Variability in Quality and Management Practices in the Mango Supply Chain from Costa Rica

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Paper prepared for presentation at the I Mediterranean Conference of Agro-Food Social Scientists. 103rd EAAE Seminar '*Adding Value to the Agro-Food Supply Chain in the Future Euromediterranean Space*'. Barcelona, Spain, April 23rd - 25th, 2007

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Abstract

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We conducted a survey and collected 51 interviews of different actors in the supply chain of mango from Costa Rica, beside, we collected 10 mangos from each actor interview to analyze the intrinsic attribute of quality. We developed a proxy of quality as the ratio between the brix and the ph.
We conclude that quality variability is affected positively related to technologic variations and socio-economic variations. In the case of the mango supply chain from Costa Rica the management differences among actors are dependent on the closeness to the consumer, therefore, actors closer to the consumer have higher variability in their indexes than those close to the production site.

Key words: Variability, Supply Chain, Quality, Management

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Introduction

Mango (Mangifera Indica) has been cultivated as a food crop for more than 40 centuries. The production originates from India and Malaysia and has been spread over tropical and subtropical countries around the world. Nowadays, there are about 150 varieties of mango known worldwide, but only a few varieties (*i.e. Haden, Irwin, Keith, Tommy Atkins*) are of commercial importance. The first imports of mango to Costa Rica took place in 1796 from different Caribbean countries (Lezema, 1989). In the early 1970s, the University of Costa Rica (UCR) introduced some special red and yellow varieties to the Orotina region for commercial purposes (Mora et al., 2002). In the beginning of the 1980's, the production of red mango varieties for (European) export markets became more important, leading to a further reduction of the local cultivated area of yellow mango (Jirón, 1995; Buzano, 1997).

Mango quality is strongly variable due to differences in taste, flavour, colour, aroma and size and as well for the managerial practices of the economic agents through the chain.

Consumers are seeking for mangos without external damage, with stable weight, colour and consistency, provided at a reasonable price. Producers' crop management and post-harvest practices as well as delivery systems have a profound impact on observable and imminent quality characteristics (Ruben et al., 2005). Although a fair amount of knowledge is available regarding the technological options for improving mango quality (see Garvin, 1984 and Montero & Cerdas, 2000), it is far less understood which economic incentives and contractual regimes could be effective for providing producers the necessary incentives for adjusting their mango production and management systems in order to enhance quality performance in line with consumers' demands.

The organization of the mango supply chain in Costa Rica includes a large number of different agents involved in numerous transactions and oriented towards multiple market outlets. Mango transactions differ in terms of volume, quality, price and delivery frequency, while the produce can be sold both at the local open market and through wholesalers, and/or at international markets through multinational trading companies. Relationships between producers' associations, (local and international) traders, retailers and consumers are structured through a complex sequence of delivery transactions.

The objective of this article will be to expose the relationship between the variability in mango quality due to variability in managerial practices among the actors in the mango supply chain. The importance of studying the variability among actors in the chain in terms of quality and management is that market gap between local and export might be breach, as wells as the possibility to standardize procedures be able to keep meeting the consumer demands and to understand which are the main factors that might help us reducing the variability of the commodities.

The article will be constructed as follow, a mango supply chain will be presented, and then we will go into the global commodity chain perspective, to move forward to describe the relationship between quality and management inside the supply chain. To solve the problem we will use regression analysis, the standard deviation and the standard error at first and then we will use the deviation coefficient (internal variability) and the meta-analysis (between groups variability). At the end results and conclusions will be presented.

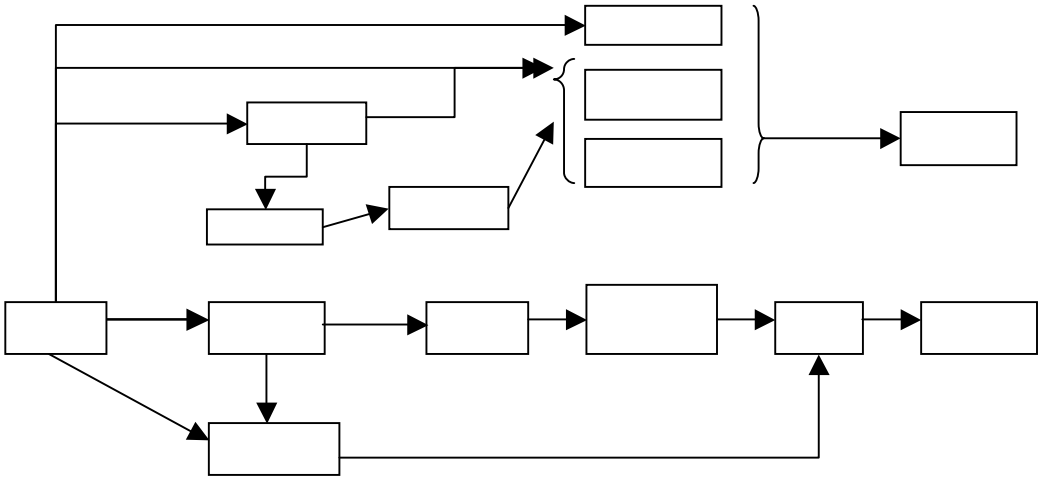
Variability and the mango supply chain in Costa Rica

The main mango varieties grown in Costa Rica and suitable for export are Tommy Atkins, Kent, Keith, Palmer and Smith (Mora, pers. Comm., 2004; Jiménez, pers. Comm.., 2003; Central Pacific Census, MAG, 2004). In 2003, the area planted with mango covers 8.350 ha in Costa Rica and the quantity produced reached 35.000 tons. In seven years (1996-2003) the surface planted increased of 7% and the quantity produced rose by 75% (Jiménez, pers. Comm., 2003), these increase happened due technological changes (Montero & Cerdas, 2000). Costa Rica counts about 1950 mango producers of which 60% cultivate less than 5ha, 35% cultivate between 5 and 20 ha and 5% own more than 20ha (Mora, personal communication, 2004; SEPSA, 2001). The producers are organized in different ways; large and medium sized producers are linked to international

trading companies and small producers are not organized or organized in co-operatives or producers associations.

The organisation of the mango supply chain is relatively simple for the export market and much more complex for the local market (see Figure 4). For the export market there is a straightforward relation with the traders of the producer, but at the local market there are a wide number of different intermediaries involved. These agents play many roles in the chain: they buy mangos from the producers, sell the produce to the CENADA (wholesale market), or buy from CENADA to deliver to local outlets like local retailers and the wet market. Hortifruti is a private company that buys directly from the producers and sells to the main supermarkets in the country.

Figure 1. Mango Supply Chain From Costa Rica



There are two main outlet choices for mango production local and export with differences in quality and in management practices toward the fruit. But as it was explained before, local market has several sub-chains that are of relevance for this study. Because quality can degrade and management practices might change from actor A to actor B in the chain, this article seeks to describe the heterogeneity of those changes in the different (actual and potential) transactions and combinations of outlet choices

Table 1. Descriptive statistics of the main actors in the chain and the main variables in the analysis.

	Exporter			**Trader**			**Retailer**		
	Mean	SD	SE	Mean	SD	SE	Mean	SD	SE
Quality (Brix/Ph)	1.85	0.17	0.04	3.15	0.48	0.12	3.12	0.86	0.23

GMI	4.16	1.06	0.24	4.12	0.75	0.18	3.00	1.68	0.45
QM	4.24	0.59	0.14	4.11	0.68	0.16	3.54	1.10	0.29
AI	4.37	0.48	0.11	4.19	0.58	0.14	4.30	0.88	0.23
OI	4.78	0.34	0.08	4.74	0.41	0.10	4.43	0.01	0.27
TV	4.31	0.43	0.10	4.13	0.73	0.18	3.53	1.60	0.43
SE	4.43	0.19	0.04	4.42	0.65	0.16	4.27	0.63	0.17

GMI = General Management Intensity; QM = Quality Management; AI = Access to Information; OI = Operation Index; TV = Technological Variation; SE = Socio-Economic Index

Supply Chain Variability and Management

Ponte (2002) explains that the global commodity chain (GCC) approach was developed by Gereffi and other within a political economy of development perspective. In this context a GCC is seen as a network of labour and production processes whose result is a finished commodity (Hopkins and Wallerstein, 1986). Gereffi (1994, 1995) identifies four dimensions of GCCs, the input-output structure, the geographical coverage, the governance structure and the institutional framework. We pay attention to the governance structure because is in here where we can distinguish between producer-driven and buyer-driven supply chains and the type of governance they used to coordinate among actors in the chain. Gereffi (1994) explains that a producer-driven chain are usually found in sectors with high technological and capital requirements, and the buyer-driven chains are generally found in more labor intensive sectors, where information cost, product design, advertising and advance supply management systems set the entry barriers. In these chains the key actors concentrate on branding, design and marketing functions. Agricultural commodities tend to fall into this category (Ponte, 2002). Normally, Commodity chains are know as well as value chains (Gibbon, 2003a; Bair, et al., 2006), and they are defined as networks of production, distribution and marketing of particular products or groups of products.

To construct a consumer-driven commodity chain coordination is very important. Coordination is meant to ensure particular product specifications, including performance processes, and logistics (Muradian, et al., 2005). Coordination is likely to arise in commodity chains involving suppliers in developing countries and buyers in industrialized countries (Hobbs, et al., 2001). And with the power relation shifting towards the supermarkets (Gibbon, 2003b), hence the result of these interaction is a more buyer-driven commodity chain (Muradian, et al., 2005). In other words, due to coordination among different actors in the chain, increases of control by the buyer (control in terms of contract specifications), the quality of the commodity increases and the power relationship is favorable to the buyer.

Quality in the mango supply chain

The different attributes included in the concept of quality depend on the relevant actor who is acquiring the product. Major actors participating in the valuation of food quality for the export market are producers, processors, exporters, importers, wholesalers,

retailers and consumers, while external agents like voluntary agencies and the government may influence these perceptions wholesalers and retailers emphasize visual attributes such as size, form, colour and shelf life, taking into consideration consumer preferences. However, consumers are interested in many more aspects related to food quality such as taste, freshness, appearance, nutritional value and food safety. Government officials are involved in regulations concerning health and safety aspects. Producers and processors commonly give preference to profit attributes, like higher yields, suitability for mechanical harvesting and industrial preparation, and resistance against plagues and diseases.

The quality performance of mango fruit is based upon the external and internal quality attributes as indicated by Kader (2002). The external attributes include the weight of the mango fruit, the presence of black spots, latex and damages. The internal quality attributes include the presence of mango fly, flesh maturity (based on flesh color), internal damages, pH and Brix % of fruit juice. The attributes are summarized in Table 5.3. The choices of attributes are based on the following; weight is an important fruit quality attribute for the whole chain. Actors, such as producers are paid on the basis of the kilograms of mango fruit delivered to the next actor in the chain. The presence of black spots is a negative quality attribute. This can be the result of a disease such as a fungus, or the damages due to latex . As a result the presence of latex, a sticky juice which exudes when the stem of the mango fruit is cut, can damage the skin of the fruit. This damage is irreversible and will appear as black streaks on the fruit skin. The presence of external damages is a negative fruit quality attribute. Damage could be for example due to harvest, tight fruit packing, transport or general rough fruit handling.

The chosen internal fruit attributes are important because for example the presence of mango fruit fly is a negative quality attribute (Prinsley & Tucker, 1987). The fly itself burrows into seed of the fruit and the fly and its larvae eat and damage the seed and the fruit flesh, which results in an uneatable fruit for the consumer. Export markets such as the United Stated have strict laws regarding the presence of pest and disease in and on fruit (Prinsley & Tucker, 1987). The result of this is, is that fruits are given a heat treatment in the sorting and packing plant to kill the fruit fly, when being exported to the United States. Mango flesh color relates to the maturity of the fruit. An optimal fruit maturity will be appreciated by the consumer and is a positive fruit quality attribute (Harvey, 1987; Shewfelt, 1993; Jha et al, 2006). A Mexican color chart is used to judge the maturity of the fruit, however the tool is subjective as the chart is not clear and made from a photocopy of a color print. The presence of internal damages is a negative fruit quality attribute (Harvey, 1987). This damage could for example be due to harvest, tight fruit packing, transport or general rough fruit handling. Further, a pH and Brix percentage measure is obtained from mango fruit juice to calculate the Brix/pH ratio. The pH of the juice indicates the acidity of the juice and the Brix percentage indicates the sweetness of the juice, both attributes are important to the consumer acceptance of mango fruit (Mizrach et al., 1999); the higher the ratio (Brix/pH) the sweeter the fruit and greater consumer acceptance.

Romano et al. (2006) stress that management practices and decisions in the orchard can affect fruit quality at the point of sale. Management in the supply chain of mango from Costa Rica is based in two international system the HACCP and the EUREPGAP certifications, mainly for mangos meant for the export market and common sense and codex alimentarius for the local market. Beside these international regulation there are other approaches toward quality management such as Just in Time and Total Quality Management that are present in the management activities of the mango producers.

Let us explain the main attributes of these standards. The HACCP stands for Hazard Analysis and Critical Control Points and it is defined as a systematic approach to the identification, evaluation and control of those steps in the food manufacturing that are critical to product safety (Luning, et al., 2002). The basic objective of the HACCP is assuring production of safe food products by prevention instead of by quality inspection (Leaper, 1997). HACCP is basically designed for application in all parts of the agri-food production, ranging from growing, harvesting, processing, manufacturing, distribution and merchandising to preparing food for consumption (NACMCF, 1998).

The EUREPGAP started in 1997 as an initiative by retailers belonging to the Euro-Retailer Produce Working Group (EUREP). EUREP started to work on harmonized standards and procedures for the development of Good Agricultural Practices (GAP) in conventional agriculture. EUREPGAP standard is primarily designed to maintain consumer confidence in food quality and food safety. Other important goals are to minimize detrimental environmental impacts of farming operations, optimize the use of inputs and to ensure a responsible approach to worker health and safety (www.eurepgap.org).

The common sense are the general standards for the producer delivering to the local market, there are many chemical that are prohibit by law, and therefore most of the producers do not use those products. Producers get advices from mainly to sources the technical assistance from the government and by networking with their neighbors. Most of them just copy what the others do in the production system. The Codex Alimentarius Commission was created in 1963 by FAO and WHO to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme. The main purposes of this Programme are protecting health of the consumers and ensuring fair trade practices in the food trade, and promoting coordination of all food standards work undertaken by international governmental and non-governmental organizations (FAO/WHO, 2005).

Kannan and Tan (2002), defined just in time (JIT) as a philosophy that advocates the elimination of waste by simplifying production processes. And they define total quality management as a movement for the development and implementation of a corporate wide culture emphasizing on customer focus, continuous improvement, employee empowerment, and data driven decision/making.

After describing the main objective of the most common management practices, we will describe what producers are doing on site. Most of the producers delivering to the export market are part of a producer association. Depending the market (USA or Europe) then they must apply a different system, but the certification process is through the organization. The producer organization gets the certification by checking the producers that deliver the produce to them. In the plot the producers meet the requirement and put sign on the plots as well as protection for the workers and improve the storage facilities. But they are more focus on keeping the appearance of the mangos as good as possible for reducing the rejection in the packing plant. Of course they most of them do not use the prohibit chemicals, because the external markets are very much strict in this matter. For the producers delivering to the local market, the record keeping of activities in the plot is almost absent; they get the information on how to produce for the technical assistance of the government or by the networking with neighbors. Therefore, the quality management standards are less strict than those for the export market. They also are aware that appearance of the fruit is one of the most important quality attributes value by the consumers.

Supply Chain Management and Quality – Management relationship.

Supply chain management deals with integration both horizontal and vertical of buyers and sellers decision processes with the goal of improving produce, information and financial flows through out all the agents in the chain (Kannan and Tan, 2002, Gereffi, 1994). Flynn et al. (1995), demonstrated that JIT and TQM practices are mutually supportive, and that their synergy contributes positively to manufacturing performing. Snell and Dean (1992), found it hard to distinguish between JIT and TQM since the two have common elements such as consumer satisfaction and product design (Chong and Rundus, 2004). The three concepts interact because in the chain perspective the actors must coordinate activities, by different governance mechanism and the main issues in quality management are the costumer focus, (because the agricultural sector is basically a customer driven supply chain) and product design main issues in the JIT and TQM perspectives.

Materials and methods

We conducted fieldwork between February and April 2006 in Costa Rica. The area of research was bigger than the production site because we where looking for actors not for geographical sites. We collected 51 interviews both the socio-economical questionnaire and the mango quality analysis. The analysis of quality where performed in the field. We collected 19 producers delivering to a producer plant which exports mostly to Europe, they were located in the northern part of the country, 9 Traders at the Wholesaler market in the Central Valley of Costa Rica, 12 traders at the Feria market (peasant market), 2 producers delivering to Hortifruti, these producers where delivering to the most important retailer company of the country, and we contacted 9 middlemen. This configuration gives us a picture of the main actors in the supply chain of mango from Costa Rica. The sample size, was not defined by any formulae, we follow the method of

snow ball, by which we where following advices from the actors in the chain in how to find other actor in the chain and complete it.

The main variables that we measure are quality of mango, general management intensity (GMI), quality management (QM), access to information (AI), operation index (OI), technological variation (TV) and socio-economic index (SE). Quality of mango was measured as a proxy of taste, which is a ratio between Brix (sugar content) and Ph (acidity). For the managerial variables a likert scale from 1 to 5 was used. These managerial variables were grouped and averaged to get an index of each particular dimension of the managerial activities[1]. In this article we are trying to understand the variability in quality, and the variability in management and their interaction. We measured the variability inside the groups[2],

When people talk about heterogeneity and variability they are talking about synonyms and on two different kinds of heterogeneity. One may reefer to the differences inside certain population. And as well reefers to the differences between groups of that population. This outcome makes it difficult for the analysis. Our proposal to solve this dilemma is by the use of several dispersion statistics measurements such as the standard deviation, the standard error, the meta-analysis and the deviation coefficient to catch both heterogeneities.

The standard deviation (Eq.1) is a measure of how well the mean represents the data. Small S indicates that the data points are close to the mean (low variability). A large S indicates that the data points are distant from the mean (high variability) (Field, 2002). The calculation is the square root of the variance.

$$s = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{x})^2} \qquad \text{(Eq. 1)}$$

Field (2002), stressed that if you take several samples from a population (in our case the mango supply chain), then these samples would differ slightly, to tackle this problem he proposed to measure the standard error. The standard error (Eq. 2) is the standard deviation of sample means. A large standard error means that there is a lot of variability between the means of different samples.

$$\sigma_{\overline{x}} = \frac{\sigma}{\sqrt{n}} \qquad \text{(Eq. 2)}$$

[1] For further description of the construction of the indexes see appendix 1.

[2] We performed a discriminant analysis to try to reduce the number of groups with a similarity reasoning, after the analysis, three groups appeared, the exporters, the traders (wholesaler, and middlemen), and the retailers (peasant market and Hortifruti)

The meta-analysis it is possible to determine the level of heterogeneity of a particular group on the total heterogeneity of the population and with the deviation coefficient we capture the heterogeneity inside a group.

The formulae for the calculation of the heterogeneity in the meta-analysis (Eq. 3) is

$$I^2 = \tau^2 / \tau^2 + \sigma^2 \qquad \text{(Eq. 3)}$$

Where, I^2 indicates the proportion of variation among groups with respect to the total variability, hence the proportion of the total variability attributable to heterogeneity, τ^2 is the variability among groups and the σ^2 is the variability inside a particular group. If the value of $I^2 < 25\%$ the heterogeneity is low, if $25\% < I^2 < 75\%$ then the heterogeneity is moderate and if $I^2 > 75\%$ the heterogeneity is perceived as high.

In our paper we change the index to capture the heterogeneity of a group due to the variability of the population (Eq. 4) and the formulae is as follows:

$$I^2 = \sigma^2 / \sigma^2 + \tau^2 \qquad \text{(Eq. 4)}$$

Where, I^2 indicates the proportion of variation among groups with respect to the total variability, hence the proportion of the total variability attributable to heterogeneity, τ^2 is the variability among groups and the σ^2 is the variability inside a particular group. We disaggregate the scale into four clusters If the value of $I^2 < 25\%$ the heterogeneity is low, if $25\% < I^2 < 50\%$ then the heterogeneity is medium low, if $50\% < I^2 < 75\%$ then the heterogeneity is medium high and if $I^2 > 75\%$ the heterogeneity is perceived as high.

The deviation coefficient (Eq. 5) is a measurement of the ratio between the standard deviation and the average of a certain group multiplied by 100. This procedure gives you the possibility to compare different groups of objects from different population in relative way. The formulae is the following,

$$D.C = \sigma / \mu * 100 \qquad \text{(Eq. 5)}$$

Where σ is the standard deviation of a certain group and μ is its average.

Results

Variability among the actors in the chain is high for the quality and the socio-economic index but the variability is lower for the other managerial indexes. In graph1. we can observe the variability of the main variables in the analysis. It is important to notice that the measurements of the managerial indexes are in terms of the importance perception in their business. The measurement of quality (ratio between brix and ph) is the average of the actual measurement of those attributes. Besides the differences between the three stages in the chain in terms of quality the other variable that shows differences among the

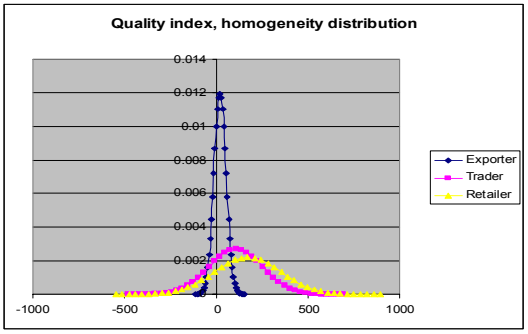
three stages is the socio-economic index. In other managerial indexes for the exporter and the traders seem to have the same perceived importance toward management but not in the case of the retailers that deviate from the other group. To check on the differences among the distributions we performed a Kolmogorov-Smirnov test, which tries to determine if two datasets differ significantly. The KS-test (as it is also known) has the advantage of making no assumption about the distribution of data[3].

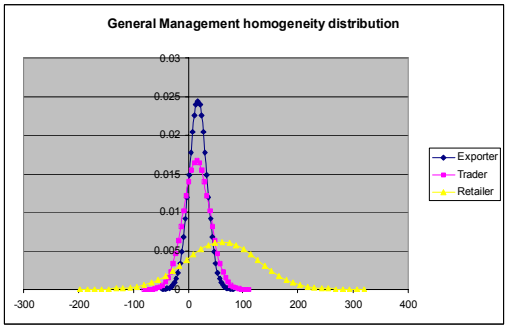
The KS-test showed that there are significant differences between the distributions of the different agents in the chain. Quality management variability among the exporter and the trader seem not to be significant, another variable that is not significant is the socio-economic index variability this time among trader and retailer. The variability among actors and the access to information variable is not significant.

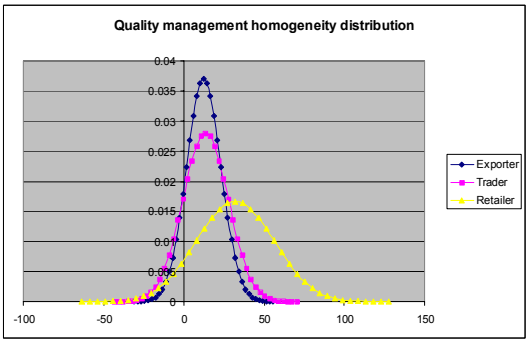
The behavior expose above in terms of quality and management might have an explanation in the way each of the links in the chain face the customer. Figure 2, shows that there are two customers well defined and different when trading occurs. In one hand producers have to decide if the sell to the export market or to the local market. These markets have different standards, but both must meet the requirements of a particular buyer that is not the final consumer of the produce. Therefore, the produce follows the EUREPGAP/HACCP requirements for the export market and the Codex Alimentarious for the local market. Rejection of mango from the export market is delivered to the local market. It is possible to find out that there are not differences in terms on management practices because all producers (for the export and wholesaler/middleman stages) are not facing the final consumer. In the other end, the stage that is beside the final consumer have different managerial practice values and quality, basically, it will the idea of a many types of consumers for different outlets and consumer preferences and whishes. Therefore the variability in the managerial practices are larger that for the other stages of the chain.

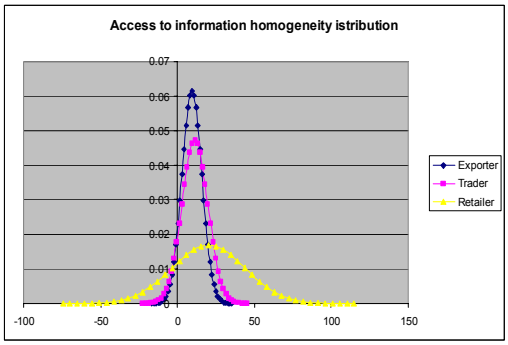
[3] See the results of the test in appendix 2.

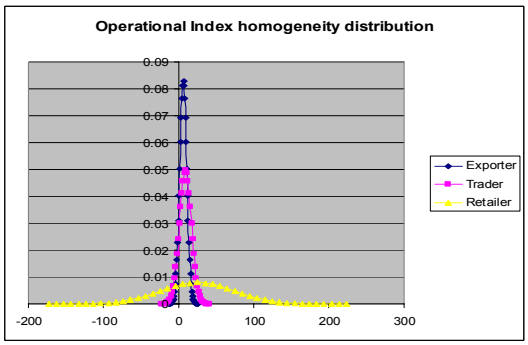
Graph 1. Visual variability of the main variables for the analysis

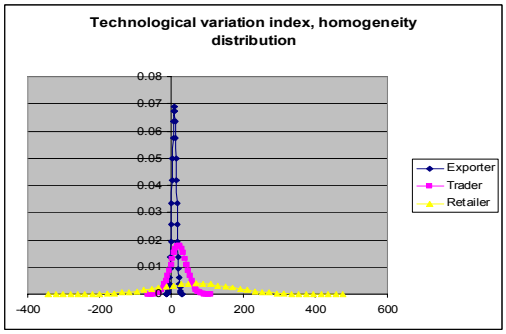












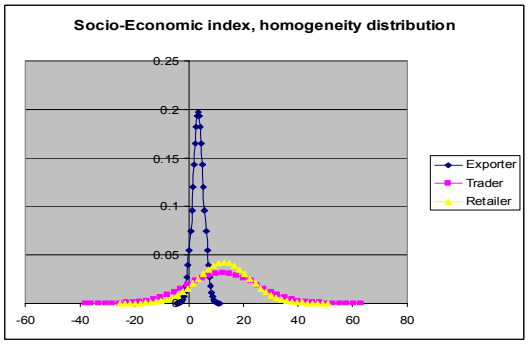
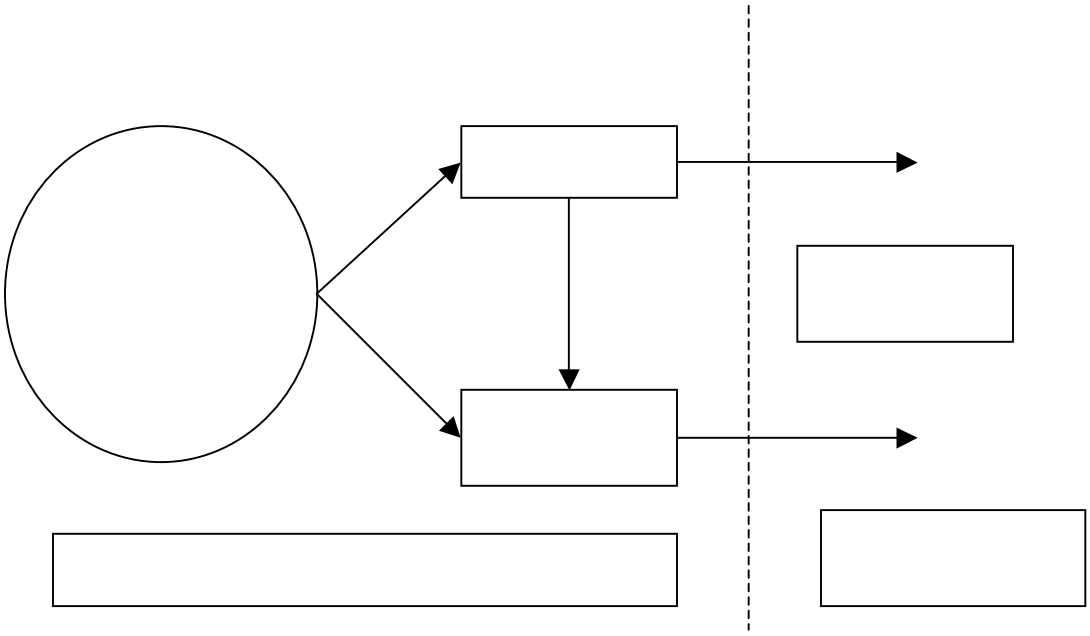


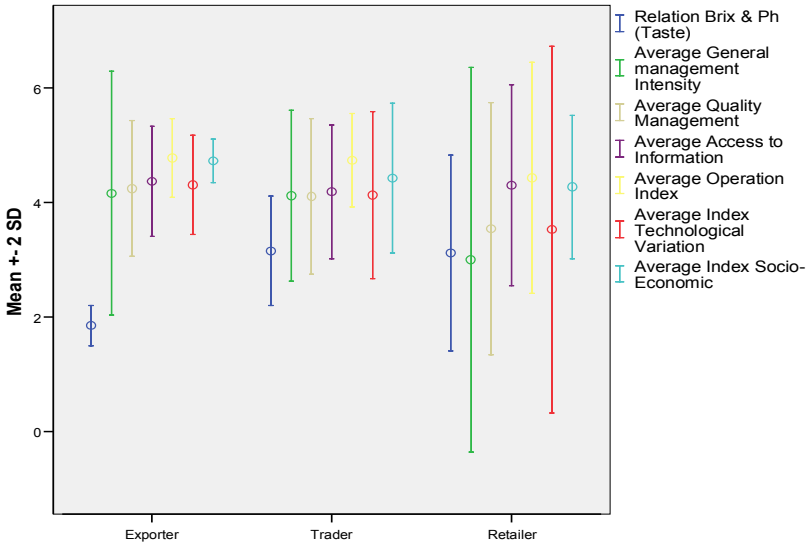
Figure 2. Different type of customers faced by the stages in the chain



Dispersion statistics and the variability of the data. Inside the groups nad between the groups

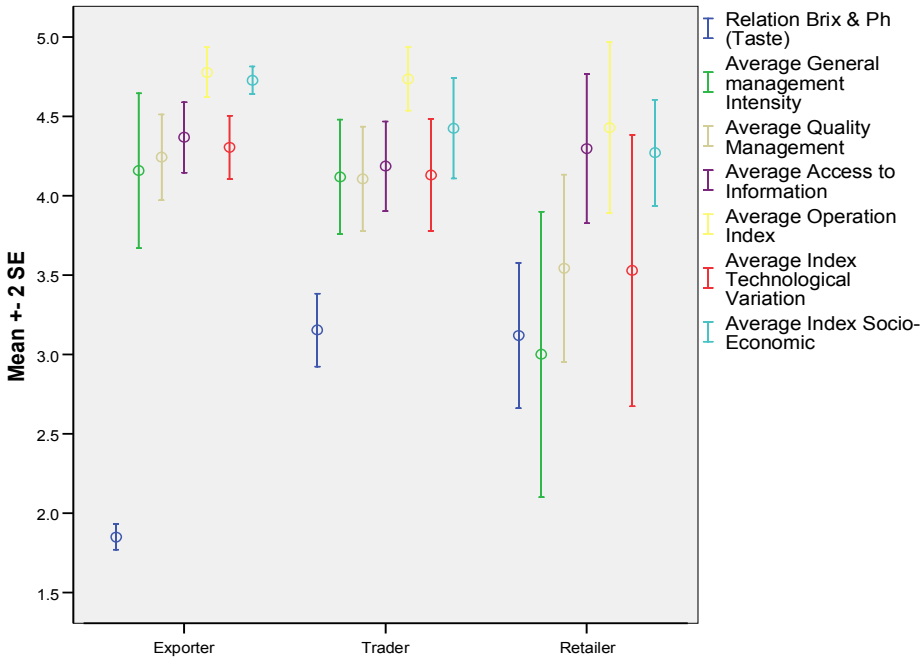
The standard deviation of the main attributes variables is presented in graph 2. We can observe that there are no important differences between the actors in the chain and the perception of the managerial activities they perform in the chain, the main difference is between the Export market quality and the rest of the quality measurements through the chain.

Graph. 2. Standard deviation of the main variables and the actors in the chain



Following to the analysis of the standard deviation we measure and graph the standard error to get the variability among samples. The results are consequent with the previous graph but graph 3. makes more explicit the differences among samples in terms of quality, but the behavior if the management attributes seems to be similar among actors through the chain.

Graph 3. Standard errors of the main variables in the analysis and the actors in the chain

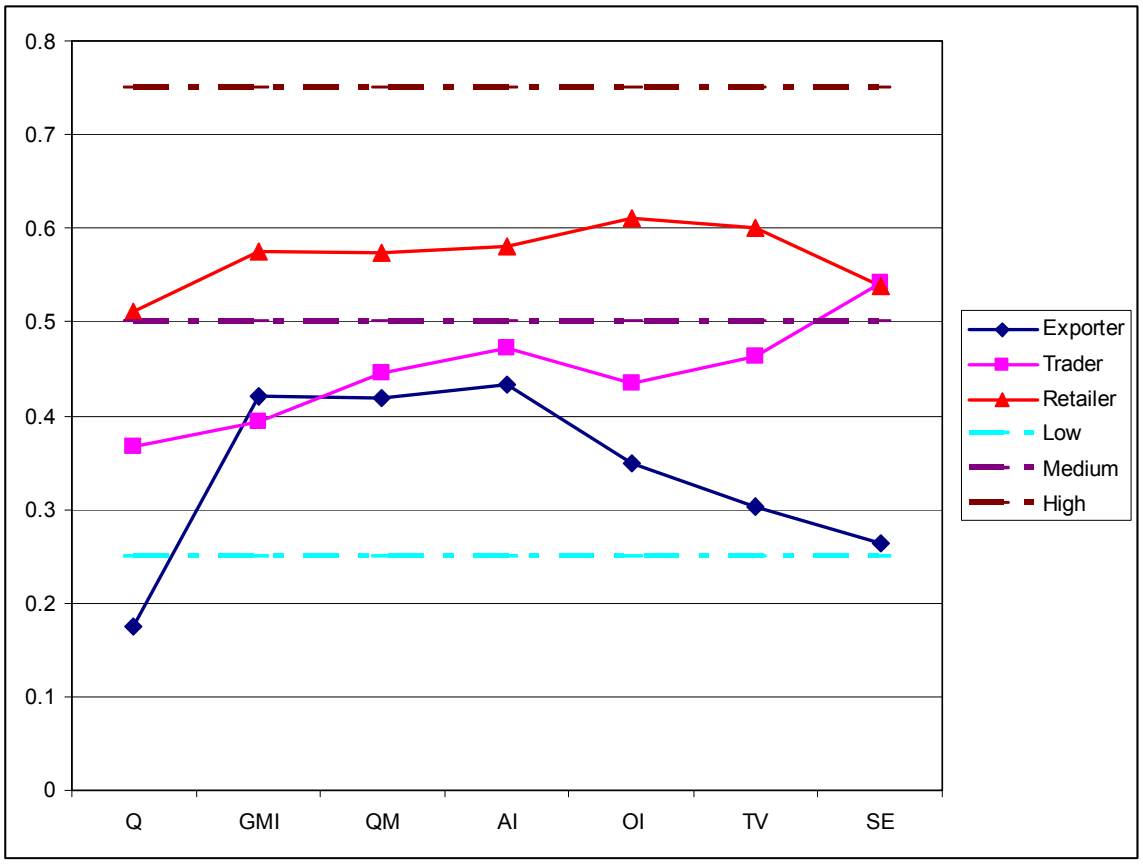


Heterogeneity among the different actors in the mango supply chain.

The description of the graph 4. related to the meta-analysis, it is important to notice that the group with less heterogeneity is the exporter and only in terms of quality. Observing the graph it it possible to appreciate that most of the managerial attributes among actors are similar and in terms of heterogeneity are between 25% and 75%. Except from the quality heterogeneity from the export producers which have a low heterogeneity (bellow 25%). We have performed a t-test analysis to check for the differences among the actor and the main attribute value and the significant results are, for the three actors (exporter, trader and retailer) quality variability is different, the general management intensity variability is only different for the retailer, and in the case of the technological variation and socio-economic variation only for the exporter are different[4].

[4] Appendix 3. Complete table of the t-test.

Graph 4. Heterogeneity among the main variables in the analysis and the actors in the chain



Variability inside the group

Table 2. shows the weight of the standard deviation in the average of a particular group, in this case the three chain actors of the analysis. Although we have not define as a hypothesis that the homogeneity of the export market will be higher than for the other markets, it is reasonable to think that might happen; because, quality standards and international regulations for export are higher than those for the local market as we have stressed before. It is important for us then to find this relationship in the data that we are describing. The data shows that our assumption is true, at least in relative terms, homogeneity of the export management and quality is higher than fro the other actors but, for the general management intensity index where the trader has the lower variability in the data. It is important to notice that in the other cases the variability behaves the same, that means exporter has the lower variability, then the trader and with the higher variability the retailers.

Table 2. Deviation coefficient for the main variables in the analysis and the actors.

Deviation Coefficient. Heterogeneity inside the group			
Variable	Exporter	Trader	Retailer
Quality	9.35	15.14	27.43
General Management Intensity	18.97	17.60	48.50
Quality Management	13.93	16.02	31.11
Access to Information	11.06	13.52	20.39
Operation Index	7.17	10.56	22.74
Technological Variation index	10.08	21.60	42.30
Socio-Economic Index	4.04	14.29	14.65

We perform a regression analysis to understand the relationships between the quality variability and the variability in the managerial activities importance. We assume that when managerial variability increases then the quality variability will increase as well therefore, we are looking for positive relationships between the variables in the analysis. First we run the analysis between the quality and its relationship with the main managerial attributes. In a second regression we disentangle the significant indexes in their original variables and run the regression to detect which are the variables that are important inside the index to explain the quality variability.

It is explain in table 3, that the quality variability is dependent on the technological variation and the socio-economic indexes. To understand the underling behavior between those variables, we performed a regression analysis (OLS). The variance is explained in 25.8%, and the Durbin-Watson statistic is 2.53. Both variables agree with our assumption, both have positive relationship with the quality, hence an increase of the variability in the technological variation index will cause an increase in quality variability, the result also applies for the socio-economic index.

Table 3. Relationship between the managerial importance variables variability and quality variability.

Variable	Coefficient	Standard Error	t-statistic	Probability
GMI	-0.004	0.575	-0.006	0.993
QM	-1.232	1.047	-1.177	0.246
AI	-0.316	2.350	-0.134	0.894
OI	-1.120	1.368	-0.818	0.418
TV	2.033	0.437	4.647	0.001***
SE	4.271	1.748	2.193	0.034**

Note: *** p< 0.01, ** p< 0.05, * p< 0.1, Adj. R2: 0.258, Durbin-Watson stat. 2.53

After performing the first step then the variables with which we have constructed the different indexes where used to disentangle the main variables that affect the quality variability due to belonging to the significant indexes. Table 4. shows the result for the variables that compound the technological variation index, these variables are genetic homogeneity in the plot, quality sampling analysis, agro-environmental conditions of the

plot, input utilization and harvest time. The model actually explains 44.8% of the variance and has a Durbin-Watson statistic of 2.36. Variables that are significant and positive are the input utilization and the harvest time. These are the technological variables that affect quality variability, hence, if the variability in the input use and the harvest time increase then the variability in mango quality will increase. To be able to have a unified mango quality producers for both markets must agree about the consumer preferences.

Table 4. Technological variables affecting the variability of mango quality

Variable	Coefficient	Standard Error	t-statistic	Probability
Genetic Diversity	0.310	0.207	1.494	0.142
Quality Samples	-0.016	0.390	-0.042	0.967
Agro- Env. Cond.$^{+}$	-0.455	0.654	-0.695	0.490
Input Utilization	1.592	0.728	2.188	0.034**
Harvesting Time	0.628	0.338	1.862	0.069**

Note: $^{+}$ Agro-Environmental Conditions
*** p< 0.01, ** p< 0.05, * p< 0.1, Adj. R2: 0.448, Durbin-Watson stat. 2.36

In table 5, we analyzed the relationship between the variability of variables which compound the socio-economic index and the quality variability. The composition of the index is as follow, to have an agreement of buying-selling, to have a defined price before sell, knowledge about the market, to have trust to the trading partners, and to have many years of trade relationship with your partner. The model explains 17.5% of the variance and has a Durbin-Watson statistic of 1.77. Market knowledge is the only significant variable and with a positive sign as well, hence an increase of market knowledge will lead to an increase of the variability in quality. This seems to be a estrange result but it is not, imaging a producer with limited knowledge of the market (only producing mango for a certain market), then the quality that he produces must be homogeneous for that market, but when the same producer gets more knowledge about the market (therefore increases the variability of the information) he can start producing mango fro several mango channels and hence the mango quality will have more variability.

Table 5. Socio-Economic variables affecting the variability of mango quality

Variable	Coefficient	Standard Error	t-statistic	Probability
To have an agreement	-0.051	0.711	-0.072	0.942
To have a defined price	0.240	0.370	0.650	0.519
Market Knowledge	5.170	1.798	2.876	0.006***
Trust in your partner	0.080	0.401	0.199	0.843
Long relationship	0.137	1.631	0.084	0.934

Note: *** p< 0.01, ** p< 0.05, * p< 0.1, Adj. R2: 0.175, Durbin-Watson stat. 1.770

Conclusions

It is clear from the analysis that quality variability is lower in the export side of the chain and the variability in quality increases the closer you get to the costumer. This might be because the closer to the costumer bigger the niches and outlets and consumer wishes the product must meet, then the retailers must have any type of mango to cope with that wide range of options. Producers delivering to the export market face the international regulations, forcing them to have a certain type of produce to meet the strict requirement for the export market. This is in line with the statement of Shewfelt (2006) in which consumer do not behave uniformly, being influenced by their cultural, historic, religious, demographic, economical and social background.

It is clear from the analysis that management is similar among the actor in the mango supply chain from Costa Rica. The research shows that the quality variability is related to management of technical variables such as the input use and the harvest time, those can be well control and execute. As well the research shows a positive relationship towards the socio-economic variation in terms of market knowledge. Producers or economic agents that better know the market are able to deliver the preferred mango quality of a certain type of costumer. Of course this is also related to the management and access to information. It is important to notice that price knowledge and to have agreement beforehand do not have an influence in the variability of the quality.

Further research must be conducted to explain if the variability in quality is due to consumer preferences or that consumer preferences are due to the variability in quality and the effect of the international regulation in the local market, increasing quality preferences for the local costumers and therefore to a homogenization of produce and processes. Romano et al. (2006) conclude that quality has different meanings for different stakeholders (producers, distributors, consumers, etc) consumer acceptance seems to be the most important factor to e consider, therefore, further research must be conducted to understand the consumer preferences and the effect of those preferences in the technical managerial decisions through the chain.

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Appendix.

Appendix 1. Indexes construction

Index	Variables	Average	Standard Deviation
Quality (Brix / Ph)		2.6504	0.8151
	Brix	10.0340	3.8070
	Ph	3.7222	0.4131
General Management Intensity		3.8235	1.2577
	Planning	3.6471	1.6592
	Organization	3.6667	1.7050
	Control and Monitoring	3.6667	1.8619
	Marketing	4.1373	1.0958
	Finance	4	1.5362
Quality Management		4.0039	0.8212
	Temperature	4.1961	1.1836
	Selection	4.3529	0.9965
	Packaging	4.4510	1.0260
	Activity registry	3.2157	1.7008
	Storage	3.8039	1.5364
Access to Information		4.2843	0.6318
	Produce price	4.8039	0.4481
	Market place	4.3137	0.9896
	Quality and quantity of inputs	4.0196	1.3189
	Plagues and diseases	3.8824	1.4785
	Quality standards	4.2549	1.0741
	Reputation	4.4314	0.9645
Operation Index		4.6422	0.6389
	Adequate fertilization	4.3137	1.2408
	Adequate harvesting	4.6275	0.8936
	Adequate selection	4.8431	0.4182
	Adequate transport	4.7843	0.8322
Technological variation index		4.0280	1.0134
	Genetic homogeneity	3.1176	1.7280
	Quality sampling	4.0196	1.4351
	Agro-environmental conditions	4.1176	1.2607
	Inputs use	4.3137	1.1746
	Harvesting time	4.48	1.0150
Socio-economic Index		4.4980	0.5357
	Agreement for buying and selling	4.3333	1.0893
	Defined price before business	4.0784	1.4946
	Market knowledge	4.7451	0.4835
	Trust among partners	4.5294	1.0070
	Long relationships	4.8039	0.5664

Appendix 2. Kolmogorov-Smirnov test. Differences among actors in the supply chain.

		General Management Intensity		
		Exporter	**Trader**	**Retailer**
GMI	**Exporter**		0.092**	
	Trader			0.002***
	Retailer	0.010***		
		Quality Management		
		Exporter	**Trader**	**Retailer**
QM	**Exporter**		0.722	
	Trader			0.006***
	Retailer	0.002***		
		Access to Information		
		Exporter	**Trader**	**Retailer**
AI	**Exporter**		0.326	
	Trader			0.375
	Retailer	0.147		
		Operation Index		
		Exporter	**Trader**	**Retailer**
OI	**Exporter**		0.0001***	
	Trader			0.005***
	Retailer	0.0001***		
		Technological Variation Index		
		Exporter	**Trader**	**Retailer**
TV	**Exporter**		0.005***	
	Trader			0.023**
	Retailer	0.001***		
		Socio-Economic Index		
		Exporter	**Trader**	**Retailer**
SE	**Exporter**		0.001***	
	Trader			0.578
	Retailer	0.001***		
		Quality		
		Exporter	**Trader**	**Retailer**
Q	**Exporter**		0.006***	
	Trader			0.039**
	Retailer	0.0001***		
Note: *** p< 0.01, ** p< 0.05, * p< 0.1				

Appendix 3. T-test for the mean differences between the main variables in the analysis and the different actors

	Exporter		**Trader**		**Retailer**	
	T-value	P-value	T-value	P-value	T-value	P-value
Quality	-6.616	0.0001***	2.994	0.0042***	1.836	0.0808*
GMI	1.485	0.1472	0.955	0.3412	-1.788	0.0921*
QM	1.34	0.1863	0.555	0.5823	-1.458	0.1650
AI	0.592	0.5575	-0.622	0.5387	0.056	0.9556
OI	0.959	0.3447	0.167	0.8691	-0.753	0.4620
TV	1.776	0.0811*	0.045	0.9649	--1.003	0.3348
SE	2.628	0.0106**	-0.387	0.7023	-1.237	0.2391
Note: *** p< 0.01, ** p< 0.05, * p< 0.1						