Chemical Composition, Nutritional Evaluation, and Economic Prospects of *Spondias purpurea* (Anacardiaceae)[1]

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Kozioł, Michael J. (*Nestlé R&D Center S.A., Casilla Postal 17-11-6053, Quito, Ecuador*) *and* **Macía, Manuel J.** (*Real Jardín Botánico de Madrid, Plaza de Murillo 2, 28014 Madrid, España. Current address: Herbario QCA, Departamento de Ciencias Biológicas, Pontificia Universidad Católica del Ecuador, Casilla Postal 17-01-2184, Quito, Ecuador*). Chemical Composition, Nutritional Evaluation, and Economic Prospects of *Spondias purpurea* (Anacardiaceae). *Economic Botany 52(4):373–380. 1998. The fruits of "ovo"* (Spondias purpurea *L.*) *had the highest caloric density of the fruits compared, 74 kcal/100 g edible portion versus 39 to 58 kcal/100 g for peach, apricot, plum, mango, and cherry. This higher caloric density is due principally to ovo's higher concentration of total carbohydrates (19.1%); fructose, glucose, and sucrose together account for 65% of the soluble matter. Unlike the other fruits, ovo retains a fair amount of starch in the mesocarp. It is a moderate source of potassium (250 mg/100 g edible portion) and an excellent source of vitamin C (49 mg/100 g edible portion). Analysis of volatile flavor compounds showed 2-hexenal to be the main flavor compound present. Although there is a local market for ovo in Ecuador, large scale exportation of the fresh fruit currently lacks the necessary infrastructure to prolong shelf life, while the current production of ovo is insufficient for large scale industrial processing of the fruit. In the near future, the best alternative to maximize the income of the small holders producing ovo is for them to concentrate on producing "value added products" such as jams, ice creams, alcoholic beverages, and vinegars.*

Composición Química, Evaluación Nutricional, y Perspectivas Económicas de *Spondias purpurea* L. (Anacardiaceae). *Los frutos del "ovo"* (Spondias purpurea *L.*) *tienen el valor más alto de densidad calórica entre los frutos comparados, 74 kcal/100 g de porción comestible frente a valores de 39 a 58 kcal/g reportados para durazno (melocotón), albaricoque, ciruela, mango y cereza (guinda). Este valor se debe principalmente a la elevada concentración de los hidratos de carbono (19.1%) en el ovo, en comparación con las otras frutas mencionadas; la concentración total de fructosa, glucosa y sacarosa representa el 65% de los sólidos totales presentes. En relación con las otras frutas, el ovo cuenta con cantidades relativamente altas de almidón en el mesocarpio. El ovo representa una fuente regular de potasio (250 mg/100 g de porción comestible) y una excelente fuente de vitamina C (49 mg/100 g de porción comestible). El análisis de los compuestos aromáticos volátiles identificó a 2-hexenal como el componente principal del aroma de la fruta. En Ecuador existe un mercado potencial para la venta de los ovos, aunque en la actualidad, la exportación a gran escala de los frutos frescos carece de la infraestructura necesaria para prolongar la estabilidad del fruto para su transporte y su venta posterior. La mejor alternativa para obtener mayores ingresos para los pequeños productores de ovo sería la venta de los productos que aportan un valor añadido: mermeladas, helados, bebidas alcohólicas y vinagres. Con la producción actual de ovo en Ecuador, sería posible una explotación a nivel de pequeña industria de estos productos elaborados.*

Key Words: *Spondias purpurea*; Anacardiaceae; edible fruit; composition; nutritional value; economic botany; Ecuador.

Two species of the pantropical genus *Spondias* (Anacardiaceae) are native to Ecuador: *S. mombin* L. which is highly polymorphic (Barfod 1987) and occurs on both sides of the Andes, and *S. purpurea* L. which is a well defined species distributed mainly on the western coastal plain of the Andean ridge. Locally, the fruits of both species of *Spondias* are most commonly and indiscriminately called "ovo." *Spondias*

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mombin, which has just begun to appear for sale in the markets in Quito, is the larger and more yellow of the two and is generally acknowledged as being bittersweet whereas the better known *S. purpurea* is smaller, orange to red colored, sweeter and the more aromatic of the two. Ovos are usually consumed fresh although they can be further processed into jams, ice creams or alcoholic beverages (for general information on the description, cultivation, and economic botany of *S. purpurea* L. see León and Shaw 1990 and Macía 1997). Two "schools" exist regarding the method of consumption of ovo: the fruit with peel is eaten whole later spitting out the rather large seeds, or the fruit pulp is softened by gently squeezing the whole fruit between the fingers followed by biting a hole in the peel at one end of the fruit and sucking out the juices and softened pulp.

The present study was undertaken to complement the information of Macía (1997), as well as to enhance the existing data on the chemical composition of *S. purpurea* and to assess its nutritional quality. In the following text, "ovo" will refer specifically to *S. purpurea.*

Materials and Methods

Ripe fruits (5 kg) were collected during the peak of the harvest at the end of March 1995 in the village of Ambuquí, Province of Imbabura, in the north of Ecuador. This village has two areas of production, "sector del pueblo" and "sector de la playa." In "sector del pueblo" a 1150 m^2 plot was selected containing 117 trees which produced 750 kg of ovo in 1995; only 25% (188 kg) of this production was harvested as tree-ripened fruit, the remainder having been harvested green for transport to market (Macía 1997). As our sample represented 2.7% of the production of ripe ovo produced in "sector del pueblo" plot we consider it a valid sampling of this one area, but not of ovo produced nationally. Given the lack of current large scale industrial interest in processing the fruit a more rigorous sampling and replication of analyses to determine the variation in the quality of ovo produced nationally could not be justified.

Upon arrival in the laboratory, samples of pulp and peel were taken for immediate analysis of moisture, pH, °Brix and aromatic compounds. Pulp and peel separated from the remaining fruits were combined and freeze-dried, ground to the consistency of flour and stored at −80°C until analysis. All values obtained for freeze-dried material were subsequently corrected to a fresh weight basis. With the exception of analysis of the aromatic volatiles in ovo, all analyses were performed on duplicate samples of plant material.

Moisture content was determined for fresh and freeze-dried plant material by oven drying for 4 h at 102°C, fat by Mojonnier-type extraction with diethyl ether, protein as Kjeldahl nitrogen × 6.25 (Kjeldahl nitrogen determined with Büchi digestion and distillation apparatus, Büchi Laboratoriums-Technik AG, Flawil, Switzerland), and minerals (ash) by incineration at 550°C for 4 h. Crude fiber was determined on defatted samples using the Fibertec system (Tecator A. B., Höganäs, Sweden) which involved a sequential extraction with 1.25% H_2SO_4 then 1.25% NaOH, drying the residue for 4 h at 102°C followed by incineration for 30 min at 600°C; the difference between the dry weight and ash content of the residue is taken as an estimation of the crude fiber content. Total carbohydrates were calculated as the difference, i.e., 100% − (% moisture) − (% protein) − (% fat) − (% ash). The caloric value per 100 g edible portion was calculated according to the system of Atwater, namely: kcal = (3.36 × % protein) + (3.60 × % total carbohydrate) + (8.37 × % fat) (Merrill and Watt 1973). The pH of the pulp was measured directly and the °Brix determined at 20°C with an Atago refractometer.

Starch was determined enzymatically according to the procedure described by Boehringer Mannheim (1989). Plant material for pectin analysis was extracted three times with boiling 80% ethanol to remove compounds which could interfere with the analysis. Residual ethanol, which can also interfere with the analysis, was removed azeotropically with diethyl ether. Total pectic substances were then extracted three times with 0.5% EDTA and quantified according to the procedure of McCready and McComb (1952).

Fructose, glucose, sucrose, and organic acids were determined by HPLC. The lyophilized plant sample was extracted for 20 min with distilled and deionized water at 60°C, neutralized to pH 7 and brought to 100 ml. After centrifugation, 20 ml of the supernatant liquid was passed through a column containing 4 ml of Dowex 1-X8 anionic exchange resin (100–200 mesh), and the resin rinsed with 5 ml of distilled and deionized water. The sample plus the rinse were then passed through a column containing 4 ml of Dowex 50W-X8 cationic exchange resin (100–200 mesh). The resin was rinsed with 5 ml of distilled and deionized water, and the rinse added to the eluate. The eluate was treated with Carrez solutions to precipitate any proteins present, adjusting the final volume to 50 ml. After centrifugation, an aliquot of the supernatant liquid was filtered (micropore filter, 0.2 μm) and 20 μl injected onto a Bio-Sil Amino 5S column (Bio-Rad) for the analysis of sugars. The mobile phase was acetonitrile: water (70:30) at a flow of 1.0 ml min^{-1} and 6.6 MPa: sugars were detected using a refractive index detector (Perkin-Elmer LC-25 RI detector; range dRI $\times 10^{-6} =$ 50, at 20°C).

Organic acids were eluted from the Dowex 1-X8 column with 10 ml of 2 N HCl. An aliquot of this eluate was filtered (micropore filter, 0.2 μm) and 20 μl injected onto an Aminex Ion Exclusion HPX-87H column (Bio-Rad) for the analysis of organic acids. The mobile phase was 0.01 N H_2SO_4 with 0.01% sodium azide at a flow rate of 0.6 ml min^{-1} and 4.2 MPa: organic acids were detected using a refractive index detector (Perkin-Elmer LC-25 RI detector; range dRI $\times 10^{-6}$ = 50, at 20°C).

Minerals were determined by flame atomic-absorption spectrophotometry (Model 4000, Perkin-Elmer, Norwalk, CT, USA), adding a solution of lanthanum chloride for the analysis of calcium.

Aromatic volatiles were determined by simultaneous steam distillation-extraction of 560 g of ovo pulp + skin for 90 min using water and *n*-pentane (method of Nickerson and Likens 1966, as modified by Maarse and Kepner 1970). For analysis, 5 μl of the organic fraction were injected into a Hewlett Packard 5890 Series II gas chromatograph coupled to a 5970 mass selective detector. Instrumental conditions were: injector temperature = 200°C; helium linear flow = 28.2 cm s^{-1}; and column = Hewlett-Packard Ultra 2, 25 m × 0.2 mm diameter with a film thickness of 0.33 μm; impact energy = 70 eV; tuning was by autotune using perfluorotributylamine. The temperature program was: hold 50°C for 1 min, increase temperature by 3°C min^{-1} to 160°C, hold 160°C for 2 min, increase temperature by 2°C min^{-1} to 220°C then by 10°C min^{-1} to 290°C, hold 290°C for 2 min. Compounds were tentatively identified by comparison of their mass spectra to those of pure compounds stored in a user-created library. Results for individual compounds are reported as their percentage of the total area of peaks in the total ion chromatogram ("abundance" in Table 2).

Results and Discussion

The values for the following analyses performed on ovo in this study are included within the ranges given in Table 1: moisture 79.7%, protein 0.9%, fat 0.24%, fiber 0.4%, ash 0.7%, total carbohydrates 18.1%, food energy 70 kcal, sucrose 7.21%, calcium 17 mg, iron 0.30 mg, sodium 9 mg, and potassium 230 mg. In addition to an analysis of the aromatic volatiles in ovo, this study also contributes values for starch, pectins, fructose, glucose, zinc, pH, °Brix, citric acid, malic acid, oxalic acid, and tartaric acid, not previously reported for ovo.

The ripe fruits of ovo most closely resemble over-ripe plums, and for this reason the nutritional evaluation was performed as a comparison with other drupe fruits, four from the family Rosaceae (plum, apricot, cherry, and peach) and one from Anacardiaceae (mango; Table 1). In ovo as purchased, the seed accounts for 34% of the weight of the fruit and the peel another 8% (Leung and Flores 1961): the pulp can account from 50–58% of fresh fruit weight (Leung and Flores 1961, Winton and Winton 1935).

In describing the food uses of *S. purpurea* Morton (1987) stated "while [the ripe fruits are] not of high quality, they are popular with people who have enjoyed them from childhood," yet ovo shows the highest energy value of the fruits compared in this study, due principally to its higher concentrations of total carbohydrates (Table 1). The fruit is rather sweet as attested by its high sucrose and fructose concentrations. The total concentrations of the three sugars quantified account for 65% of the total soluble solids measured as °Brix. The fiber content of ovo is uncharacteristically low for fruits, while there is a considerable amount of starch in the ripe fruit (the starch content of the unripe fruit is higher still, at 8.45 g per 100 g edible portion). The free sugars and starch are readily available as fermentable substrates, which is taken advantage of by local people to produce a very refreshing and incredibly effervescent wine.

Although the pectin content is rather low, it is still sufficient for producing a jam without the need to add more pectin. Given the acidity of

TABLE 1. COMPARISON OF CHEMICAL COMPOSITION OF OVO (*S. PURPUREA*) WITH OTHER FRUITS, PER 100 G EDIBLE PORTION.

		Ovo			Other drupe fruits[a]				
Component	Unit	Range	Average	Ref[b]	Plum	Apricot	Cherry	Peach	Mango
Moisture	g	65.0–87.0	77.6 (9)	[1–8]	83.7	85.3	82.8	87.5	82.0
Protein	g	0.1–1.0	0.7 (9)	[1–8]	0.6	0.9	0.9	0.8	0.6
Fat	g	0.03–0.8	0.2 (7)	[1–4, 6]	0.2	0.1	0.4	0.1	0.3
Fiber	g	0.2–0.7	0.5 (8)	[1–7]	1.7	1.9*	1.9	0.8	1.7
Minerals (ash)	g	0.3–1.1	0.7 (9)	[1–8]	0.5	0.7	0.5	0.5	0.5
Total carbohydrates	g	16.0–22.3	19.1 (5)	[1–5]	11.9	9.9	12.7	8.7	12.8
Food energy	kcal	61–86	74 (5)	[1–5]	52	44	58	39	56
Starch	g		2.47	[1]	0*	traces	0*	0*	0.3*
Pectins	g		0.22	[1]	0.8	1.0	0.4	0.5	
Fructose	g		2.53	[1]	2.1	0.9	5.5	1.3	2.6
Glucose	g		2.00	[1]	2.7	1.7	6.1	1.2	0.9
Reducing sugars	g		8.08	[8]					
Sucrose	g	5.97–7.21	6.59 (2)	[1,8]	2.8	5.1	0.2	5.4	9.0
Calcium	mg	6–25	17 (8)	[1–7]	14	16	17	8	12
Phosphorus	mg	32–56	42 (7)	[2–7]	18	21	20	23	13
Iron	mg	0.09–1.22	0.72 (8)	[1–7]	0.4	0.7	0.4	0.5	0.4
Sodium	mg	2–9	6 (2)	[1,3]	2	2	3	1	5
Potassium	mg	230–270	250 (2)	[1,3]	221	278	229	205	190
Zinc	μg		20	[1]	70	70	150	20	100*
Carotene[c]	μg	4–225	119 (6)	[2–7]	210	1790	84	440	2770
Thiamine	μg	33–110	84 (7)	[2–7]	70	40	40	30	50
Riboflavin	μg	14–80	40 (7)	[2–7]	40	50	40	50	50
Niacin	mg	0.4–1.8	1.0 (7)	[2–7]	0.4	0.8	0.3	0.9	0.7
Ascorbic acid	mg	26–73	49 (7)	[2–7]	5	9	15	10	39
pH			3.29	[1]					
°Brix			18	[1]					
Citric acid	mg		30	[1]	34	400	13	240	296
Malic acid	mg		110	[1]	1220	1000	940	330	74
Oxalic acid	mg		30	[1]	12	3	7	0	36
Tartaric acid	mg		20	[1]			traces		81

[a] Data from Souci, Fachmann, and Kraut (1986) for plum (*Prunus domestica*), apricot (*Prunus armeniaca*), cherry (*Prunus avium*), peach (*Prunus persica*), and mango (*Magnifera indica*), respectively, except data marked with an asterisk (*) which are from McCance and Widdowson (1991).

[b] Source of data for ovo: 1, this study: 2, División de Investigaciones en Alimentos (1983) for "ciruela de huesito"; 3, Duke and Atchley (1986) for *Spondias purpurea*, citing data from Leung, Butrum and Chang (1972); 4, Instituto Nacional de Nutrición (1965) for "ciruela hobo"; 5, Leung and Flores (1961) for "mombin, purple ('jobo')"; 6, Morton (1987) for "purple mombin"; 7, Sturrock (1959) for "red mombin"; and 8, Winton and Winton (1935) for "red mombin". Some of the published sources listed single values, others a range of values. Where ranges were reported, the high and low values were included in the calculation of the "Average" given in the Table, and the number of values averaged given in parenthesis after each value. Where a range of values was averaged, the number of values averaged will be greater than the number of authors cited.

[c] As the lowest value reported by Morton (1987) for carotene (4 μg) is almost 17 times lower than the next lowest value reported in the literature (66 μg both by the División de Investigaciones en Alimentos 1983 and by Sturrock 1959) we must assume some error either in reporting or in analysis. This suspiciously low value has therefore been excluded in the calculation of the average value of carotene. To standardize the presentation of the data, carotene content was calculated from the vitamin A value reported by the Instituto Nacional de Nutrición (1965) and from the retinol equivalents reported by the División de Investigaciones en Alimentos (1983).

the fruit (pH = 3.3) and the formation of jams without additional gelling agents, it is most likely that native pectins are of the "high methoxyl" type, i.e., with degrees of esterification in excess of 50% (Mitchell, Buckley, and Burrows 1978).

Ovo is a moderate source of potassium (i.e., providing between 100 and 300 mg per serving; Guthrie 1979). Although potassium is recognized as a dietary essential, no minimal requirements have been established; rather, requirements for growth per day are estimated to average 15–20 mg/kg body mass for children 1–10 years old and 35 mg/kg body mass for adolescents (National Research Council 1989). We calculate that a 100 g edible portion of ovo would provide 63% of the potassium requirements for children 4–6 years old, 44% for children 7–10 years old, 16% for adolescents 11–14

TABLE 2. VOLATILE FLAVOR COMPOUNDS IDENTIFIED IN *S. PURPUREA*.

Compound	Abundance	Odor quality
Hexanal	6.95	Fatty, green grass-like[a]
2-Hexenal	38.99	Green, fruity, vegetable-like[a]
3-Methylbutyl acetate	0.22	Fruity, pear-like, banana-like[a]
4-Penten-1yl-acetate	1.29	
3-Methyl-2-buten-1-ol acetate	1.30	
Ethyl 2-methyl but-2-enoate	0.19	
2-Heptenal	0.07	Pungent green, somewhat fatty odor, pleasant only on extreme dilution[c]
2,6,6–Trimethyl-2-ethylenetetrahydro-2H-pyran	0.20	
2,4-Heptadienal	0.08	Rotten apple, rancid, hazelnut[d]
Ethyl hexanoate	0.89	Fruity, floral, wine-like[a]; powerful fruity with pineapple-banana note[b]
3-Hexen-1-ol acetate	0.88	
Trans-Ocimene	0.03	Warm, herbaceous[a]
Phenylacetaldehyde	0.04	Pungent green, floral, sweet, wallflowers-like[a]
α-Pinene	0.12	Floral, warm, resinous, pine, cedar-wood like[a]
Linalool oxide	0.40	Sweet, woody, floral, earthy[a]
Methyl benzoate	0.76	Fruity, similar to cananga[c]
α-Terpinolene	1.19	Floral, sweet, pine-like[a]
Methyl 4-pyridinecarboxylate (methyl isonicotinate)	0.05	
Ethyl benzoate	0.21	Blackcurrant-like[a]
Methyl 2-hydroxybenzoate	0.49	
Ethyl octanoate	0.45	Apricot-like, banana-like, wine-like[a]
3-Ethyl-5-methyl-1-propyl-cyclohexane	0.26	
1,1,6-Trimethyl-1,2-dihydronaphthalene	0.11	
Ethyl decanoate	0.47	Floral, sweet, oily nut-like, brandy-like[a]
Ethyl dodecanoate	0.55	Faint fruity, flower petal-like, slightly mango-like[a]
Tetradecanoic acid	3.07	Faint waxy, oily[a]
Ethyl tetradecanoate	0.66	Oily, ethereal, violet-like, orris-like[a]
1,2-Benzenedicarboxylic acid	0.52	
Hexadecanoic acid	18.51	Virtually odorless[a]

Values for "abundance" are the percentages of the area of the total ion chromatagram represented by the peaks of each of the compounds identified. References cited as to the odor characteristics of the compounds identified are:
[a] Shibamoto and Tang (1990).
[b] Engel, Heidlas and Tressl (1990).
[c] Furia and Bellanca (1975).
[d] Kochhar (1996).

years old, 12% for adolescents 15–18 years old, and 10% for adults.

The vitamin C (ascorbic acid) content of ovo is the highest of the fruits compared, and a 100 g edible portion would provide 98–123% of the recommended dietary allowance (RDA) for children 1–14 years old, and 82% of the RDA for people over 14 years old (National Research Council 1989).

Table 2 presents some of the volatile compounds we were able to identify by comparison of their mass spectra with those in our mass spectrum library of volatile aromatics; where the information was available, the literature reports of the odor characteristics of these compounds is also given. The major aromatic compound was 2-hexenal, whose peak area represented 38.99% of the total ion chromatogram. Unfortunately the chromatographic analysis could not distinguish between the *E* and *Z* isomers of 2-hexenal but their odor and taste thresholds are similar, with both showing an odor threshold of

0.01 ppm and taste thresholds of 0.06 and 0.08 ppm for the *E* and *Z* isomers, respectively (Hatanaka 1993). Although this compound is the most abundant, it is unlikely as in most fruits that the aroma of ovo derives principally from one compound, but rather from the complex interaction of the various aromatics present.

Economic Prospects

Between 1965 and 1994, the area devoted to the cultivation of ovo in Ecuador fluctuated between 400 and 1900 ha, with 1987 and 1990–1992 representing the only years in which more than 1800 ha were devoted to this fruit and in which more than 4500 metric tonnes were harvested (INEC 1987–1995, MAG 1994). The highest yield reported was 10 000 metric tonnes, which we estimate would be sufficient to make industrial processing of the fruit commercially viable (depending on the food product being produced, an industrial processor would probably need about 4500 metric tonnes of ovo per year). Current production levels, i.e., well below 4500 metric tonnes a year, necessarily limit commercial possibilities to processing ovo at the level of a cottage industry or small industrial scale.

Cottage Industry

In Ambuquí, 75% of the production of ovo is harvested green: these fruits ripen in 4–5 days and have a shelf life of an additional 2–3 days. Tree-ripened fruit has a shelf life of only 1–2 days after picking. As ovo is a soft fruit that is easily damaged during transport and as it has a limited shelf life the international exportation of ovo as a fresh fruit is rather restricted, especially given the scarcity of refrigerated and/or modified atmosphere storage facilities and shipping containers to delay ripening and prolong shelf life. Most of the production of ovo is destined for markets in the larger Ecuadorian cities, and although there are "local" reports of some exportation to Colombia and Perú (Macía 1997), no official register of such international trade exists. Its sale as a fresh fruit also limits the income of the small holders as the majority of the profits go to the middlemen who buy the fruit in bulk and transport it to the markets in the larger cities (Macía 1997). In Ambuquí, increases in tourism and a change to the cultivation of more profitable crops such as beans, tomatoes, and grapes combine to decrease the amount of land and effort dedicated to the cultivation of ovo.

To assure any economic future for ovo the small holders must concentrate on "value added products" rather than on the sale of fresh fruits. For example, small holders may be paid US$ 0.10–0.30/kg of fresh fruit (higher prices at the beginning of the season) whereas a 300 g jar of jam could be sold for US$ 1.45. With production costs[2] for such a jam roughly estimated at US$ 1.00/kg the small holders' profit increases to about US$ 3.83/kg of ovo processed. Distribution, however, still remains a problem and one must travel to the areas of production to purchase such products as the jam, ice cream and alcoholic beverages: marketing and advertising are virtually nonexistent. More aid from national and international sources is needed to help the cottage/small industry produce and promote ovo and ovo-based products.

In addition to the traditional products of jams, ice creams and alcoholic beverages, cottage production of an ovo vinegar, ovo flavored hot chili sauce, and dried fruit slices could be viable new products. In the coastal Province of Manabí (Ecuador) there is a cottage industry producing a banana vinegar which is unusual in that it results from a mixed acid fermentation. The best vinegars have acetic and lactic acids in a 2:1 ratio, which gives a pleasantly "rounded" acidity that complements the slight banana flavor of the vinegar. The high concentration of fermentable substrate in ovo, combined with its aroma, might yield an interesting fruit vinegar. Recently, a small food company has started marketing, and even exporting, hot chili sauces which are flavored with local fruits such as maracuyá (an acidic and aromatic passion fruit, *Passiflora edulis* var. *flavicarpa*). An ovo flavor might be an interesting addition to such a range of products.

[2] For producing a jam 33% ovo and 50% sugar by weight the production costs were calculated on the basis of: sugar purchased in bulk, US$ 0.40/kg; glass jars with metal lids purchased in bulk, US$ 0.21/each; and fuel US$ 0.10 to produce 1 kg of jam. The basic jam recipe was assumed to be 1 kg ovo, 1.5 kg sugar and 0.5 kg water. For 3 kg of jam: total production cost, US$ 3.00; sales US$ 14.50; profit US$ 11.50. Costs of fruit and labor were not included as these would be provided by the small holders. Overheads such as electricity and water were excluded as well.

Industrial

Being highly aromatic, ovo could probably be used industrially as an "exotic" fruit or flavoring for the extension of existing food product lines such as jams, candies and other sweets, ice creams, juices, and alcoholic beverages (perhaps most appropriately liqueurs as the unusually effervescent fermented beverage produced by the cottage industry has a tendency to cause bottles to explode). Ovo might even conceivably find a niche as an exotic fragrance in cosmetic products such as soaps, shampoos, hand creams, body lotions and other personal care products. Before ovo can be successfully commercialized on an industrial scale, food manufacturers will need to be convinced that its flavor is sufficiently "exotic" yet agreeable to consumers, that its use would contribute a competitive edge when extending product lines, and that sufficient supplies of the raw material of appropriate quality are available for processing.

Although an industrial interest in ovo would most likely provide the needed impetus for improvement of varieties in terms of yield, fruit to seed ratio, disease resistance, as well as improvements in methods of cultivation and postharvest management, the industry would not be likely to hold its interest in abeyance until such time that sufficient quantities of ovo of appropriate quality become available for processing. Nor would the small holders be likely to fare better economically by selling fruit to industrial processors rather than to the middlemen who currently market the fresh fruit.

Conclusions

Although ovo is valued as a seasonal treat, only its vitamin C content will have an important, albeit short-lived, nutritional impact on consumers. With few exceptions, yearly production has been under 4500 metric tonnes, implying that the per capita consumption of ovo in Ecuador is well below 650 g/year. It is uncertain to what extent local consumption could be expanded. International commercialization of ovo as a fresh fruit would require costly investment in improved post-harvest management (cold storage and/or modified atmosphere storage) and shipping facilities. Foreign purchasers would have to be assured of a reasonable shelf life for the sale of the fruit. A more promising economic future for ovo would derive from the promotion of cottage/small industry production of ovo-based products, which might eventually catch the interest of large-scale industrial food producers.

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