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Research Article

Value chains of cherimoya (*Annona cherimola* Mill.) in a centre of diversity and its on-farm conservation implications

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Abstract
This paper uses value chain analysis as a novel method to examine the conservation status of and strategies for cherimoya (*Annona cherimola* Mill.), an underutilized, perennial fruit species native to the Andean valleys of Ecuador, Peru and Bolivia. It was found that value chain features such as market channels, chain governance, quality performance and distribution of added value over chain actors differ significantly between cherimoya fruits that are registered by a collective trademark such as the Cumbe variety and another group of more traditionally produced and commercialized cherimoya fruits. The former is exported from its production area (Lima province in Peru) to neighboring Andean countries, is graded and selected intensively, has a higher quality perception and creates significantly more added value for both producers and traders than the other, locally produced cherimoyas whose value chain is governed less intensively. Previous studies on the genetic diversity of cherimoya in the countries of origin have stressed the necessity of conserving cherimoya germplasm in areas characterized by highly diverse (southern Ecuador and northern Peru) or rare (Bolivia) cherimoya germplasm. Although value chain development is generally considered crucial in on-farm conservation of underutilized species, the example of the Cumbe cherimoya shows that intraspecific diversity can be threatened by commercial success. Farmers who believe that quality is exclusively linked to a certain genotype have purchased Cumbe cherimoya grafts from each other, leading to genetic erosion of the local cherimoya genetic base.

Keywords: value chain analysis, underutilized species, genetic erosion, *in situ* conservation

Resumen
Este artículo utiliza un análisis innovador de la cadena de valor en el estudio del estado de, y las estrategias para la conservación de chirimoya (*Annona cherimola* Mill.), una especie perenne, subutilizada y nativa de los valles andinos de Ecuador, Perú y Bolivia. Los resultados demuestran una diferencia significativa en las características típicas de cadenas de valor, como los canales para la comercialización, la gobernanza en la cadena, la calidad y la distribución del valor agregado sobre los actores de esta, entre chirimoyas registradas con la marca colectiva Cumbe y otra clase de chirimoyas que son producidas y comercializadas más tradicionalmente. Las chirimoyas Cumbe son exportadas desde su área de producción (la provincia de Lima, Perú) a los países vecinos, son seleccionadas y clasificadas más estrictamente tienen una percepción de calidad e un valor monetario más elevado para productores y comerciantes comparado a las otras chirimoyas que son producidas localmente y manejadas de una manera menos estricta. Estudios anteriores sobre la diversidad genética de la chirimoya en los países de origen enfatizan la necesidad de la conservación de su germoplasma en las áreas caracterizadas por tener un germoplasma de chirimoya altamente diverso (sur de Ecuador y norte de Perú) o raro (Bolivia). Aunque el desarrollo de cadenas de valor es generalmente considerado crucial para la conservación de las especies subutilizadas en fincas, el ejemplo de la chirimoya Cumbe demuestra que la diversidad intra-específica puede ser amenazada por su éxito comercial. Los productores que creen que la calidad en la chirimoya esta exclusivamente vinculada a algunos genotipos compraron y vendieron injertos entre sí, lo que causa erosión genética de las chirimoyas locales.

Palabras clave: cadenas de valor, especies subutilizadas, erosión genética, conservación *in situ*

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Introduction

Cherimoya (*Annona cherimola* Mill.) is one of the many edible fruit species in the *Annona* genus [1] that belongs to the Annonaceae family in the Magnoliales order [2]. It is a semi-deciduous, erect, but low-branched tree, frequently branched off at ground level [1,3]. The heart-shaped cherimoya fruit usually weighs between 150 and 500 g [4]. It exhibits five different so-called botanical forms: *laevis*, *impressa*, *umbonata*, *tuberculata* and *mamillata* [5] (Fig. 1), differing in their degree of protuberances on the fruit skin. Fruit pulp is snow-white, fleshy and juicy. It has a pleasing aroma and delicious sub-acid flavor, and contains numerous hard, brown or black, beanlike, glossy seeds [3]. Cherimoya fruit is considered among the finest fruits on earth [6,7].

With a total cultivated area of around 3000 ha, Spain is the world’s largest cherimoya producer [1]. However, in Spain cherimoya is a minor crop compared to other fruit species such as grapes, oranges or peaches. In the Andes, cherimoya occurs in natural stands or as semi-domesticated plants in home gardens in the valleys of Ecuador, Peru and Bolivia [4,8].

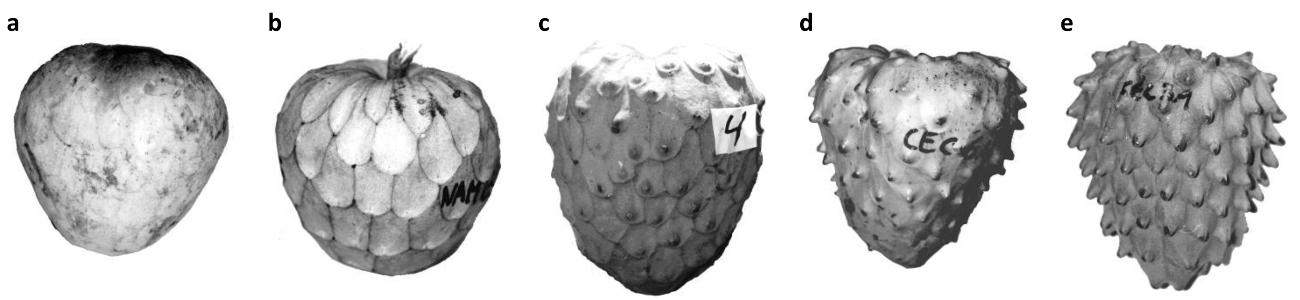

Fig. 1. Five botanical types of Annona cherimola Mill.: Laevis (a), Impressa (b), Umbonata (c), Tuberculata (d), and Mamillata (e) [5] (Pictures: Dr. X. Scheldeman).

In the latter countries, cherimoya is frequently reported as an underutilized species [4,9-11]. This means that despite its exquisite organoleptic qualities, economic use of cherimoya fruit remains below potential levels. Poor phytosanitary management in the face of a good number of pests, and particularly fruit fly infestation (mainly *Anastrepha* spp.) are considered to be the main causes of loss of cherimoya market quality in Ecuador, Peru and Bolivia [8,12,13]. In southern Ecuador, fruit fly infestations and subsequent losses were documented to reduce commercial production volumes by up to 50% in 1999. Lack of appropriate infrastructure, low value added, a basically non-enabling policy environment and poor institutional support further add to cherimoya's underutilized status in Andean countries [8].

Although the precise centre of origin of cherimoya is still under dispute, there is consensus that the mountainous area of South Ecuador and North Peru is at least a hotspot of cherimoya diversity [4,6,7,14]. Based on molecular marker studies [12], it was claimed that cherimoya originated in Mexico and was then brought by pre-Inca traders to southern Ecuador/northern Peru where it further diversified. If this is true, cherimoya must have been introduced to South America in ancient times, since archaeological evidence from Ecuador [15] shows that cherimoya was already known to the Valdivia culture (3500 – 1600 B.C.). Paleobotanical [16], and archaeological and linguistic findings [17] prove the presence of cherimoya in Peru already in 2500 B.C. Annonaceae species tend to naturalize easily. This makes establishing the 'true' centre of origin difficult because morphologic features adapt rapidly to new environmental conditions [18].

Based on a subset of 9 simple sequence repeats (SSRs), selected from 52 polymorphic SSR markers from cherimoya [9], in combination with Geographic Information Systems (GIS) techniques, van Zonneveld et al. [19] studied spatial patterns of genetic diversity of semi-cultivated and wild cherimoya trees in the Ecuadorian, Peruvian and Bolivian Andes. The latter authors found that allelic richness, locally common alleles and expected heterozygosity are high in the putative centre of origin (southern Ecuador and northern Peru). On the other hand, levels of diversity were significantly lower in northern Ecuador, Bolivia and particularly in the area around the Peruvian capital of Lima.

Bolivian cherimoyas seem to be less diverse, but were classified in a second cluster (separate from the one in southern Ecuador and northern Peru) with genetically similar trees. Due to unique allele compositions in that cluster, Bolivia should also be considered an important area for *in situ* conservation of cherimoya. In the Lima region, cherimoyas showed the lowest allelic richness within Peru as well as a highly negative fixation index. The latter reflects an excess in heterozygosis, probably due to large-scale distribution by vegetative propagation of the cultivar Cumbe, which is heralded for its prime quality. In the Spanish collection based at *la Estación Experimental La Mayora* in Malaga, the latter cultivar is heterozygote for eight of the nine microsatellite loci analyzed by van Zonneveld et al. [19]. Analysis of the average genetic distance between the Cumbe accession and genotypes in grid cells with 20 or more trees in the Lima area clearly shows that trees in the latter area are very similar to the Cumbe cultivar.

The history of the Cumbe cultivar started in 1996, when Matildo Pérez, cherimoya producer of Santo Toribio de Cumbe (a village in the Cumbe valley in Huarochirí province, Lima region) tried to register a “Cherimoya Cumbe” brand with *the Instituto Nacional de Defensa de la Competencia y de la Protección de la Propiedad Intelectual del Perú* (INDECOPI). The request was declined, however, since denominations can not be assigned to individuals. Some time later, in 1997, a farmer group of the aforementioned village succeeded in obtaining the collective brand ‘Cherimoya Cumbe ®’. According to Peru´s Legislative Decree 823 (Law on Industrial Property), article 196, collective brands serve to *distinguish the origin or any other common feature, of products that use the brand under the control of the holder* [20]. In this way, Peruvian law distinguishes collective trademarks from brands (used without indication of origin) and denominations of origin, which are valid for any producer in the area it covers [21]. Through the latter process, the producers of Santa Toribio de Cumbe managed to increase their competitiveness in wholesale and retail markets in Lima.

In situ conservation of agrobiodiversity is increasingly seen as a method highly complementary to *ex situ* conservation because it allows for evolution of crops through continued natural and human-driven selection [22]. On-farm conservation can be considered a subset of *in situ* conservation. A fundamental element of on-farm conservation is its 'conservation through use' dimension. It offers the opportunity to tailor conservation policy decisions to farmers' needs and concerns [23]. In general, sustainable use and improved commercialization of plant resources through value chain development are considered crucial in achieving on-farm conservation goals, particularly in the case of underutilized species [24-29]. However, it should be noted that often, on-farm conservation of underutilized species is recorded as the maintenance of a limited number of varieties in agricultural production systems and not as the conservation of genetic diversity within a given species, as should ideally be the case. Greater research attention on *in situ*/on-farm conservation [22] is expected to shed more light on how such an approach for underutilized crops can be effectively pursued.

Commercial development of underutilized species might also lead to so-called commoditization, whereby discovery of a successful (high yielding, pest resistant, etc.) genotype leads to genetic erosion of intraspecific diversity [30-33]. The latter seems to be the case for cherimoyas from the area around Lima [19], where cherimoyas show very low allelic richness. This paper uses a value chain analysis approach to cherimoyas produced in different Andean areas in order to compare the relative performances of the different value chains for cherimoya products, as well as to examine the impact of the different value chains on the on-farm conservation status of Andean cherimoya germplasm.

A value chain describes the process of transforming raw produce to final products and making them available to the consumer. Generally, a vast number of persons and activities are involved [34,35]. Value chains should not be considered as a mere network of firms or persons, but rather as a set of activities that need to be performed to deliver a final product. Will [34], however, states that value chains comprise both functions (activities) and their operators (= actors, chain links). Value chains rely to a large extent on services delivered by other supply chains or individual service providers [36,37]. Such chain services can be products or intangible services: e.g. training, supplies of pesticides or irrigation equipment to farmers; transport and packaging services to processing factories and wholesalers, etc. Value chains always operate within a political, economic and technological environment that can either be local, regional or international [36,38].

To a certain degree, all value chains are vertically integrated. This means that parameters requiring product, process and logistic qualifications formulated by a chain link, have consequences up or down the value chain. Governance is the process in which both vertical as well as horizontal (i.e. collaboration between chain actors from the same level) integration is managed [35,39]. Value chain innovation implies strengthening the vertical integration by enhancing the levels of trust among the different chain actors [38]. Most agricultural value chains are buyer-driven, meaning that rules and/or standards are set at the end of the chain, forcing other actors down the chain to comply [35].

Methods

We applied a rational framework for analyzing value chains of tropical food products in developing countries, such as the one offered by Ruben et al. [39]. The framework distinguishes four strongly interlinked key dimensions of value chains for perishable tropical food products: market channels, governance regime, quality performance and added value distribution. The *channels* dimension describes how cherimoya fruits currently reach the final customer and which alternative channels could be developed in the future. Analysis of the *governance regime* covers transactions, interactions, and cooperation among chain actors. *Quality performance* deals with how consumer quality expectations are met. The latter will vary among different groups in society, each of which should be specifically targeted when designing marketing plans for cherimoya in the Andes. To conclude, the distribution of the added value along the value chain will be described.

Secondary data were obtained from the internet, from oral communications with Andean cherimoya researchers, and from the scarce studies with reference to cherimoya marketing: [1,4,6,40-44]. Primary data for the value chain analysis were obtained from informal talks with relevant sector stakeholders (NGOs, government institutes, researchers) and from structured interviews with cherimoya producers, traders, processors and consumers in Ecuador, Peru and Bolivia.

Producers were surveyed between 5 October and 20 December 2006. Survey areas cover main cherimoya production regions in Ecuador, Peru and Bolivia and correspond to main sampling regions in the study of van Zonneveld et al. [19]. Interviews were taken from 152 cherimoya producers in 9 departments (provinces in Ecuador) in Bolivia, Peru and Ecuador by means of questionnaires (Table 1). Surveys were composed of open and closed questions regarding: i) respondent's socio-economic profile, ii) crop management, iii) farm management and financing, and iv) market access. For data analysis, survey regions were divided into 6 main areas i.e. North Ecuador, South Ecuador, North Peru, Lima, South Peru and Bolivia (Table 1).

Traders were surveyed between 9 August and 15 October 2007. Information on main commercial centers was obtained from the results of producers' surveys (Table 1). Due to the marginal importance of local village markets compared to city markets, the former were not considered in the present study. A total of 434 interviews were eventually taken (107 wholesalers and 337 retailers, including 38 supermarkets) (Table 1). Within each market, cherimoya traders were randomly selected for questioning. Open and closed questions provided information on i) their socio-economic profile; ii) quantities and prices of weekly cherimoya purchases; iii) quantities and prices of cherimoya sales; and iv) obstacles and prospects for cherimoya trade.

The demand side of the cherimoya value chain was studied by means of 501 surveys (260 men and 241 women) (between 9 August and 15 October 2007) with cherimoya consumers who were randomly selected in the major commercial cherimoya sites: Quito, Loja (Ecuador), Piura, Chiclayo, Trujillo, Lima, Ayacucho, Cusco (Peru), La Paz, Cochabamba, Sucre and Santa Cruz (Table 1). In order to assure each correspondent's cooperation, each was approached in city parks or other areas where people were found relaxing. Consumers were asked for information on their i) socio-economic profile; ii) cherimoya consumption pattern within the family; and iii) cherimoya quality preferences, by means of closed questions.

The only commercial cherimoya processors in the Andean area consist of ice cream processors/parlors in Bolivia. Interviews were conducted with 36 ice cream parlors in total: 12 in La Paz, 6 in Cochabamba, 13 in Sucre and 5 in Santa Cruz. Surveys with ice cream parlors focused on i) socio-economic profile; ii) volumes and prices of cherimoya purchases; iii) ice cream sales; and iv) perceived obstacles and prospects for fresh and processed cherimoya trade, by means of open and closed questions.

Price data always refer to prices in the full harvest season because in lower production periods (beginning and end of the harvest season), cherimoya prices can rise considerably. Fresh cherimoya fruit market prices were converted from local currencies to USD ($) per kg by means of mean currency exchange rates (source: http://www.oanda.com/) for the years in which price data were gathered (2006 and 2007). USD was chosen for price comparison because both the Bolivian Boliviano as well as the Peruvian Nuevo Sol had a more stable exchange rate to the USD than to the EUR in the 2006 – 2007 period (Ecuador has used USD as its national currency since 2000). Differences between continuous data across categories (regions, countries or sociological) were statistically determined by analysis of variance (ANOVA). Frequency distribution across different categories (Goodness of fit) was analyzed by means of Pearson's χ^2-test. Statistical software used was SPSS 19.0, and graphs were drawn up in MS-Excel.

Table 1. Residence and number of interviewed cherimoya producers, traders and consumers. [a] Departments are called provinces in Ecuador. [b] Piura is a Peruvian Department but classified here within South Ecuador because surveys were performed in the Piura area that borders the Ecuadorian province of Loja.

Area	Department [a]	Producers	Traders	Consumers
North Ecuador	Imbabura	-	-	2
	Pichincha	30	20	85
	Tungurahua	-	-	11
South Ecuador	Guayas	-	-	3
	Azuay	-	-	1
	El Oro	-	-	1
	Loja	16	28	24
	Piura (PER[b])	11	24	13
North Peru	Cajamarca	21	-	4
	Lambayeque	-	39	29
	La Libertad	-	40	14
	Huánuco	-	-	2
	Ancash	-	-	1
Lima	Lima	20	25	70
South Peru	Junín	-	-	4
	Ica	-	-	1
	Ayacucho	13	26	17
	Apurímac	7	-	-
	Cusco	-	29	12
	Puno	-	-	1
Bolivia	La Paz	-	71	62
	Cochabamba	22	43	47
	Chuquisaca	-	27	49
	Santa Cruz	12	62	48
TOTAL		152	434	501

Results

Cherimoya production features across the Andes

Andean cherimoya producers are typically small-scale producers. They usually cultivate small areas (3.5 ha on average; 75 % of respondents have less than 5 ha total area cropped). On these fields, besides cherimoya, usually a whole range of horticultural crops and/or perennial fruit trees is managed. The latter occur next to the cherimoya orchard or can be found intercropped with cherimoya trees. The median Andean cherimoya producer has 60 cherimoya trees. Young producers (< 30 years) have only 37 cherimoya trees on average, whereas producers aged 30 to 50 years manage an average of 180 trees. The oldest (> 50 years) even have plantations of 295 trees on average (differences significant at the 0.05 level – ANOVA, Dunnett's T3).

Yield estimates vary between 4 and 460 kg per tree per year. The median producer estimated annual cherimoya yield per tree at just 60 kg. Since cherimoya is a secondary, minor crop for most producers, production data are not recorded. As a result, yield figures per ha could not be provided by respondents. The farther south production is situated, the later in the year the harvest season occurs, according to producers. Harvest typically lasts from February to May in Ecuador and North Peru, from February to August in Lima, and from April to August in Bolivia.

Plant propagation techniques differ substantially among the regions under consideration. The majority (83 %) of growers from North Ecuador use seeds from previous harvests. In South Ecuador, most producers (74 %) have managed semi-cultivated cherimoya trees. This means that producers have no idea of the origin of the cherimoya trees on their fields. Spontaneously emerged cherimoya seedlings are tolerated in the field and harvested at maturity. In Lima, cherimoya tree propagation is more formal: 85 % of cherimoya growers propagate trees by grafting, mostly with the Cumbe variety as a scion and local seedlings as a rootstock. In Bolivia, in a few cases, cherimoya seedlings are traded in seedling fairs between farmers, or between NGOs or government agencies and farmers (mentioned by 8 % of Bolivian respondents). In the six Andean cherimoya areas under consideration, artificial pollination – which in Spain has proven to significantly improve fruit set and shape [45] - was only observed in Lima (applied by 40 % of producers). However, artificial pollination was only recently adopted as a result of extension services provided by the Peruvian state research institutes *Instituto Nacional de Investigación y Extensión Agraria* (INIEA) and *Servicio Nacional de Sanidad Agraria* (SENASA). Application of fertilizers is rare in all areas considered, except for Lima, where almost all producers apply both mineral (usually NPK 15-15-15) and organic fertilizers (chicken or cow dung) in their cherimoya fields (varying but unspecified quantities).

The Andean cherimoya chain

Cherimoya channels

In Ecuador, Peru and Bolivia, cherimoya value chains are usually very short. The simplest case is where only 2 actors are involved: the producer who sells directly to the consumer on local village markets. In other cases, value chains are more elaborate: cherimoya fruits are sold to middlemen who sometimes sell to other middlemen, wholesalers or retailers, until finally cherimoyas reach the consumer.

Almost all Bolivian (96 %) and North Ecuadorian (93 %) cherimoya producers rely on middlemen for cherimoya sales, whereas in South Peru and Lima, the percentages are only 72 % and 75 %, respectively (frequencies significantly different between categories at 0.05 level, χ^2-test, Cramer's V = 0.259). Sales to middlemen can be performed on-farm or at a nearby point of sale (usually in the nearby village centre). Leftovers (lower in quality and refused by middlemen) are sold to consumers in nearby village markets or in stalls along the road. The small number of middlemen interviewed mentioned that in their outlets cherimoya fruits are resold to other intermediaries, wholesalers and retailers, or else to consumers. Only in Lima, middlemen and producers mentioned sales of cherimoya to wholesale-exporters, who distribute the fruit to the rest of Peru and to neighboring countries of Bolivia and Ecuador. Usually, however, neither producers nor middlemen have a clear idea of the exact location of the eventual consumers of their cherimoyas.

Surveys with traders in the main commercial cities of Ecuador, Peru and Bolivia revealed that both wholesalers and retailers can sell local cherimoyas, which reach the customer through short value chains, as well as the Cumbe variety, which is produced in the Lima department. Cumbe cherimoyas are the only cherimoyas found with a brand (usually a sticker with the Cumbe trademark) in markets in Ecuador, Bolivia or Peru. Although most traders sell both Cumbe fruits and local cherimoyas, they usually focus their commercial activities on one of either 'variety'. In Ecuador, 20 % of traders interviewed deal with Cumbe cherimoyas. In Peru and Bolivia, this number was 53.6 % and 34 %, respectively. Furthermore, in Bolivia, next to local and Cumbe cherimoyas, some cherimoyas of Chilean origin are found in the city markets (6 % of interviewed traders).

Cherimoya is generally on the menu of many Andean consumers on a daily basis during the harvest season. In Bolivia, consumption is lowest; almost 60 % of all surveyed consumers state they only rarely eat cherimoya fruits. In Ecuador, the majority (64 %) consume cherimoya fruits only once a month. Consumption is most frequent in Peru: 14 % consume cherimoya on a daily basis, whereas 46 % enjoy cherimoya fruits on a weekly basis. Differences between countries were found to be significant at 0.05 level (χ^2-test, Cramer's V = 0.448). Consumers were classified in a group that predominantly consumes local cherimoyas (n = 130) and another group that almost exclusively consumes Cumbe fruits (n = 220). Consumption frequency of the latter group is significantly lower than that of the first group. In all Andean areas, more than 60 % of consumers of local cherimoyas eat them at least once per week, whereas only 37 % of Cumbe cherimoya consumers enjoy cherimoya on a weekly basis.

For the vast majority (88 %) of respondents, cherimoya's exquisite taste is the predominant incentive for consumption. Health benefits were mentioned as a motive by 8 % of all consumers. All consumers surveyed mainly consume cherimoya as a fresh fruit. Alternative forms mentioned by respondents include ice cream, juice and yoghurt. Cherimoya ice cream is regularly enjoyed by 71 % of all Andean consumers. Nevertheless, significant differences (χ^2-test, Cramer's V = 0.287) were found between the three considered countries. Cherimoya ice cream is very commonly consumed in Bolivia (87 % of respondents), whereas in Peru, juices containing cherimoya fruits are more popular than ice cream and are regularly consumed by more than half of the population.

Chain governance

In the 6 Andean cherimoya areas under consideration, most producers who are members of a farmer organization were found in Lima (65 % of surveyed producers). By contrast, in South Ecuador scarcely 7 % of cherimoya producers are members of such an organization. However, over all three considered countries only one out of seven cherimoya producers belonging to a farmer organization mentioned that their association performs any cherimoya production or trading activity. All of the organizations to which cherimoya producers belong are local: all members are from the same or nearby villages. Moreover, they all deal with a broad range of agricultural topics. Most frequently mentioned services provided by producer organizations are i) joint acquisition of inputs, ii) easier access to extension services, and iii) market access facilitation (each mentioned by one third of producer organization members).

In South Ecuador, where lack of institutional support to producers has been identified as an important bottleneck in raising (commercial) cherimoya quality [8], a mere 19 % of producers received any training at all in cherimoya cultivation over the last 10 years. This contrasts with Lima where 85 % of producers received advice or currently benefit from extension services on cherimoya cultivation from various institutions. Topics generally treated by Bolivian, Peruvian and Ecuadorian extension institutes in cherimoya cultivation include: fruit fly control, pruning, pollination, generative and vegetative propagation, selection of interesting varieties, and commercialization.

The degree of vertical integration, i.e. the existence of a strategic network between chain actors of different levels, was determined by assessing trust between chain actors. High-trust chains are characterized by strong relationships between supplier and buyer, whereas low-trust chains, such as most agricultural value chains, are characterized by mass-production in which buyers can more easily change between suppliers [35]. Both wholesalers and retailers were asked if they would change their current cherimoya supplier(s) and also the reasons for doing so. In all three countries, most traders would indeed change suppliers if they had the chance to. Trust is slightly (but significantly) higher in Ecuador, where 'only' 70 % would change their current suppliers (compared to 80 % and 85 % in Peru and Bolivia, respectively). In Peru three quarters of traders state that they look for more quality at a more reasonable price, while 6 % wish to raise trade volumes by seeking new suppliers. In Ecuador, one third of traders are looking for higher cherimoya trade volumes. In Peru, cherimoya traders in Lima (n = 19) have a significantly higher trust in suppliers than those from other Peruvian departments (n = 153): 42 % of traders from Lima are satisfied with their current suppliers. Power is another important characteristic of value chain governance. Chain actors with high power can enforce standards and practices on other actors and neglect desires from other actors [35]. In the Andean cherimoya sector, power of producers is low. In all three countries, a large majority (> 80 %) of producers claim that prices are exclusively set by middlemen. In the Lima area, where the renowned Cumbe cherimoyas are produced, power of producers is slightly higher. However, even in Lima only 30 % of producers claims to be able to negotiate with buyers on the terms of trade.

Quality performance

Quality perception

Cherimoya producers were asked how they appreciate the quality of cherimoyas they market in terms of taste, shape, peel cleanliness, seed content, etc. on a 1 to 9 Likert scale (1 = 'Very Bad', 3 = 'Bad', 5 = 'Regular', 7 = 'Good', 9 = 'Excellent'). Average value for all producers (n = 109) was 5.3, which is between regular and good. Producers from the Cumbe-producing department of Lima are most satisfied with the quality of their cherimoya production. Least-satisfied producers were found in Bolivia and North Peru. Fruit quality problems most frequently mentioned by producers are related to fruit fly infestation and high seed indices (i.e. number of seeds per 100 g of fruit pulp) and to a lesser extent to small fruit sizes, irregular fruit shapes and/or unsatisfactory flavour. According to 83 % of producers in North Ecuador and 71 % of producers in South Ecuador, cherimoya seed indices are too elevated, whereas in Bolivia this is a problem for only 7 % of surveyed producers.

Average liking of all surveyed consumers was 7.6 on a 1 to 9 Likert scale with a 95 % confidence interval of between 7.4 and 7.7. This means that most consumers have a good to very good opinion of cherimoya quality. Average liking scores are only significantly lower in Peru (7.1) compared to those in Bolivia (7.8) and Ecuador (7.7) (Kruskal-Wallis test). There were no significant differences between the liking scores of consumers predominantly consuming Cumbe and those mainly consuming local cherimoyas.

Unsmooth peels (not *laevis* or *impressa* types) are considered problematic for traders, because peel protuberances get easily damaged and blackened during handling and transport, and because they damage other fruits. High seed indices and maggots, caused by fruit fly infestation, are considered less problematic by retailers, wholesalers and consumers than by producers (Fig. 2). Impurities in fruit peel and/or pulp, small fruits and fruit fly infestations are considered a quality problem more by traders of local cherimoyas than by traders of Cumbe cherimoyas (Fig. 3).

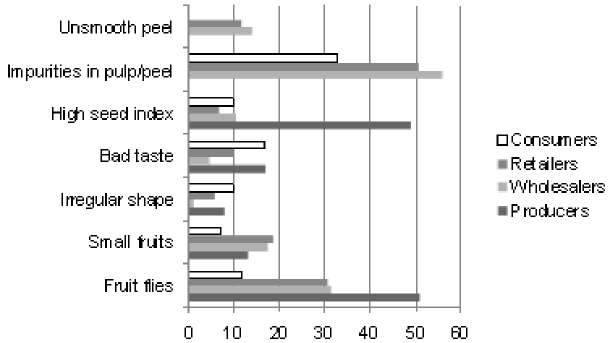

Fig. 2. Quality problems perceived by producers (n = 89), retailers (n = 205) and wholesalers (n = 80) (in % of respondents) in the Andean cherimoya value chain.

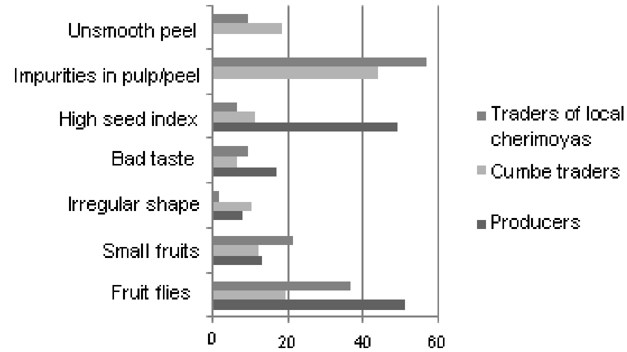

Fig. 3. Quality problems perceived by producers (n = 89) and traders of both Cumbe (n = 98) and local (n = 198) cherimoyas (in % of respondents) in the Andean cherimoya value chain.

Supermarkets and Bolivian ice cream parlors seem to experience fewer problems with impurities in the fruit pulp and/or peel, taste or fruit flies, indicating that supplies of supermarkets and ice cream parlors are of higher quality than supplies reaching other retail markets. Almost a quarter of supermarkets experience fruit shape as problematic. Also, hardly any ice cream parlor has problems with fruit flies in its cherimoya supplies. The difference with supermarkets and other retailers (Fig. 4) is high. This indicates that ice cream parlors manage to contract producers and/or traders who deliver adequate quality. Of greater concern is the taste of cherimoya, which is troublesome for almost half of the surveyed ice cream parlors. This does not mean, however, that they consider the taste bad, but that they experience too much variability in cherimoya acidity, aroma and sugar content. The latter variability is a constraint in standardizing cherimoya ice cream flavor.

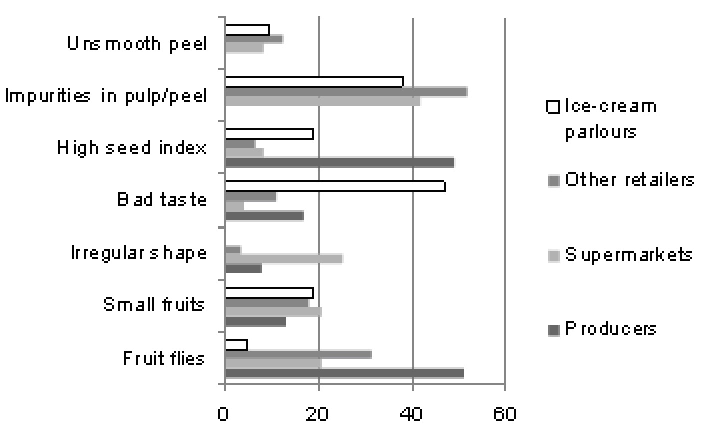

Fig. 4. Quality problems perceived by producers (n = 89), supermarkets (n = 24), Bolivian ice cream parlours (n = 21) and other retailers (n = 184) (in % of respondents) in the Andean cherimoya value chain.

Quality and governance

In order to evaluate the relative importance of the correspondence between quality requirements of buyers and delivered quality by suppliers in the cherimoya chain governance regime, the reaction of buyers to unmet quality expectations was assessed. Four different responses of traders were observed when quality of cherimoya supplies was unsatisfactory: i) rejection of the whole lot; ii) offering to buy the supply at a lower price (assuming the trader would thus compensate his losses after sorting out unacceptable cherimoyas and selling those with acceptable quality); iii) purchase of the supply at normal price conditions; and iv) no particular response, because the quality is always good. With retailers, the general behavior is to reject the whole lot when quality expectations are not met (65 % of retailers). Only 14 % of retailers lower the price when confronted with an unsatisfactory cherimoya lot (Fig. 5). With wholesalers, the situation is significantly different (χ^2-test, Cramer's V = 0.344): 44 % will offer a lower price to suppliers of bad quality cherimoyas (usually middlemen or producers) whereas 39 % will reject the whole lot. The results further show that Cumbe cherimoyas have a good reputation among traders. Four out of ten Cumbe traders state that they are never confronted with bad quality cherimoyas, whereas this was the case for only 4 % of traders of local cherimoyas (differences are statistically significant at the 0.05 level, χ^2-test, Cramer's V = 0.478).

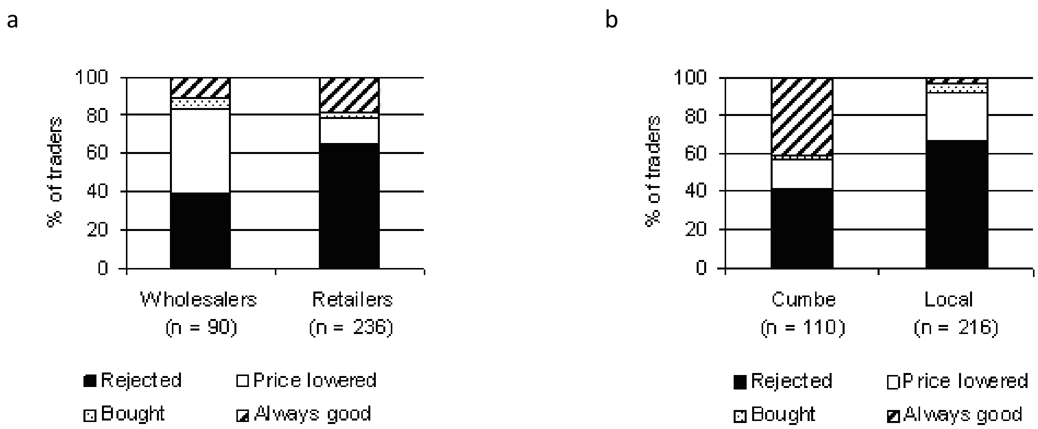

Fig. 5. Reaction of wholesalers and retailers (a) and of Cumbe-traders and traders of local cherimoyas (b) to unsatisfactory cherimoya quality.

Three quarters of Peruvian consumers who buy bad quality cherimoyas at the price set by traders are Cumbe buyers. This means that the Cumbe brand creates a high trust relation with consumers, regardless of observed quality attributes.

Skin type preferences

The majority of traders prefer the smooth skin types *laevis* and *impressa* (Fig. 6). In Peru and Bolivia, smooth types are preferred by more than 90 % of respondents. Comparison of these figures with consumer preferences reveals that smooth types are desired by only (roughly) 6 out of 10 consumers. Morphological data (type of skin, number of seeds, weight, brix, and fruit length and width) were collected in 2006 from 367 cherimoya accessions in 10 Andean cherimoya cultivation areas (6 from Peru, 2 from Ecuador and 2 from Bolivia) (unpublished). Only in Ecuador, the skin types that are found on-farm (85 % smooth types) are well able to match the preferences of traders (75 % smooth types preferred) and consumers (71 % smooth types preferred). In Bolivia, consumer's age is remarkably negatively correlated with the preference for protuberances on the fruit skin (Pearson's χ^2 = -0.303, correlation is significant at the 1 % level).

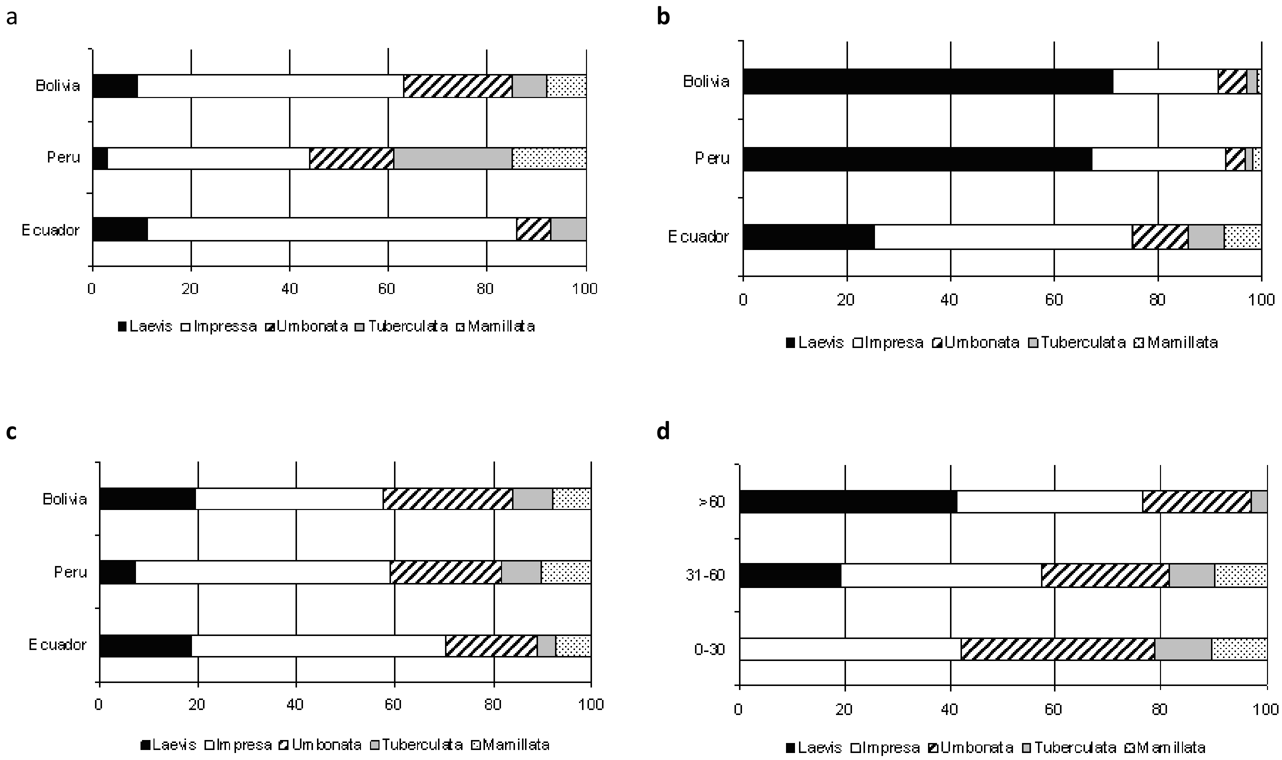

Fig. 6. Distribution (in %) of (a) skin types (unpublished) found in *in situ* cherimoya accessions of Ecuador (n = 84), Peru (n = 164) and Bolivia (n = 101) and (b) skin type preferences of traders in Ecuador (n = 28), Peru (n = 155) and Bolivia (n = 104); (c) of consumers in Ecuador (n = 27), Peru (n = 167) and Bolivia (n = 175); and (d) of Bolivian consumers by age categories 0-30 years (n = 38), 31-60 years (n = 103) and > 60 years (n = 34).

Packaging

Andean traders reported six different forms of packaging for cherimoya fruits: i) a wooden crate (ranging 10 - 25 kg); ii) bags (usually of 50 liters, in which also potatoes, onions, etc. are transported); iii) cardboard boxes; iv) no packaging (cherimoyas are transported and traded in bulk); v) baskets; or vi) plastic boxes. Survey results show a considerable divide between packaging materials used in transport by traders of Cumbe and those selling local cherimoya fruits. Wooden crates are the most popular means of transport of Cumbe cherimoyas. Local cherimoya fruits are packed in a wider range of materials (Fig. 7). In Peru and Bolivia, 86 % and 87 % respectively of Cumbe traders use wooden crates. In Ecuador, however, only half of Cumbe cherimoya traders use bags together with wooden crates. In supermarkets, the fruits receive additional protection with a net-like structure of extruded polystyrene foam. This packaging is usually performed at a central management and distribution centre where fruit and vegetable products are selected, graded and packed, and from which they are transported to country-wide department stores.

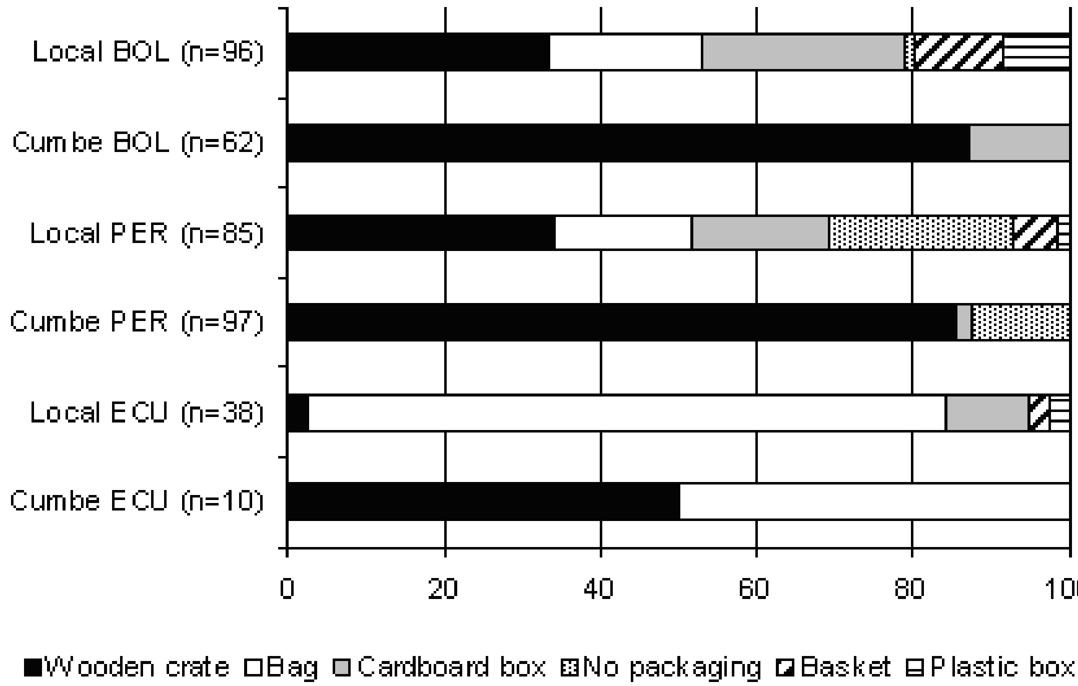

Fig. 7. Packaging in which cherimoya fruits reach traders of Cumbe and local cherimoyas in Bolivia (BOL), Peru (PER) and Ecuador (ECU) (in % of traders).

Distribution of added value to cherimoya in the value chain

In this section, added value is simply defined as price differences between different value chain actors for a given quantity of fresh cherimoya fruit. In all three countries, the share of total added value taken by middlemen never exceeds 30 %. For the Cumbe channels, highest share in total value added by actors from producers to retailers is taken by wholesalers in Ecuador, and by producers in Peru (Fig. 8). The highest share of added value for local cherimoyas in Ecuador is taken by wholesalers (34 %), in Peru by retailers (41 %) and in Bolivia by producers (41 %). These figures indicate that distribution of added value shows very different characteristics in the three countries under consideration.

Cherimoya in Andean countries is usually commercialized using different quality classes, for which grading starts at producer level. The most popular way of grading is according to fruit weight, with usually three quality classes (first: > 800 g; second: 400 – 800 g; and third: < 400 g). At production level, ANOVA ($p < 0.05$) evidenced significant differences between the prices of local cherimoyas in the 3 quality classes (Fig. 9). At the other levels (middlemen, wholesalers and retailers), there are no significant price differences between different quality classes. Apart from the retail level, at all levels of the Cumbe value chain, price differences between different quality classes prove to be significant (ANOVA, $p < 0.05$) (Fig. 9). Retail prices for both Cumbe and local cherimoyas were benchmarked with retail prices for three frequently consumed fruit species (avocado, oranges and bananas) in 11 Andean cities (Table 2).

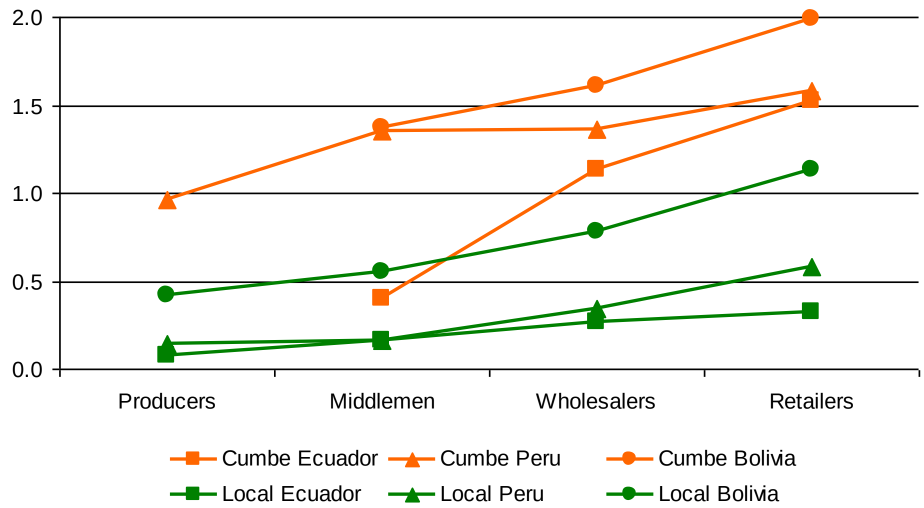

Fig. 8. Mean cherimoya prices ($/ kg) paid to different actors of the value chain of Cumbe (orange) and local cherimoyas (green) in Ecuador, Peru and Bolivia.

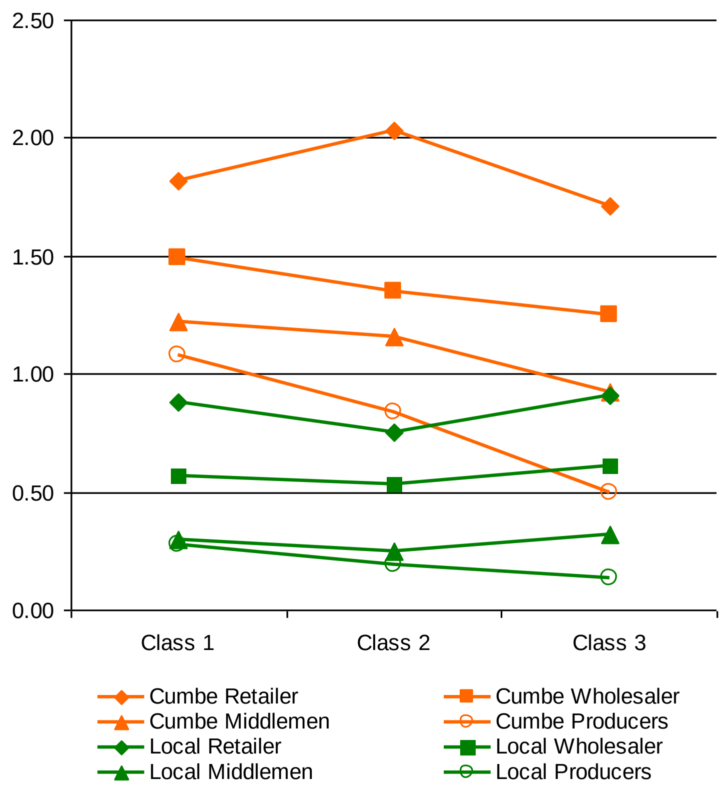

Fig. 9. Mean sales prices ($/kg) of cherimoyas from 3 quality classes of 4 different actors in the Andean Cumbe (orange) and local (green) cherimoya value chain in Ecuador, Peru and Bolivia.

The retail price gap between Cumbe and local cherimoyas is widest in Chiclayo, Piura (both in Peru) and Loja (Ecuador). In the four Bolivian cities, the gap is narrower, mainly due to higher prices for local cherimoyas. The retail price of Cumbe cherimoyas in all Andean cities studied is higher than retail prices for avocados, oranges and bananas. The only exception is Quito, where Cumbe cherimoyas are sold at a considerably lower price than in other Andean markets. It is nevertheless fair to state that Cumbe cherimoyas are among the most expensive fruits on Andean markets. Retail prices for local cherimoyas are situated around those for oranges and bananas, but substantially lower than retail prices for avocados in all Peruvian and Ecuadorian cities studied. In Bolivia, avocado prices are lower than prices for both Cumbe and local cherimoyas. Remarkably, local cherimoyas are more expensive in Bolivia than those in Peru and Ecuador. As a result, in Bolivia cherimoya prices are perceived as expensive by 9 out of 10 consumers. For almost half of Peruvian consumers, however, cherimoya fruits are considered cheap. Notwithstanding price perception of cherimoyas is generally high, 92 % of Andean consumers claim that they prefer to pay a high price for good quality cherimoya fruit, rather than to have cheap but inferior cherimoyas.

Table 2 . Comparison of 2007 retail prices ($/kg) for Cumbe and local cherimoyas (class 1 only) and three other fruits in 11 Andean cities. [a]Avocado, orange and banana prices are at national level. Sources: for Ecuador: Statistics of the Ministry of Agriculture (http://www.sica.gov.ec); for Peru: Statistics of the Agricultural Agencies of the Ministry of Agriculture (http://www.agropiura.gob.pe, http://www.agrolambayeque.gob.pe, http://www.agrolima.gob.pe, http://www.agroayacucho.gob.pe http://www.agrocusco.gob.pe); for Bolivia: Daily Market Prices Information sheets, Foundation Los Valles & Ministry of Rural Development, Agriculture and Environment.

		Avocado	Orange	Banana	Cherimoya Cumbe	Local Cherimoya
Ecuador	Quito[a]	1.21	0.37	0.27	0.54	0.43
	Loja[a]	1.21	0.37	0.27	1.63	0.33
Peru	Piura	1.04	0.26	0.25	1.87	0.21
	Chiclayo	0.89	0.23	0.23	1.69	0.24
	Lima	0.95	0.18	0.24	1.25	1.25
	Ayacucho	0.95	0.37	0.35	1.33	0.65
	Cusco	1.24	0.37	0.4	1.68	0.84
Bolivia	La Paz	0.5	0.09	0.13	1.9	1.22
	Cochabamba	0.39	0.09	0.08	2.07	1.17
	Sucre	No data	0.14	0.08	1.58	1.05
	Santa Cruz	0.3	0.09	0.1	2	1.1

Discussion

Perennial crops such as cherimoya contrast with annual crops in that the former are less labor intensive [46]. Nevertheless, in the cherimoya value chain, certain cultivation practices are crucial in order to assure an acceptable yield and quality. The most important are: irrigation, especially in regions where rainfall is scarce [15]; pruning, to control tree height and improve fructification quality [15,47]; fertilization, especially nitrogen and potassium that are extracted in considerable amounts from the soils where cherimoya is harvested [48]; pesticides, for the control of a wide range of pests, especially fruit fly (*Anastrepha* spp. and *Ceratitis capitata*) [49]; artificial pollination, which improves fructification and fruit formation, and shortens the production cycle [6,45,50,51]; and intercropping, as it enriches soils with often scarce nitrogen, prevents soil erosion, provides cherimoya growers with additional crops for marketing, and might attract pollinating insects [52]. Pruning and irrigation are generally applied in Andean cherimoya cultivation, whereas pesticide application and fertilization (apart from Lima) are much less common.

Channels

Strategies for improving commercialization of underutilized plant species should always take into account competition from other production regions of the target species [36]. Availability of cherimoya in a certain region at times when no cherimoya is available from other production regions is an important asset if one wants to increase competitiveness of that region. Furthermore, commercialization of agricultural products favors regions where there is pre-existing demand for these products [36]. Thus, where harvest seasons do not coincide, growers can find markets in off-season areas. For example, Cumbe cherimoyas are sold at Bolivian and Ecuadorian markets when local cherimoyas are not available. Chile already exports some cherimoya to Bolivia during the September to November period, and to the USA from June to November [53]. If cherimoya production from the areas of Lima, South Peru and Bolivia were able to comply with strict phytosanitary and quality requirements, cherimoyas from these regions could be exported to the USA in the period of June to August and/or to Chile from March to June. Both North and South Ecuador would also be able to export cherimoyas to Chile from March to May. Export to transcontinental markets, however, is particularly hampered by the short shelf life of cherimoya and the consequent need for costly air transport. The latter is estimated at 1 US$/kg (personal communication from Eduardo Talavera Larenas, consultant of the Commission for the Promotion of Exports, PROMPEX, in Lima, Peru, November 17th 2006).

Cherimoya fruits can also be enjoyed processed into ice cream, juices, yoghurt, flans, wine, sorbet and numerous pastries [6]. Warm processing of cherimoya fruits is troublesome since it results in a brown pulp color and ruins its delicate aroma following enzymatic oxidation [54]. These findings can be used in the development of new product-market combinations [55]. Cherimoya juices or pastries might be sold in stalls on existing fruit markets, where currently only fresh cherimoya fruits are sold. Cherimoya ice cream is very popular in Bolivia, but likely has potential to penetrate Peruvian or Ecuadorian markets as well.

Governance

In Peru, generally more extension service is provided to cherimoya cultivation than in Bolivia or in Ecuador. Moreover, five out of the nine reported Peruvian extension institutions are run by government, evidencing a considerably larger political interest in cherimoya production than in Bolivia or South Ecuador. As expected, producer organizations have easier access to extension services. Producers from Lima (where 65 % of producers are members of such an organization) mentioned various extension institutes. This contrasts with those from Ecuador, where NCI and INIAP are the sole extension institutes. It is possible, however, that farmer groups were in fact promoted by the many institutes that provided extension in the region before formal associations were formed.

Since cherimoya fruits within a single village are abundantly available in full harvest season, producers are often forced into a price-taking situation. Middlemen will simply move to neighboring producers if the price offered is not considered satisfactory. Producers from remote and isolated areas have no other option than to sell their produce elsewhere. Based on the low negotiation power of producers, one might assume that middlemen have greater power in the Andean cherimoya value chain. However, if standards are enforced at a higher level (e.g. retailers), it is possible that for middlemen also, negotiation margin and thus power, are low.

Quality performance

Blemished peels or impurities in the pulp, mostly caused by fruit fly infestations, are significant and widely spread quality problems experienced by all Andean chain actors. Economies of scale, however, allow wholesalers to be left with enough acceptable cherimoyas after selection (discarding those that have unsatisfactory quality), in order to still make some profit after resale.

Production and trade of cherimoya in Lima are relatively high compared to other Andean commercial centers. One third of overall cherimoya production from Ecuador, Peru and Bolivia is produced in Lima department [43]. Selection and grading are consequently more intense there than on any other market in the Andean region, thus putting pressure on prices paid to suppliers. Only best quality cherimoyas are exported to other wholesale markets in Ecuador, Peru and Bolivia. This explains the observed differences between intrinsic quality at farm gate and quality perceived by traders. It also explains why trust in Cumbe cherimoyas by traders is commonly high. Survey data show that consumers do not have a preference for cherimoyas with a specific skin type. As a result, consumption quality of the unsmooth types is not necessarily equal to commercial quality. Traders prefer smooth types because these suffer less blackening during transport. Consumers link Cumbe cherimoyas to smoothly peeled fruits. This is another reason why Cumbe traders are more sensitive to unsmooth peels. In Bolivia, older cherimoya consumers were found to be keener on smoother skin types than younger ones. The latter is important for cherimoya marketing in Bolivia, where smoother and unsmooth types can be targeted towards the elderly and young consumers, respectively.

Cherimoya fruit has a typically climacteric ripening pattern. Respiration increases from two to three days after harvest. This is associated with a peak in ethylene production leading to accelerated senescence [4,56]. As a consequence, shelf life of cherimoya fruits is short: five to eight days at room temperature and only 15-20 days in cooler circumstances. The fast softening of the fruit peel makes packaging and transport crucial in safeguarding its (superficial) quality. Transport in wooden crates is the most commonly applied practice in the Andean cherimoya value chain. However, more appropriate forms of packaging are currently applied in agro-industrial cherimoya cultivation in Spain, where a cardboard box with 5 to 18 depressions is used, allowing packing cherimoyas of different sizes (personal observation). Most cherimoya producers in the USA (California) reduce packaging costs by using hard cardboard boxes in which cherimoya fruits are protected by straw or locally produced lemons with low market quality (personal communication with Dr. Dario Grossberger, former board member of The California Cherimoya Association; see also http://www.cherimoya.com). The significantly higher shares (χ^2-tested; Cramer's V = 0.295) of Cumbe traders using wooden crates, compared to traders of local cherimoyas, suggest that Cumbe cherimoya's perceived high quality may be partly attributed to a more adequate packaging method. Where fruit fly infestation is effectively controlled, introduction of wooden or cardboard boxes that could be reused and recycled throughout the value chain, would considerably enhance cherimoya quality at retail markets, and eventually lower costs.

Distribution of added value

Contrary to what is usually assumed, middlemen do not strongly influence cherimoya price fixing [57,58]. In long cherimoya channels, where more than one wholesaler is involved, value added at the wholesale level is in reality distributed over several intermediaries. This is possibly the case with Cumbe cherimoyas reaching the Ecuadorian market, where the 48 % share in total added value is actually spread over 2 or even 3 wholesalers.

In all countries, cherimoya prices in the Cumbe chain are well above those of local cherimoyas. Grading of cherimoya fruits according to fruit weight is a common practice, notwithstanding that mean prices per kg of fresh fruit do not differ significantly between different weight classes. However, given that many cherimoya traders sell cherimoyas per piece, the unit price is much lower for cherimoyas in lower weight classes. Grading of cherimoyas is consequently only a matter of facilitating consumer convenience at the moment of purchase (and giving the false idea of buying cheaper). The lower consumption frequency of Cumbe cherimoyas in comparison with local cherimoyas indicates that although the former have exquisite taste and quality properties, the elevated price limits frequent consumption. Cumbe cherimoyas thus seem more a special treat for the Andean consumer than locally produced cherimoyas that are consumed on a more regular basis.

During the market surveys, many Cumbe cherimoyas were found with a label that differed from the one officially deposited at INDECOPI in 1997. We thus suspected large-scale piracy of the Cumbe trademark. In effect, this means the trademark is fraudulently usurped by producers and traders in and outside the Lima department who are able to produce and/or grade cherimoyas so that the fruit meets all quality expectations associated with Cumbe cherimoyas. Piracy of the Cumbe trademark is clearly illustrated by the contradiction between the prices Ecuadorian middlemen obtain for Cumbe cherimoyas and the higher prices charged by producers of Cumbe cherimoyas in Peru (Fig. 8). Good quality cherimoyas from Peru (or Ecuador) are purchased at a low price and illegitimately resold by wholesalers as Cumbe cherimoyas for which a much higher price can be obtained. Poor management and monitoring of the Cumbe trademark maintain this abuse, highlighting the need for appropriate enforcement of national laws concerning geographical denominations. This would reward producers who are legally allowed to use the collective trademark with a premium, and sanction producers and/or traders who abuse it.

Implication for conservation

The present paper shows that within the Andean cherimoya value chain, two clear, distinct channel types prevail: Cumbe cherimoyas that are produced in the Lima region in Peru and marketed in the whole Andean region; and local cherimoyas that are elsewhere produced, marketed and consumed. The Cumbe cherimoya value chain was identified as the more competitive of the two. Cumbe cherimoyas are found on markets in all Andean countries considered in this study, whereas their value chain is typically longer (including more intermediaries) than those of local cherimoyas. The latter are distributed to local village markets or to the nearest domestic city (wholesale and retail) markets. Governance regimes are generally weak, but nevertheless stronger with Cumbe cherimoyas than with local cherimoyas.

Trust of traders and consumers in the Cumbe chain is higher, indicating that Cumbe cherimoyas meet quality standards set by traders and consumers more than local cherimoyas. However, it was shown that organoleptic on-farm quality is not distinctively better for Cumbe cherimoyas compared to local cherimoyas. Intensive grading and selection at wholesale markets (mostly in Lima), where large amounts of Cumbe cherimoyas are traded, result in outstanding quality farther along the value chain. Organoleptic quality of cherimoya fruits is highly praised by Andean consumers, who are consequently willing to pay elevated prices for cherimoya, but demand exquisite quality in exchange. Due to Cumbe's distinctive quality, prices along the whole value chain of Cumbe cherimoyas are higher than prices fetched by local cherimoyas. Added value is quite evenly distributed over all chain actors. For the Cumbe chain, highest share in added value is taken by producers.

In general, producers from the Lima region profit from their unique location. Proximity to the Lima metropolis results in a better education, better access to extension services and farm implements of cherimoya farmers, and in stronger horizontal and vertical integration and reduced transport costs in the cherimoya value chain.

Although the seed index is an important quality parameter in cherimoya characterization [4] and breeding [1], Andean consumers and traders are least concerned about high amounts of seeds in cherimoya fruits, which they consider an authentic cherimoya feature. Selection of elite cherimoya germplasm should consequently put less emphasis on low seed indices, which will put less pressure on local cherimoya diversity where seed indices are usually high.

van Zonneveld et al. [19] point to two Andean areas of interest for *in situ* cherimoya conservation: i) the putative centre of origin in southern Ecuador and northern Peru, where diversity is high; and ii) Bolivia, where rare genotypes (i.e. with unique allele compositions) occur. Both areas, however, share some disadvantages regarding cherimoya value chain development: i) low access to extension services, resulting in ii) high rates of fruit fly infestation; iii) short harvest seasons (just 2 months); and iv) production areas that are remote and where adequate transport is hampered by bad roads and inadequate packaging material. Improvement of the cherimoya value chain performance in these areas would encourage farmers to continue growing cherimoya and can consequently be considered as a potential tool for on-farm, and thus *in situ* conservation of cherimoya germplasm. The fact that average liking of Cumbe and local cherimoyas is equally high across Andean consumers shows that intrinsic fruit quality is not hampering value chain development of local cherimoyas. Actions to enhance the Andean value chain of local cherimoyas should include i) the formation of farmer organizations; ii) transfer of scientific knowledge about adequate cultivation practices to farmers (extension); iii) introduction of elite germplasm material; iv) introduction of more adequate packaging material; v) market information systems, communicating both quality standards as well as pricing according to different quality classes; and vi) construction of (centralized) warehouses for cherimoya fruit.

However, the case of Cumbe cherimoyas clearly illustrates that such interventions in the cherimoya value chain can lead to genetic erosion of cherimoya diversity, particularly if successful cultivars are spread among farmers at the cost of local germplasm diversity. However, if cherimoya value chains remain undeveloped, the semi-cultivated crop will be gradually replaced by more remunerative alternatives, which would also lead to genetic erosion. Expansion of the number of geographic indications[1] to other cherimoya production areas might be a way out of this paradox. Such indications should then stress the relation between the qualities of cherimoya fruit and the production area rather than a certain cultivar. Obviously, even geographic indications will not be able to halt the ongoing genetic erosion of cherimoya in the Andean area. In addition to enhancing the private value of cherimoya, governments could reward farmers for cultivating local cherimoyas through payment for

[1] Geographical indications are names or signs used on certain products which correspond to a specific geographical location or origin (e.g. a town, region, or country). The use of a geographical indication may act as a certification that the product possesses certain qualities, is made according to traditional methods, or enjoys a certain reputation, due to its geographical origin. In many countries the protection afforded to geographical indications by law is similar to the protection afforded to trademarks. Geographical indications law restricts use of geographical indications for the purpose of identifying a particular type of product, unless the product and/or its constituent materials and/or its fabrication method originate from a particular area and/or meet certain standards.

agrobiodiversity conservation services (PACS) [59]. The latter is a sub-category of payment for ecosystem services (PES) to compensate farmers' opportunity costs of maintaining traditional crops and varieties instead of adopting more profitable crops.

In conclusion, on-farm conservation efforts as proposed in the present paper need to be complemented by conservation of natural areas with wild stands of cherimoya and by *ex situ* conservation strategies (germplasm collections).

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