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THE APPLE AND ITS FRUCTOSE CONTENT CULTIVAR SANSA – A CASE STUDY

MAÇÃS E SEU CONTEÚDO DE FRUCTOSE CULTIVAR SANSA – UM ESTUDO DE CASO

Gilvan Wosiacki[1*], Nelci Catarina Chiquetto Silva[1], Alessandro Nogueira[2], Frederico Denardi[3]

[1*] Autor para contato: Universidade Estadual de Ponta Grossa - UEPG, Departamento de Engenharia de Alimentos, Campus em Uvaranas, Ponta Grossa, PR, Brasil; (42) 3220 3093; e-mail: wosiacki@uol.com.br

[2] Universidade Estadual de Ponta Grossa - UEPG, Departamento de Engenharia de Alimentos, Campus em Uvaranas, bolsista recém-doutor do CNPq

[3] Pesquisador da Estação Experimental de Caçador, EPAGRI/SC

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ABSTRACT

Besides the high fructose content, the level of malic acid and of phenolic compounds clearly show apples as fruits with industrial appeal and it is possible to discriminate the cv. **Sansa** as a good alternative of raw-material for processing purposes, especially for the clarified juice healthy for obese person or for those with an insulin deficiency being assisted by a physician.

Key words: fructose, apple**,** sugars, processing

RESUMO

Não somente o elevado conteúdo de fructose, mas também os teores de ácido málico e de compostos fenólicos claramente indicam as maçãs como frutas com forte apelo industrial. Dentre elas é possível discriminar a variedade Sansa como uma boa alternativa de matéria-prima para processamento especialmente visando a obtenção de sucos clarificados saudáveis para pessoas obesas e para pessoas que apresentam deficiência na produção de insulina desde que sob controle médico.

Palavras-chave: frutose, maçã, açúcar, processamento, apelo nutricional

The apple in the history of the occidental civilization

From places with a well-defined mildly cold climate in Asia, apple trees were easily domesticated in similar climatic conditions all over the world. Indeed, many countries such as Chile, New Zealand and France are now excellent apple producers, besides China, which has always been the biggest apple producer in the world, with around 21 millions ton of fruit (www.abpm.org.br; Ping and Feng, 2000).

As to fruits produced under mild or subtropical climates, grapes are the most important, both in qualitative and in quantitative aspects, and the apple production reaches the second position, always in a close competition with oranges. But none of them show the "glamour" of apples, which are still one of the most important symbols in Occidental civilization: Paradise and the forbidden fruit, Snow White and the poisoned apple (was it Red delicious?), the Trojan war and the apple of discord (was it Golden delicious?), Newton under an apple tree and the Law of Universal Gravity, Wilhelm Tell shooting an arrow at an apple on his son's head, among so many other examples that have been used by people all around the world.

The apple contains bioactive compounds

The popular English saying "an apple a day keeps the doctor away" has a strong scientific basis on the pectic substances and malic acid contents, but nowadays this idea could be expressed with the interesting parody "an apple a day keeps *diabettes* away", stressing a functional-appeal among many other already known presented by the fruit (www.appleproducts.org). Among the several bioactive compounds found in apples, fructose should be highlighted because it makes the fruit and some of its products display important features, such as a high sweetness level allied to a low caloric value, with little impact on human glicemy considering its preferential utilization as fuel by intestinal epitelium cells.

The apple contains special carbohydrates

Some vegetal structures called plastidia give support to the fixation of the CO_2 from the atmosphere and the starch formation is somehow the final target reached through an anaerobic metabolism in which carbohydrates with 3 up to 7 carbon units are interconverted. These compounds are metabolites from the shunt of pentoses-phosphate and one possible product, sorbitol, is indeed very important in the composition of apples. Sucrose can be synthetized only in vegetal tissues and is a soluble compound able to flow in order to translocate carbohydrates for starch synthesis. This polysaccharide is stored as a chemical energy reservoir that may be activated for energy purposes, as well as to promote special bioconversion, like the **de novo** synthesis of sucrose and to liberate glucose and fructose, its components. Researches made with apple starch (Fig.1) were able to show that its granules, very sensitive to the isolation procedures, were similar in shape to those from cassava, but after pasting the rheology was **short** type and the gel itself was very strong like that of corn starch. It is interesting to note that the clarity of apple starch paste was intermediary to that of both control starches (Demiate *et al.*, 2003).

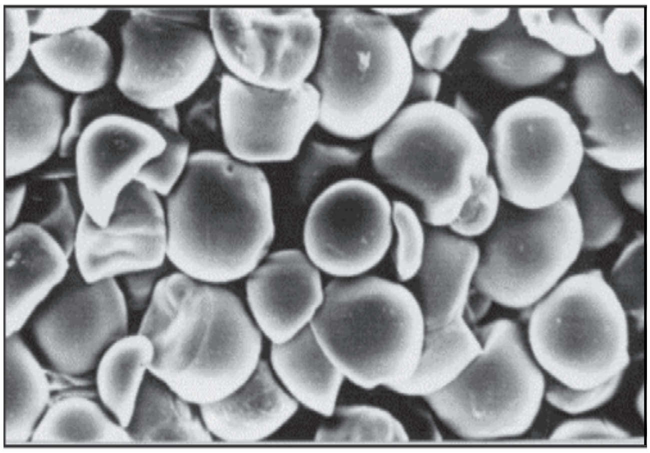

Figure 1 - Apple starch granules.

The apple and its main sugars

Some reports in the late 1980's showed the composition profile of apple samples as well as many other commercially important fruit (RSK, 1985). They discriminate some fruits that are rich in fructose or in glucose or even others that are in equilibrium with similar amounts of both sugars. So, it is statet that glucose, fructose and sucrose are the main sugars in apples and may be derived from the starch methabolism. Thus, it does not seem correct to use the term “inverted sugar” for this set of sugar because they have nothing to do with yeast invertase, but there are some authors who use this name for vegetal sucrases, showing that there is the acid one, whose evolution shows a peak in unripe fruits, and the neutral one, in ripe apples (Berueter and Studer Feusi, 1997; Berueter, Studler, Rueedi, 1997). The authors, after determining some enzymatic activities during ripening, stated that starch is primarily synthesized from precursors from sucrose synthesis. After forming sorbitol and sucrose, the ripening fruit accumulates fructose and sucrose, and the starch peaks aproximately in the middle of the development period. The authors also showed that the fructose content positively correlates with sorbitol dehydrogenase, but inversely with frutokinase, making evident the reduction of NAD^+ and the formation of fructose. Fructose is indeed the main sugar in apples reaching around 70% of the soluble sugar fraction as found in the analysis made from juice obtained from several commercial and experimental apples in several seasons (Kimura *et al.*, 2003; Czelusniak *et al.*, 2003; Wosiacki, Pholmann, Nogueira, 2004).

Sucrose synthesis, as a classical example of glycoside formation, occurs only in vegetal tissues and demands the participation of UDP-glucose in order to act as a glucosil donor to fructose-phosphate (Mahler and Cordes, 1971). Such a reaction is not a common one because it joins together two anomeric carbons leading to a non-reducing sugar, with a low energetic demand (ΔG^0 = -1 kcal/mol). However, sucrose-phosphate dephosphorilation and pyro-phosphate hydrolysis explain the presence of sucrose that has a high hydrolysis free energy (ΔG^0 = - 6.6 kcal/mol). After hydrolysis by sucrase, glucose and fructose are delivered as reducing sugars (Nelson and Cox, 2000).

The three soluble sugars in apple juices

Such metabolic pathways explain the presence of the three soluble sugars but not necessarily their relative percentage, an atribute that each kind of fruit has particularly. Apparently, the metabolism of carbohydrates in apples is specialyzed to use glucose as a fuel, and fructose accumulates as a consequence of the sorbitol oxidation recovering with the coenzymes $NADH^+$, the necessary chemical energy for reactions that need ATP. UDP-Glucose is also the substrate for the synthesis of glycuronides in animals and for ascorbic acid in vegetals. As results of sugar analysis in depectinized apple juices processed with raw material colleted in many seasons it may be stated the relative amount of fructose [1,0], glucose [0,25] and sucrose [0,45] (Fig.2) (Kimura *et al*, 2003; Czelusniak *et al*, 2003; Wosiacki, Pholmann, Nogueira, 2004), what is in agreement with the literature (RSK, 1985). If only total monossaccharides were considered, the relationship fructose : glucose would be 1,0 : 0,43.

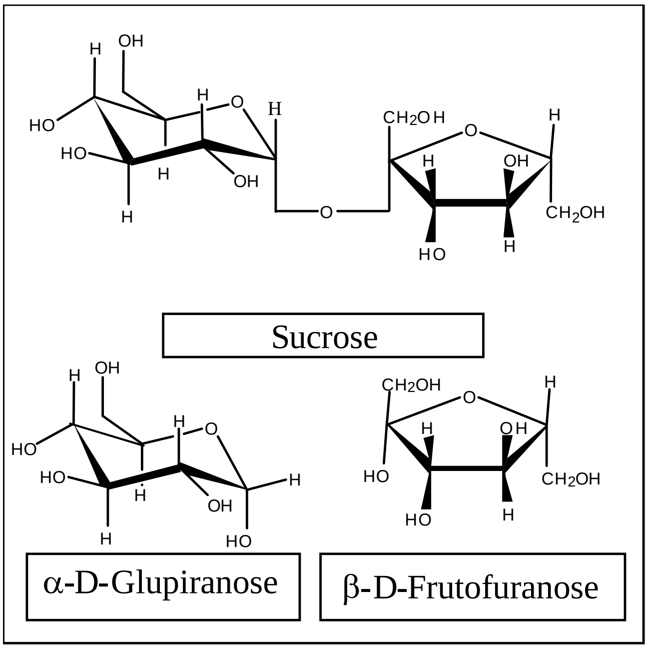

Figure 2 - Products of sucrose hydrolyses.

Fructose and apple juice quality

In many countries the law does not allow the addition of any substances during apple juice processing, not even those recovered from the fruit itself, such as malic acid. Not even the addition of pear juice is allowed. In order to correct the composition of clarified apple juice it is possible to add more acidic, or sweeter, or bitter apple juice. However fructose exists in considerable amounts in apples, reaching an average value of 69% of the total soluble sugar (Kimura *et al.*, 2003; Czelusniak *et al*., 2003; Wosiacki, Pholmann, Nogueira, 2004), and to add something to modify juice and to restore the original level of carbohydrates with High Fructose Syrup may be seen as an atractive option to adulterate juices because it is dificult to detect it. In such cases the correcting agent is fructose syrup, which may be obtained through starch or inulin hydrolysis. Nowadays, however, it is possible to confirm the fraud looking for the presence of oligofructossaccharides not naturally present in apple juice by the HPLC technique (Balmer and Mclellan, 1997). When the adulteration is done with pear juice a simple determination of the amount of prolin is enough to confirm it (RSK, 1985). By the way, it is possible to add pear juice up to 30% in order to have a proper must which, when fermented, can produce an alcoholic beverage like cider.

Yeast - aerobic and anaerobic metabolic pathways

The mixture of these sugars in apple juice enables the yeast to assimilate carbon and grow under aerobiosis and to produce alcohol in anaerobiosis, because it is supposed to be a facultative anaerobic microorganism. Sucrose is hydrolysed by invertase (b-frutofuranosidase)**,** a unique example of a case in which the enzyme is still linked to the cellular wall structure of the microorganism (Figure 3). After a chemical treatment with calcium carbonate it is possible to obtain, in the laboratory, a preparation still nominated *Lebedev juice,* with a high activity of the enzyme; this enzyme recognizes the fructosyl side of sucrose and promotes the remotion of the aglicon fraction, namely glucose. As to energy the aerobic process mobilizes less carbohydrates in order to form a microbial biomass but in anaerobic condition the cell demands 19 times more sugar to reach the same energy yield because the oxidation is partial when alcohol is accumulated and CO_2 is liberated into the atmosphere. Once in the microbial cytosol, the soluble sugars glucose and fructose are substrate for glycolysis being quickly mobilized. In this step the activity of three enzymes is necessary to activate these free sugars: Hexokinase PI and PII are able to phosphorilate glucose and fructose although with quite different yields, glucose being a preferable substrate. On the other side glucokinase is specific for glucose at high concentrations of the substrate (D'Amore *et al.,* 1989; Marc, 1982). Fermentation is a natural procedure and the must usually contains all nutritional requirements for microbial cells and it is also possible to add some microbial inhibitors, such as potassium meta bisulphyte, able to prevent wild yeast growth (Ribereau-Gayon *et al*., 1998).

The microbial activity concerning the fermentation of total soluble sugar in apples is quite important, but there is another very important factor necessary to get a product of high quality. It is the composition in terms of phenolic compounds, the main molecules related to important features such as colour and visual perception, and taste and oral sensation. Both aspects are hedonistic approaches. The first one gives the consummer a certain curiosity and compels him to taste the beverage with a good visual appeal, a juice with colour, but clear and bright. The colour is due to the polymeric structure of condensed phenolic compounds and the clarity is a result of taking out the browning products of polyphenoloxidases. The brightness is a consequence of the high sugar content that increases the refraction index. The second one is related to taste, a quality marker that may provide the motivation for the periodical consumption of the product, and which in apple juice must be sweet, acid and adstringent in a harmonic balance according to the consumer's expectation. It must be taken into account that a person buys and drinks apple juice because of these hedonistic activators, and no attention is given to nutritional, caloric or dietary makers; vitamin C, for instance, may be found as a nutraceutical product available in any convenience store.

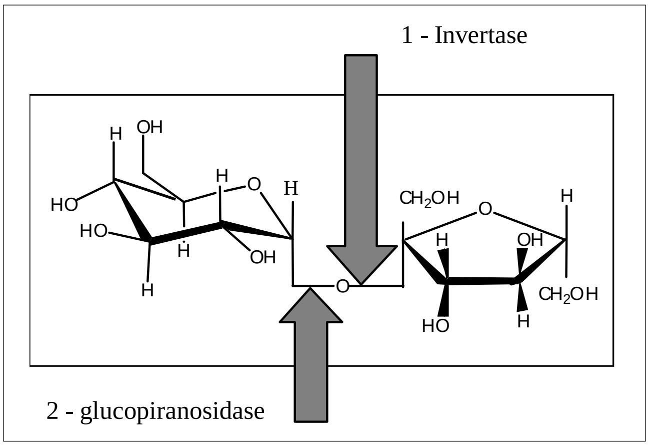

Figure 3 - Enzymes of sucrose hydrolyses.

Human metabolism and apple sugar utilization

It is easy to accept that sucrose – or the set of soluble sugars – is very important considering human utilization as one of the most important sources of carbon and energy. Sucrose is partially hydrolysed in the stomach by HCl, where pH may drops down to 1.0-1.5, but all remaining sucrose is recognized by á – glucopyranosidase from the pancreatic juice liberated in the duoden and both monosaccharides are ready to be absorbed in the intestinal tract. It must be stressed that both hydrolysis processes which occur in yeast or in human intestins give the same results in terms of monosaccharide production. Glucose absorption is done against a concentration gradient and so demands chemical energy from ATP to reach the portal blood system, where it raises glycemy and is conducted directly to liver. Fructose, without any specific carrier, difuses into the intestinal cells and in the cytosol is immediately recognized by frutokinase and is activated to enter the Embdem Meyerhoff Parnass pathways to be metabolysed down to pyruvic acid. About 50% of the total fructose absorbed goes to the blood stream in the form of lactate and is further metabolysed in the liver gluconeogenesis. Because of this behaviour, fructose may be considered a dietetic sugar for its role in glycemy, suppose to be small.

The functional appeal of fructose – *diabetes melitus* and obesity

Because in apples the fructose contents are high and those of glucose relatively small, one may conclude thats apple may have a functional appeal in relation to obesity, for sure, and to *diabetes*, with restrictions. Indeed, considering that sucrose is totally hydrolysed the system is actually fructose/glucose and so the input of 342g of sucrose represents the input of 2 x 180 g of the monossaccharide, which means an increase of 5% in total sugar. What happens in ***in vitro*** essays is the same as what happens ***in vivo***, both in yeast fermentation and in the human intestinal/blood system; 100 g of sucrose represents 105% of glucose/fructose. If it is considered total fructose and total glucose in apple as a binary system (sucrose will be totally hydrolyzed anyway), fructose may reach a high level of 83 and 85% of total sugar (cv. Sansa and Condessa, respectively, measured in the crop 2001) what suggests to be an especial food with an evident functional appeal. The fruit in itseft is considered GRAS in both pathologies and with such a level of fructose some studies should be done, from the production of up to their utilization by humans.

Some aspects to be considered concerning fructose metabolism

There are some disorders of fructose metabolism to be considered is one desires to promote the utilization of high fructose apple for human nutrition. All three disorders are inherited as autosomal recessive traits (Gitzelmann, Steinmann, Van Den Berghe, sd).

The first one is the *essential fructosuria*, a benign and asymptomatic metabolic anomaly caused by the absence of hepatic fructokinase. The main symptoms are alimentary hyperfructosemia and fructosuria. In spite of the interruption of the specific fructose pathway up to 90% of fructose is metabolized by fructokinase-deficient people through hexokinase in adipose tissue and skeletal muscle. This rare and benign error of metabolism was first described in 1876 but since is asymptomatic and harmless many cases may remain undetected. The presence of reducing sugars in urine in higher amount then glucose measured by enzymatic method suggests fructose or galactose error of metabolism.

The second, *hereditary fructose intolerance,* with severe hypoglycemia and vomiting shortly after the intake of the sugar, was first reported in 1956 and characterized in 1961. Prolonged fructose ingestion in infants leads to poor feeding, hepatomegaly, jaundice, hemorrhage, proximal renal tubular syndrome, hepatic failure and dead. The biochemical solution of this intolerance is the 1-6 bisphosphate aldolase of the liver, kidney cortex and small intestine; the enzymes in skeletal muscle and brain are not affected. Hypoglycemia after fructose ingestion is caused by fructose-1-phosphate that inhibits glycogenolysis at the phosphorilase level and gluconeogenesis at the mutant-aldolase level. As soon as the intolerance is suspected all food sources of fructose must be eliminated at once from both the diet and from medication, and the aldolase-deficient subject may have a high life quality.

The last one to be considered is *hereditary fructose 1-6 bisphosphatase deficiency*, reported in 1970 and characterized by episodic spells of hyperventilation, apnea, hypoglycemia, ketosis and lactic acidosis with often a lethal course in the newborn infant. The biochemical solution is the fructose 1-6 bisphosphatase absent in liver, jejunum, kidney and leukocytes, which is a key enzyme in gluconeogenesis. The gluconeogenesis is severely impaired due to the enzyme defect and the precursors like amino acids, lactate and ketones accumulate as soon as liver glycogen stores are depleted. It is not surprising that more then 50% of the afflicted infants become symptomatic within the first week of life when they are dependent on the metabolic pathway. On subsequent days the ingestion of milk and other foods seems to postpone further manifestations. In order to maintain the level of blood glucose the patients need an exogenous source of this sugar. The patients do not vomit after fructose intake and do not develop any aversion to sweets. Their tolerance to fasting grows with age and after childhood may develop normally.

Markers and criteria for the qualification of apples

Physichal and chemical profiles of Brazilian apple are *in concert* and nowadays the results of analyses are in the scientific media, from single articles in periodicals to scientific communications in technical meetings (Kimura *et al.*, 2003; Czelusniak *et al.*, 2003; Wosiacki, Pholmann, Nogueira, 2004)**,** and the new information network (www.uepg.br./gtm.htm). At the begining of the research some parameters were utilized such as total soluble solids, total titrated acidity, pH, and also derived atributes as the total sugar/acid ratio. As the work proceeded and the results were compared to the specialyzed literature, the real importance of markers of quality in smaller amounts became evident and it is possible to cite the [1] **total sugar** as glucose in g/100 mL, the [2] **total tritable acidity** as malic acid in g/100 mL, and the [3] **phenolic compounds** as mg/L of catechin. The number of quality markers may still drop down if one considers the [4] **sugar/acid ratio.** As criteria for quality profiles, the following values are being used everywhere: **0,45 g/100 mL,** to distinguish the acid from the sweet cultivar, and for total phenolic compounds, **200 mg/L,** to discriminate the bitter from the non-bitter, and the total sugar/acid ratio of **20** to indicate those with and industrial appeal and those useful as table fruit (LEA, 1995).

Physico-chemical classification of apples in Brazil

Brazilian apple fields have affected the socio-economical life in the Southern States especially those with high altitudes, including the South of Paraná, the Center of Santa Catarina and the Mountains in Rio Grande do Sul, transforming the landscape as well generating lots of possibilities for working people who live in small cities.

The chemical profile shown in Table 1 can be used to show that the sellected samples had total sugar contents with a small variation coeficient (12%), which indicates a homogeneous set. Higher values for total fructose were observed by cv Condessa and Sansa - higher then average values plus 1 standard deviation. The values found for malic acid contents were relatively low with an average of 0,28 g/100 mL; only cv Primícia has an average value higher then that used as conventional criteria. As to phenolic compounds, the results are a little more interesting, because cv. Imperatriz showed around 685 mg/L. The total sugar/acid ratio did not show any interesting variety from an industrial point of view.

Table 1 - Physical and chemical profile of apples harvested in 2001 in Brazil.

Cultivar	Total sugar g/100mL	Total fructose g/100mL	Fructose %	Malic acid g/100mL	Phenolic compound mg/L	Sugar/acidity Ratio
Imperatriz	12,11	8,56	70,69	0,32	685	37,84
Condessa	11,46	9,81	85,60	0,15	122	76,40
Melrose	8,25	5,02	60,85	0,34	239	24,26
Fred Hough	12,00	7,99	66,58	0,12	269	100,0
Baronesa	12,16	7,95	65,38	0,25	312	48,64
Belgolden	11,26	7,07	62,79	0,21	226	53,61
Fuji Suprema	11,46	7,48	65,27	0,32	259	35,81
Marquesa	9,10	6,48	71,21	0,22	270	41,36
Sansa	13,80	11,56	83,77	0,37	398	37,29
Primícia	10,83	7,06	65,19	0,48	353	22,56
Princesa	11,52	7,62	66,15	0,42	227	27,42
Catarina	12,70	8,80	69,29	0,34	425	37,35
Gala	10,62	7,82	73,63	0,12	222	88,50
Fuji	12,50	8,67	69,36	0,31	261	40,32
Average	11,41	7,99	69,69	0,28	304	47,95
Standard deviation	1,37	1,48	6,95	0,10	129	22,98
V.C. %	12,00	18,54	9,97	37,26	42,35	47,93

Note: *V.C. = variation coefficient. Adapted from: Czelusniak *et al*., 2003.

The results showed in Table 2 make clear that the fruit samples were very homogeneous in relation to ripeness, if one uses the total sugar content as a referential with a 6,80% variation coefficient only. At that time cv Sansa showed an average value that was not significantly different from the average of all samples. But in terms of total phenolic compounds, Imperatriz and Rainha have high values, thus showing a strong industrial appeal even with the low acidity level found in the set. It is worth mentioning that experimental cv MRC 11/95 and cv Eva are proper for juice and fermented beverage processing (Kimura *et al*., 2003).

Table 2 - Physical and chemical profile of apples harvested in 2002 in Brazil.

Cultivar	Total sugar g/100mL	Total fructose g/100mL	Fructose %	Malic acid g/100mL	Phenolic compound mg/L	Sugar/acidity ratio,
Gala	12,86	9,04	70,30	0,287	142	44,80
Eva	13,80	9,93	71,96	0,414	109	33,33
Fred	13,16	8,86	67,33	0,290	276	45,37
Imperatriz	11,87	8,73	73,55	0,301	407	39,43
MRC 11/95	12,81	7,89	61,59	0,508	127	25,21
Rainha	12,56	8,31	66,16	0,328	531	38,29
Sansa	14,88	10,49	70,50	0,356	575	41,79
Average	13,13	9,03	68,76	0,354	309	38,32
Standard deviation	0,89	0,83	3,75	0,075	181	6,56
V,C, %	6,80	9,23	5,46	21,13	58,77	17,13

Note: *V.C. = variation coefficient. Adapted from: Kimura *et al.*, 2003.

Table 3 shows that Sansa has some industrial appeal in relation to the relative fructose value and the absolute acidity value and phenolic compounds, all of them quite above the average, in agreement with the criteria for adequate raw material. The same quality markers were found in samples harvested in two different geographic places, Caçador and São Joaquim, both in Santa Catarina State. Although cv 'Granny Smith' shows the best industrial index, in this case the high phenolic compounds and sugar content suggest an inadequate ripeness state. Cv Eva showed a high amount of malic acid and Granny and Sansa the highest level of phenolic compounds (Santos *et al.*, 2004).

Table 3 - Physical-chemical profile of apples harvested in 2003 in Brazil.

Cultivar	Total sugar g/100mL	Total fructose g/100mL	Fructose %	Malic acid g/100mL	Phenolic compound mg/L	Sugar/acidity ratio
Gala	9,32	5,83	62,55	0,250	493	37,28
Fuji	10,17	6,29	61,85	0,346	374	29,39
Granny Smith	9,36	5,65	60,36	0,545	833	17,17
Fred hough	11,35	7,57	66,70	0,187	194	60,70
Condessa	10,99	8,64	78,62	0,337	275	32,61
Eva	13,09	8,87	67,76	0,406	219	32,24
Sansa CD	15,00	11,31	75,40	0,475	663	31,58
Sansa SJ	13,84	10,18	73,55	0,413	474	33,51
M-6/00	12,77	7,73	60,53	0,421	252	30,33
M-12/00	13,17	8,55	64,92	0,236	263	55,81
M-13/00	11,72	7,25	61,86	0,280	195	41,86
Average	11,89	7,99	66,74	0,35	385,00	36,59
Standard deviation	1,77	1,68	6,12	0,10	200,57	11,74
V.C. %	14,88	21,07	9,16	29,52	52,10	32,09

Note: *V.C.: variation coefficient, %. (Santos *et al.*, 2004).

The figures in Table 4 state the medium value 69.81% as the total fructose fraction for 11 cultivars and confirm the cv 'Condessa' and 'Sansa' as two promising raw material sources because they show the highest relative fructose contents. In relation to total acidity, the commercial cv. Belgolden and cv. Melrose and the experimental sellections Coop 25, Coop 26 e Malus 67/90 should be cited. As to phenolic compounds, cv. Coop 26, 'Sansa' and Malus 67/90 have higher amounts than the other samples (Wosiacki, Pholmann, Nogueira, 2004).

Table 4 - Physical-chemical profile of apples harvested in 1996.

Cultivar	Total sugar g/100mL	Total fructose g/100mL	Fructose %	Malic acid g/100mL	Phenolic compound mg/L	Sugar/acidity ratio
Belgolden	11,66	8,43	72,30	0,57	340	20,60
Coop 25	11,20	6,73	60,09	0,58	256	19,24
Coop 26	11,35	7,67	67,58	0,47	411	24,40
Fred Hough	11,24	8,45	75,18	0,21	251	53,52
M-51/90	11,88	9,00	75,76	0,31	284	38,20
Melrose	10,72	7,47	69,68	0,56	329	19,21
Marquesa	9,10	6,48	71,21	0,22	270	41,74
Romus 50	12,24	9,18	75,00	0,27	372	45,84
Sansa	13,90	11,56	83,17	0,37	398	37,57
Malus 67/90	12,79	8,96	70,05	0,63	418	20,40
Malus 71/90	10,44	6,50	62,26	0,15	213	71,02
Malus 72/90	13,15	9,56	72,70	0,13	236	98,87
Malus 92/90	12,34	8,50	68,88	0,35	406	35,26
Malus 94/90	10,97	7,72	70,37	0,30	263	36,08
Malus 59/91	13,75	9,12	66,33	0,34	288	41,42
Average	11.63	8.13	69.81	0.36	309.79	40.41
Standard deviation	1.15	1.00	4.45	0.16	66.78	21.64
V.C. %	9.91	12.33	6.38	44.78	21.56	53.54

Note: *V.C.= variation coefficient, %.. Adapted from Wosiacki, Pholmann, Nogueira. 2004.

Why Sansa was sellected

With the purpose of establishing quantitatively the functional appeal of apple varieties presenting a high level of fructose we made a statistical analysis of average values of the marker of quality previously sellected, which revealed that two of them – Condessa and Sansa - showed higher fructose fraction values than the average value of 70% (Wosiacki *et al.*, 2004). In order to further investigate this feature cv Sansa, a commercial pollinator produced simultaneously with cv 'Gala'was choose. Table 5 and Table 6 show the values found and discriminates the cv 'Sansa' as the one with the highest total sugar content (14%) and a fructose fraction of 77% in average, still presenting high malic acid content and total phenolic compounds, always one standard deviation above the average value, which means inside the limit of confidence of 95%. In all the essays done, the cv Sansa showed the highest levels of total sugar and total reducing sugar.

Table 5 - Average values for quality markers from the set of commercial and experimental cultivars (N= 46) produced in Brazil.

Selected cultivar	Total sugar g/100mL	Total fructose g/100mL	Fructose %	Malic acid g/100mL	Phenolic compound mg/L	Sugar/acid ity ratio
Average	11,61	7,93	68,22	0,329	307	42,00
Standard deviation	1,29	1,13	5,41	0,130	138	19,83
V.C. %	11,16	14,26	7,93	39,59	45,02	47,23

Source: Wosiacki *et al*., 2004.

Table 6 - Average values for quality markers from cv. Sansa (N= 4) produced in Brazil.

Cultivar Sansa	Total sugar g/100mL	Total fructose g/100mL	Fructose %	Malic acid g/100mL	Phenolic compound mg/L	Sugar/acidity ratio
Average	14,38	10,89	75,81	0,400	527	36,04
Standard deviation	0,65	0,66	5,68	0,050	115	4,51
V.C. %	4,51	6,02	7,49	13,25	21,96	12,50

Source: Wosiacki *et al*., 2004.

Evolution of fructose after total blooming

The production of sugars in fruit samples of cv Sansa proceeded in the seasons 2001/2002 and 2002/2003 and the results were absolutely congruent (Table 6). The samples were collected 50 days after full blooming and were frozen when they were unripe, but only refrigerated in the different stages of ripeness. The analysis showed results of the same magnitude in both experiments in such a way that it was possible to make a single table or plot to understand the evolution. Table 6 shows that after 60 days after full blooming the collected samples had some features of ripeness and the rate of sugar evolution showed some decreased. Fructose fraction showed some fluctuation, but could be considered stable and reached the level of 81%. Malic acid showed small fluctuation, being relatively constant all over the experimental period with an average value of 0.40 g/100mL while total phenolic compound decreased from higher levels at the beginning of the experiment and then remained on a level around 577 mg/L.

Table 7 - Sugar evolution after 50 days of full blooming.

DAFC*	Total sugar g/100mL	Total glucose g/100mL	Total fructose g/100mL	Fructose fraction %	Malic acid g/100mL	Total phenolic compounds mg/L	Sugar/acid ratio
50	2.10	0.41	1.69	80.48	0.47	7935	4.46
57	5.20	1.62	3.58	68.85	0.40	2479	13.00
60	6.54	2.27	4.27	65.29	0.56	1669	11.67
67	8.50	2.65	5.85	68.82	0.38	739	22.36
72	9.43	2.85	6.59	69.88	0.55	-	17.14
78	9.90	2.55	7.35	74.24	0.46	973	21.52
89	10.2	2.86	7.34	71.96	0.43	862	23.72
99	10.9	2.76	8.14	74.68	0.39	761	27.94
100	11.1	2.59	8.51	76.67	0.48	583	23.12
110	11.6	2.88	8.72	75.17	0.41	674	28.29
150	13.5	2.55	10.95	81.11	0.36	583	37.50

Note *DAFC= Days after full blooming. Shadowed lines indicate season 2003 samples and unshadowed lines indicate season 2002 samples.

Figure 4 shows the evolution of sugars during the 100 days actually covered by the experiment. The fructose fraction is higher then the general value of 70% demonstrated to occur in several apple cultivars in Brazil. Allied to such a high content of fuctose, the total acidity and the phenolic compounds reflects a set of chemical qualities desirable for a cultivar with industrial appeal, and so cv. Sansa emerges as a good alternative as a raw material for apple industry especially directed to the production of a clarified juice.

Some features of cultivar Sansa

Cultivar Sansa came from Japan. It was introduce in the market in 1988 after a 14 years selection procedure and it is the result of a crossing between cv Gala and cv Akane. It starts crop early and the species is highly productive, for in general it does not show any problems with bianual bearring. It is not affected with dropping in the pre-harvest period. It shows good resistence to *Alternaria* and to *V. inaequalis,* but it is susceptible to *C. gloeosporioides* and to *P. leucotricha*. It requires more chilling during winter then Gala and do needs a specific treatment to break the dormancy in places with an altitude lower then 1.300 meters. The blooming occurs between September 15 and October 15 varying according to the climante and it is more precocious in colder places. In general it flowers at the same time of Gala, being for this reason used as a commercial pollinator for this last. The fruit ripening 7-10 days before cv Gala allows for special market prices. The fruits are medium size, round-conical shaped, flatter in warmer places. The fruit stem a medium size diameter and also a length and diameter. The fruit skin is smooth, has a bright red coloration over a yelowish-green ground color. Under mild winter climatic conditions it shows more *russeting* than on cold areas. The flesh is cream white with a fine texture. It is juicy, crunchy and slightly aromatic. The fruits may be stored during 2-3 weeks at room temperatures and for a month in a conventional refrigerator. Concerning agronomical aspects, the main advantage of cv. Sansa is the precocity of fruit ripening - around 10 days before Gala -, facilitating the cultural practices in the orchard when used as pollinator for later ripening varieties.

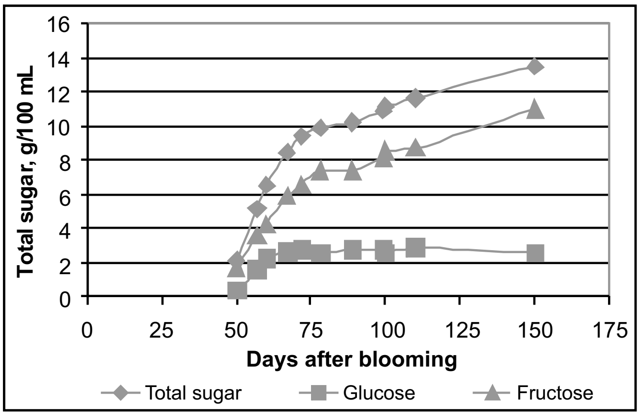

Figura 4 - Sugar evolution after blooming complet.

Prognosis

The cv. Sansa in Brazil does not have any commercial importance as commercial fruit producer for fresh market. Although it produces acceptable fruits for brazilian market, the plants are of high chilling requirement and the fruits show severe problems with 'russeting' and 'bitter pit', serious physiological disorders in the south of Brazil, with dramatic impacts on fruit appearance. On the other hand this cultivar is very efficient as pollinator for some other important commercial cultivars like Gala, Catarina and Fuji. As pollinator it participates with 10 to 12% of the plants in a commercial orchard, meaning 4.5 to 5.4 t/ha of fruit in an orchard of an average of 45 t/ha, a raw material from which an expressive volume of apple juice or other industrial products could be obtained. As cv. Sansa shows high total sugar contents, acidity above average and a high phenolic compound content it could be used for the development of a varietal juice or fermented beverage. It must be take in account remember that the high fructose fraction represents a functional appeal for the obese person or for the insulin-dependent consumer under medical care.

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