	Directly[a] from primary producers	1-5	12	36	13	0	40	0	0	0
		6-10	34	9	0	0	20	0	0	0
		≥11	34	27	0	0	0	0	100	100
		Total	80	72	13	0	60	0	100	100
	Through middlemen	1-2	20	55	0	0	0	0	0	0
		3-4	20	9	0	0	30	29	0	0
		≥5	9	18	0	0	70	71	0	0
		Total	49	82	0	0	100	100	0	0
Wholesalers[b]	Directly from wholesalers	1-3	14	18	40	100	20	0	0	0
		4-6	14	27	47	0	10	14	0	0
		≥7	6	0	13	0	30	42	0	0
		Total	34	45	100	100	60	56	0	0

[a]. Directly from primary producers means they contact primary producers themselves either by cell phone or face to face
[b]. No customers obtained their pineapple from wholesalers through middlemen

Table 8. Percentage of actor groups producing/supplying Sugarloaf pineapple and valuing the different quality criteria within each quality attribute

Quality attributes	Quality criteria	Primary producers (n=97)	Wholesalers Local market (n=19)	Regional market (n=16)	Retailers (n=15)	Processors (n=10)	Kruskal Wallis test(H)
Taste	Always a taste like sugar	72	47	81	53	10	20.54 ***
	Always a taste in between sugar and lemon	28	53	19	40	90	
	Always the lemon taste	0	0	0	7	0	
Firmness	Always firm pineapple	62	100	100	100	40	29.66 ***
	Always pineapple with low firmness	38	0	0	0	60	
Skin colour	0-25% of the eyes has yellow colour	33	68	56	53	70	13.33 ***
	25-50% of the eyes has yellow colour	65	32	44	40	30	
	50-75% of the eyes has yellow colour	2	0	0	7	0	
	>75% of the eyes has yellow colour	0	0	0	0	0	
Translucency	0-25% of the flesh translucent	15	69	56	53	30	27.84 ***
	25-50% of the flesh translucent	70	26	38	40	70	
	>50% of the flesh translucent	15	5	6	7	0	
Internal browning	0-25% of the blackheart symptoms	100	100	100	100	100	-[a]
	25-50% of the blackheart symptoms	0	0	0	0	0	
	50-75% of the blackheart symptoms	0	0	0	0	0	
	>75% of the blackheart symptoms	0	0	0	0	0	
Skin damage	Free of damage	100	100	100	100	100	-[a]
	Damage on 1-4% of the skin area	0	0	0	0	0	
	Damage on 4-8% of the skin area	0	0	0	0	0	
	Damage on more than 8% of the skin area	0	0	0	0	0	

***: Significant, $P < 0.001$; **: Significant, $P < 0.01$

[a]: Kruskal-Wallis test was not performed because actor groups answers felt in the same quality criteria

Table 9. Percentage of actor groups producing/supplying Smooth Cayenne pineapple and valuing the different quality criteria within each quality attribute

Quality attributes	Quality criteria	Primary producers	Wholesalers Local market	Wholesalers Regional market	Retailers	Processors	Kruskal-Wallis test(H)
		(n=30)	(n=6)	(n=5)	(n=2)	(n=7)	
Taste	Always a taste like sugar	83	50	60	100	15	14.22 **
	Always a taste in between sugar and lemon	17	50	40	0	85	
	Always the lemon taste	0	0	0	0	0	
Firmness	Always firm pineapple	60	100	100	100	43	8.85 ns
	Always pineapple with low firmness	40	0	0	0	57	
Skin colour	0-25% of the eyes has yellow colour	10	0	0	0	0	30.56 ***
	25-50% of the eyes has yellow colour	80	0	0	50	29	
	50-75% of the eyes has yellow colour	10	50	80	50	71	
	>75% of the eyes has yellow colour	0	50	20	0	0	
Translucency	0-25% of the flesh translucent	57	83	20	50	71	5.03 ns
	25-50% of the flesh translucent	43	17	80	50	29	
	>50% of the flesh translucent	0	0	0	0	0	
Internal browning	0-25% of the blackheart symptoms	100	100	100	100	100	-[a]
	25-50% of the blackheart symptoms	0	0	0	0	0	
	50-75% of the blackheart symptoms	0	0	0	0	0	
	>75% of the blackheart symptoms	0	0	0	0	0	
Skin damage	Free of damage	100	100	100	100	100	-[a]
	Damage on 1-4% of the skin area	0	0	0	0	0	
	Damage on 4-8% of the skin area	0	0	0	0	0	
	Damage on more than 8% of the skin area	0	0	0	0	0	

***: Significant, $P < 0.001$; **: Significant, $P < 0.01$

[a]: Kruskal-Wallis test was not performed because actor groups answers felt in the same quality criteria

Table 10. Mann-Whitney U test values comparing actor groups producing/supplying Sugarloaf pineapple for the different quality criteria within each quality attribute

Quality attributes	Quality criteria	Actor group	Primary producers	Wholesalers local market	Wholesalers regional market	Retailers	Processors
Taste	Always a taste like sugar	Primary producers	-	693.0 ns	705.0 ns	577.0 ns	183.5 *
	Always a taste in between sugar and lemon	Wholesalers local market	693.0 ns	-	100.5 ns	139.0 ns	59.5 ns
		Wholesalers regional market	705.5 ns	100.5 ns	-	85.0 ns	23.0 *
	Always the lemon taste	Retailers	577.0 ns	139.0 ns	85.0 ns	-	47.0 ns
		Processors	183.5 *	59.5 ns	23.0 *	47.0 ns	-
Firmness	Always firm pineapple	Primary producers	-	570.0 *	480.0 *	450.0 *	379.0 ns
	Always pineapple with low firmness	Wholesalers local market	570.0 *	-	152.0 ns	142.0 ns	38.0 *
		Wholesalers regional market	480.0 *	152.0 ns	-	120.0 ns	32.0 *
		Retailers	450.0 *	142.5 ns	120.0 ns	-	30.0 *
		Processors	379.0 ns	38.0 *	32.0 *	30.0 *	-
Skin colour	0-25% of the eyes has yellow colour	Primary producers	-	589.0 *	588.0 ns	605.5 ns	302.5 ns
	25-50% of the eyes has yellow colour	Wholesalers local market	589.0 *	-	133.0 ns	118.0 ns	93.5 ns
	50-75% of the eyes has yellow colour	Wholesalers regional market	588.5 ns	133.5 ns	-	113.0 ns	69.0 ns
	>75% of the eyes has yellow colour	Retailers	605.0 ns	118.0 ns	113.0 ns	-	61.0 ns
		Processors	302.5 ns	93.5 ns	69.0 ns	61.0 ns	-
Translucency	0-25% of the flesh translucent	Primary producers	-	492.5 *	446.0 *	440.5 *	362.0 ns
	25-50% of the flesh translucent	Wholesalers local market	492.5 *	-	134.0 ns	121.0 ns	62.0 ns
	>50% of the flesh translucent	Wholesalers regional market	448.0 *	134.0 ns	-	116.0 ns	62.5 ns
		Retailers	440.5 *	121.5 ns	116.0 ns	-	61.0 ns
		Processors	362.0 ns	62.0 ns	62.0 ns	61.0 ns	-

*: Significant, $P < 0.005$ (0.005 was selected based on Bonferroni's correction); ns: Not significant, $P \geq 0.005$

Table 11. Mann-Whitney U test values comparing actor groups producing/selling Smooth Cayenne pineapple for the different quality criteria within each quality attribute

Quality attributes	Quality criteria	Actor group	Primary producers	Wholesalers local market	Wholesalers regional market	Retailers	Processors
Taste	Always a taste like sugar	Primary producers	-	60.0 ns	57.5 ns	25.0 ns	32.5 *
	Always a taste in between sugar and lemon	Wholesalers local market	60.0 ns	-	13.5 ns	3.0 ns	13.5 ns
		Wholesalers regional market	57.0 ns	13.5 ns	-	3.0 ns	9.5 ns
	Always the lemon taste	Retailers	25.0 ns	3.0 ns	3.0 ns	-	1.0 ns
		Processors	32.5 *	13.5 ns	9.5 ns	1.0 ns	-
Skin color	0-25% of the eyes has yellow color	Primary producers	-	4.5 *	6.0 *	16.5 ns	37.5 *
	25-50% of the eyes has yellow color	Wholesalers local market	4.5 *	-	10.5 ns	1.5 ns	7.5 ns
	50-75% of the eyes has yellow color	Wholesalers regional market	6.0 *	10.5 ns	-	2.0 ns	10.0 ns
	>75% of the eyes has yellow color	Retailers	16.5 ns	1.5 ns	2.0 ns	-	5.5 ns
		Processors	37.5 *	7.5 ns	10.0 ns	5.5 ns	-

*: Significant, $P < 0.005$ (0.005 was selected based on Bonferroni's correction); ns: Not significant, $P \geq 0.005$