Food ©2007 Global Science Books

Mango Carbohydrates

Luis A. Bello-Pérez* • Francisco J. L. García-Suárez • Edith Agama-Acevedo

Center for Development of Biotic Products, National Polytechnic Institute, Carretera Yautepec-Jojuttla Km 8.5, Yautepec, Morelos, CP 62731, México

Corresponding author: * labellop@ipn.mx

ABSTRACT

The mango is a climacteric fruit, containing mainly carbohydrates ranged between 90.1 and 93.6% and a dietary fiber level between 3.85 and 12.64%. The carbohydrate profile of this fruit is modified during the ripening process from complex carbohydrates such as starch to single sugars such as monosaccharide (glucose, fructose) and disaccharides (sucrose). Additionally, the mango fruit has other components of the dietary fibre such as cellulose, hemicelluloses and lignin. Pectin is other polysaccharide present in the fruit in the unripe stage that is hydrolyzed during ripening. The mango variety and ripening stage play an important role in the amount of carbohydrates present in the fruit. A direct relationship was found between aroma compounds and ethylene production during ripening of the fruit, and the increse in fatty acids level during ripening was related to an increase in the aroma of the fruit. Due to the high starch amount in the unripe fruit, it is possible to obtain flour with a high level of indigestible carbohydrates to use in bakery products. This review summarizes the present knowledge of carbohydrates in mango fruit at different ripening stages.

Keywords: pre-ripening, ripening, starch, sucrose-phosphate synthase, sucrose synthase
Abbreviations: DF, dietary fiber; **IDF**, insoluble dietary fiber; **SDF**, soluble dietary fiber; **SPS**, sucrose-phosphate synthase; **SS**, sucrose synthase; **WHC**, water holding capacity

CONTENTS

INTRODUCTION

The mango (*Mangifera indica* L.) is the most important member of the *Anarcadiaceae* family. The mango is native to southern Asia, especially Burma and eastern India. It spread early on to Malaisya, eastern Asia and eastern Africa. The genus *Mangifera* includes approximately 50 species, but only 3 to 4 produce edible fruits. The fruit usually named mango has a weight between 150 g and 2 kg with an ovoid-oblong shape, with a size between 4 to 25 cm long and 1.5-10 cm thick.

The mango tree has become adapted in many tropics and subtropics regions of the world. However, its fruit is fragile and significant postharvest wastage occurs in producing countries due to insufficiently established practices of handling, convoying, storage and ripening (Sreenath *et al.* 1987). When the fruit is ripe it is consumed raw as a dessert fruit, while the rest of production is processed into diverse products such as nectar, juice powder, canned mango slices in syrup chutney, etc. (Wu *et al*. 1993).

Mango fruits are harvested at a mature green stage and stored for ripening. If fruit is fully-grown and ready for picking, the stem snaps easily. Depending on the variety and environmental conditions, the fruit takes 6-10 days to ripen under ambient conditions (temperaure and relative humidity), and become over-ripe and spoiled within 15 days after harvest provoking that fruits are eliminated and not consumed (Tharanathan *et al*. 2006; **Fig. 1**).

CHEMICAL COMPOSITION

Mango is a climacteric fruit composed mainly of water and carbohydrates, with small content of dietary fiber, protein, lipid and vitamins (**Table 1**). Depending on the mango variety the carbohydrate content (on a dry weight basis) ranges between 90.1 and 93.6% with a caloric supply of between 62 and 68 Kcal (**Table 1**). The dietary fiber amount ranges between 3.85 and 12.64%, indicating that this fruit is an adequate dietary fiber source. The principal vitamin present in mango is ascorbic acid, with levels that range between 27 and 80 mg/100 g of fresh pulp. The predominant carbohydrate in the unripe mango is starch, which in the mature fruit is replaced to a great extent by monosaccharide and disaccharide like sucrose, glucose and fructose (Wu *et al*. 1993; Ollé 1996). Aroma is an important parameter in mango. Volatile compounds that contribute to the aroma in this fruit have been widely studied in various cultivars. Volatile compounds are synthetized during ripening of the fruit from acetyl CoA, which is produced by several metabolic pathways (Gomez-Lim 1997). It was reported that more than

Received: 17 February, 2007. Accepted: 26 March, 2007.

Invited Mini-Review

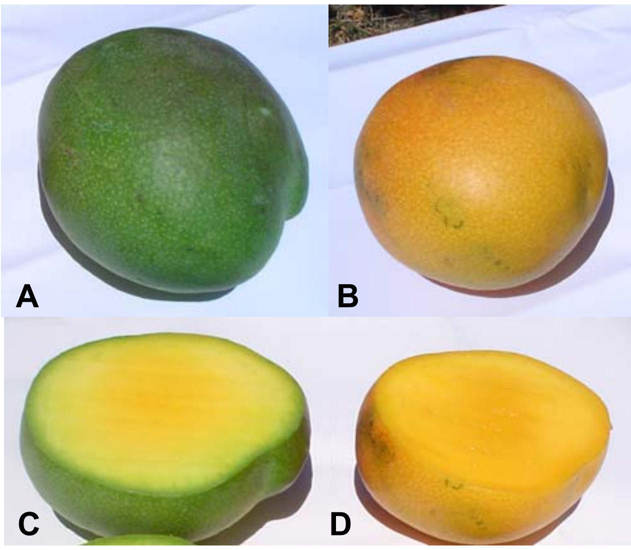

Fig. 1 Color of mango. Color skin of unripe mango (**A**) color skin of ripe mango (**B**), color pulp of unripe mango (**C**) color pulp of ripe mango (**D**).

270 volatile compounds have been identified until today, of those, monoterpene and sesquiterpene are the most abundant, whilst esters and lactones were found that play an important role in the unique flavour of certain cultivars (Pino and Mesa 2006). The profile of volatile compounds during ripening seems to be mediated by ethylene, because ethylene production and respiration reached a peak on the fourth day of ripening of 'Kensington Pride' mango, with the concomitant increase in the fatty acids contents during ripening (Lalel *et al*. 2003). The increase in fatty acids during ripening of mango was related to an increase in the aroma of the fruit (Lalel and Singh 2004). However, non-direct relationship has been found between carbohydrates and the compounds responsible of aroma in mango.

POLYSACCHARIDES

Starch

Starch is the major storage carbohydrate of higher plants. This polysaccharide is deposited in the first stage of developing of the fruit in the form of granules partially crystalline. Starch owes much of its functionality to two major high-molecular weight carbohydrates components, amylose and amylopectin, as well as to the physical organization of these macromolecules into the granular structure (French 1984). After harvest, the starch content of var. 'Carabao' decreased from 11.41% (1 day) to 0.17% (7 day), whilst in var. 'Haden' starch level decreased from 260 mg/g of alcohol insoluble matter to none after 10 days of storage (**Table 2**).

Studies on mango starch characterization isolated from the pulp, showed that granule size has an average of 10 µm, with an A-type X-ray diffraction pattern and an amylose content of 13%. The gelatinization temperature of starch mango was lower than that obtained for corn starch, but the water retention capacity, swelling and solubility values were higher in mango than corn starch (Aparicio-Saguilan *et al*. 2005). In other study, starch was isolated from kernels of five different Indian mango cultivars and its physicochemical, morphological, thermal and rheological properties were assessed. The granule size ranged between 15.8 and 21.7 µm and amylose content was in the range reported for the starch isolated from the unripe mango pulp (9.1-16.3%). The peak temperature was in the range of 77.9 and 80.2ºC with enthalpy values between 12.0 and 13.2 j/g. The authors concluded that various properties of mango kernel starch are comparable with starches from diverse sources such as corn, wheat, rice and potato and could be effectively utilized as a starch source in diverse industrial applications (Kaur *et al*. 2004).

Dietary fiber

Chemically, dietary fiber (DF) consists of cellulose, hemicellulose, lignin, pectin, β-glucans and gums (Gallaher and Schneeman 2001; Figuerola *et al*. 2005). The parenchymatous tissues and cell walls are the DF supply for fruits and vegetables. DF components are grouped in two major classes: polymers that are soluble in water (SDF), such as pectins and gums, and those water insoluble materials (IDF), where cellulose, hemicellulose and lignin are included (Thebaudin and Lefebvre 1997).

A high DF intake has been related to several physiological and metabolic effects (Drzikova *et al*. 2005). In the digestive tract, DF exerts a buffering effect that links excess of acid in the stomach, increases the fecal bulk and stimulates the intestinal evacuation; besides, it provides a favorable environment for the growth of the beneficial intestinal flora. In the past decade, high dietary fiber materials from fruits or its peel (citrus, apple, grape and others) have been steadily introduced in the occidental world markets. According to Saura-Calixto (1998), the presence of significant amounts of bioactive compounds, such as flavonoids and carotenoids, in DF from fruits imparts them considerable nutritional value. The antioxidant properties of flavonoids and carotenoids increase the nutraceutical effect of DF. The DF of mango fruit depend of the variety and ripening stage (Limonta-Carvalho *et al*. 2004; Bally 2006), ranging between 12.64 and 3.85%. Otherwise, mango peel is a rich source of indigestible polysaccharides that are components of the DF, principally IDF. Larrauri *et al*. (1996) reported DF content in a powder obtained from mango peel of 65-71

Table 1 Chemical composition of mango.

	Variety			
Determination	**Unknown**[1]	**Mexican mango varieties**[2]*	**Haden**[3]	**Tommy Atkins**[3]
Total carbohydrates (g/100 g)	92.89	90.10	93.86	93.10
Energy (Kcal/100 g)	65	62-64	68.3	63.3
Ascorbic acid (mg)	27.2	80.0	36.6	31.7
Proteins (g/100 g)	0.51	0.50	0.14	0.30
Lipids(g/100 g)	0.27	-	0.29	0.27

[1]Bally, 2006
[2]Infoagro.com/frutas 1996
[3]Limonta-Carvalho *et al*. 2004
* Varieties: Haden, Tommy Atkins, Kent, Keitt, Ataulfo, Zill, Sensation, Oro, Manila, Manilla, Irwin, Diplomático, Criollos.

Table 2 Changes of starch content during mango ripening.

	Storage time (days)							
Variety	**0**	**1**	**2**	**4**	**6**	**7**	**10**	**Reference**
Carabao (%)	-	11.41	9.78	3.37	0.36	0.17	-	Morga 1979
Haden (mg/g)	260	-	175	132	102	0	0	Fuchs 1980

Table 3 Changes of mango pectin at two ripening stages (g/100 g of pulp).

Variety	Améliorée		Keitt		Mango		Palmer	
Stage	Pre-ripe	Ripe	Pre-ripe	Ripe	Pre-ripe	Ripe	Pre-ripe	Ripe
Pectin	2.2	1.7	1.8	1.6	2.0	2.4	2.1	1.7

Based on Kansci *et al*. 2003

Table 4 Sugar composition of the mangoes at pre-ripe stage during storage at 20.3ºC ± 0.3 and 85 % RH (g/100 g of fresh matter).

	Determination			
Varieties	Sucrose	Fructose	Glucose	Reference
Améliorée	2.8	4.0	0.55	Kansci *et al.* 2003
Keitt	0.7	2.4	0.55	Kansci *et al.* 2003
Mango	1.8	3.4	0.1	Kansci *et al.* 2003
Palmer	1.7	3.3	0.44	Kansci *et al.* 2003
Haden	1.3	2.1	1.0	Castrillo *et al.* 1992

Table 5 Sugar composition of the mango at ripe stage during storage at 20.3ºC ± 0.3 and 85% RH (g/100 g of fresh matter).

	Determination			
Varieties	Sucrose	Fructose	Glucose	Reference
Améliorée*	4.5	9.4	1.4	Kansci *et al.* 2003
Keitt*	1.7	6.4	1.5	Kansci *et al.* 2003
Mango*	4.7	8.1	0.8	Kansci *et al.* 2003
Palmer**	4.3	8.0	1.0	Kansci *et al.* 2003
Haden**	10.5	4.1	0.1	Castrillo *et al.* 1992
Mango***	2.47	4.5	0.26	Sanz *et al.* 2004

Varieties from: *Cameroon, **Spain, ***Venezuela

g/100 g of dry sample; this powder presented total soluble polyphenols of between 44 and 70 mg/g of dry sample. The functional properties of DF of mango peel showed that the water holding capacity was 11 g of water/g of dry sample and the oil holding capacity of approximately 4 g of oil/g of dry sample. With the idea of diversifying the use of mango fruit in an unripe stage, a mango dietary fiber (MDF) was obtained from the whole fruit (pulp and peel) (Vergara-Valencia *et al*. 2007). The MDF powder presented a DF content of 28.1 g/100 g of dry sample, with a good balance of SDF (14.25%) and IDF (13.8%) that is important from a nutritional point of view. Other DFs obtained from peel fruits such as Mexican lima (Ubando *et al*. 2005), *Citrus sinensis* (Chau and Huang 2003), guava (Jiménez-Escrig *et al*. 2001) and mango (Larrauri *et al*. 1996), showed a higher proportion of IDF.

The total soluble polyphenols content in MDF was 16.1 mg/g of dry sample, a lower value than that obtained in DF of mango peel, indicating that this type of compound is present in the peel of mango fruit. The water holding capacity (WHC) value of MDF increased with processing temperature. This behavior might be due to the high SDF and starch contents present in this fiber preparation. Oil holding capacity (OHC) in MDF ranged between 1.0 and 1.5 g of oil/g of dry sample. These values were lower than those reported in other fiber concentrates, e.g. mango peel DF (approximately 4 g of oil/g of dry sample) (Larrauri *et al*. 1996) and in citrus peel fiber (2.35-5.09 g of oil/g of dry sample) (Chau and Huang 2003). The authors concluded that MDF may be appropriate in products where emulsifying properties are not required (Vergara-Valencia *et al*. 2007).

Pectin

Pectin denotes a family of compounds which is part of a larger family of “pectic substances”. Chemically pectin is formed by galacturonic acid with various contents of methyl ester groups. Pectins are present in the cell walls and intracellular layers of all land plants. The functionality of pectin in the tissue of fruits is to provide firmness, when the fruit is unripe the pectin concentration is high and the level decrease during ripening of the tissue. Pectin content of diverse pre-ripe mango varieties ranged between 1.8 and 2.2 g/100 g of pulp (**Table 3**); However, when fruit ripe the pectin content decreased, except for the var. “mango” where pectin increase from 2.0 g/100 g of pulp to 2.4 g/100 g of pulp. This pattern is related with polygalacturonase activity, because this enzyme is responsible for pectin degradation and an increase in its activity was shown during the ripening of the fruit (Ketsa *et al*. 1999). Lower pectin contents were determined in ripe mango of var. ‘Haden’ (1.10 g/100 g of pulp) and ‘Tommy Atkins’ (0.95 g/100 g of pulp) (Limonta-Carvalho *et al*. 2004). In a study carried out in var. ‘Carabao’ to evaluate the effect of the storage time on pectin content, pectin concentration increased from 0.45 g/100 g of pulp in the sample stored for one day after harvest to 0.83 g/100 g of pulp after 7 days (Morga 1979).

These results showed that the synthesis of pectin is present in this fruit during storage and perhaps the activity of pectinesterase is high. The pectinesterase hydrolyzes the methylester linkage of pectin and produces pectic acid and methanol, whilst polygalacturonase depolymerizes the pectin (acting on glucosidic bond between two galacturonic acid monomers) producing monomers. For this reason polygalacturonase is related with ripening of the fruit. In var. ‘Nam Dokmai’ the activity of pectinesterase decreased with storage time of mango and the polygalacturonase activity increased (Ketsa *et al*. 1999). However, the storage conditions (temperature and relative humidity) were also important factors in this pattern.

SUGARS

Reducing sugars is a group of carbohydrates that have the capacity to reduce silver or copper (II) ions. During this reduction the aldehyde group of aldoses is oxidized to a carboxyl group, and under alkaline conditions of the Fehling test, the ketoses are isomerized to aldoses. In mango, when starch hydrolysis is carried out during ripening of the fruit some oligosaccharides, maltose and glucose are produced (depending on the ripening stage) and they are quantified as reducing sugars. Additionally, fructose is produced by the fruit and it is quantified inside this group. Total reducing sugars is determined using glucose as standard. For unripe mango var. ‘Tommy Atkins’, the reducing sugars were 1.5% (de Oliveira *et al*. 2001), lower than that determined in ripe ‘Coité’ mango (3.8%, Cabral *et al*. 2003) and ripe var. ‘Kensington’ (4.3%, Malik *et al*. 2006). This pattern is due to the fact that in the unripe fruit only the reducing groups of starch chains were determined, and for ripe mango oligosaccharides from starch hydrolysis, maltose, glucose and fructose were quantified. Depending on the mango variety, the non-reducing sugars can be present in higher content. In var. 'Haden' (Fuchs 1980) non-reducing sugars were lower (0.8%) than reducing sugars (3.5%), but an inverse pattern was showed in 'Tommy Atkins' (de Oliveira *et al*. 2001) and Kensington (Malik *et al*. 2006) varieties where non-reducing sugars were higher (3.5 and 11.6%, respectively) than reducing sugars (1.5 and 4.3%, respectively). Principally, non-reducing sugars of mango are due to the presence of sucrose, which increases during ripening (Fuchs 1980; de Oliveira *et al*. 2001). The application of exogeneous polyamines on fruitlet retention in mango was tested and no substantial effect was shown between reducing and non-reducing sugars; this pattern was due to the slower conversion of starch to sugars and that the polyamines may have suppressed the activity of sucrose phosphate synthase (SPS) involved in sucrose synthesis (Malik *et al*. 2006).

Individual sugars such as sucrose, fructose and glucose were determined in mango varieties during the pre-ripe stage (immediately after harvesting). Sucrose was higher in var. 'Améliorée' (2.8 g/100 g of fresh matter) and var. 'Keitt' (0.7 g/100 g of fresh matter) showed the lowest value, other varieties had sucrose between 1.3-1.7 g/100 g fresh matter (**Table 4**). A similar pattern was shown in the fructose level, where 'Améliorée' presented the highest value (4.0 g/100 g of fresh matter) but 'Haden' had the lowest level (2.1 g/100 g of fresh matter). Glucose was the lowest sugar in mango in the pre-ripe stage with values that ranged between 0.1 and 1.0 g/100 g of fresh matter (**Table 4**). When mango was analyzed in the ripe stage, the values of sucrose and fructose increased, but glucose concentration decreased (**Table 5**). This pattern is associated with the synthesis and degradation of sucrose by SPS and sucrose synthase (SS), respectively. It was found that SPS activity (approximately 10 μmol.h^{-1}.g^{-1} (fresh weight)) increased with the ripening period (105 μmol.h^{-1}.g^{-1} (fresh weight)), indicating that synthesis of sucrose was carried out with the concomitant decrease of glucose and increase of sucrose (Castrillo *et al*. 1992). In general, the principal sugar in ripe mango is fructose, although var. 'Haden' has a higher amount of sucrose. This is an important nutritional characteristic of ripe mango, since the metabolism of sucrose and fructose is different to that of glucose. The metabolism of those sugars is related with the glycemic charge, because glucose is very quickly metabolized increasing its level in blood, an undesirable characteristic for diabetic or overweight people.

CONCLUDING REMARKS

The mechanisms of synthesis and degradation of carbohydrates present in mango affect the nutritional and technological application of the fruit. In the unripe stage the main carbohydrate is starch that during the ripening process is hydrolyzed to glucose, this monosaccharide participates in the biosynthesis of sucrose and fructose in the ripe stage of the fruit, thus the majority of the mango varieties show high levels of both sugars and low amount of glucose. Unripe mango may be a good source of starch and dietary fiber, mainly for dietary fiber where it was found to have similar levels of soluble and insoluble fractions. In addition, in the commercial source of dietary fiber prepared with citrus and grape skin the insoluble fraction is the predominant.

Due to the high starch level present in the unripe mango flour is possible to modify it using an acid hydrolysis and to obtain flour with higher dietary fiber due to the resistant starch formation. The idea is to diversify the use of mango fruit and produce a functional ingredient.

ACKNOWLEDGEMENTS

We appreciate the economic support from SIP-IPN, CONACYT-México, EDI-IPN and COFAA-IPN.

REFERENCES

Aparicio-Saguilán A, Flores-Huicochea E, Tovar J, García-Suárez FJL, Gutiérrez-Meraz F, Bello-Pérez LA (2005) Resistant starch-rich powders prepared by autoclaving of native and lintnerized banana starch: partial characterization. *Starch/Stärke* **57**, 405-412

Bally ISE (2006) Species Profiles Island Agroforestry. Available online: www.traditionaltree.org

Chau CF, Huang YL (2003) Comparison of the chemical composition and physicochemical properties of different fiber prepared from de peel of *Citrus sinensis* L. cv. Liucheng. *Journal of Agricultural and Food Chemistry* **51**, 2615-2618

Cabral BMC, Arraes MG, Pontes LD, de Sá Parente EJ, Cabral CC, Renata Tieko NR, Feitosa T, Machado de Sousa PH (2003) Análise físico-química, microbiológica e sensorial de frutos de manga submetidos à desidratação osmótico-solar. *Revista Brasileira de Fruticultura* **25**, 38-41

Castrillo M, Kruger NJ, Whatley FR (1992) Sucrose metabolism in mango fruit during ripening. *Plant Science* **84**, 45-51

de Oliveira LC, Bosco A, Chitarra MI (2001) Changes in amylase starch and sugars contents in mango fruit pulp Cv Tommy Atkins with spongy tissue. *Brazilian Archives of Biology and Technology* **44**, 59-62

Drzikova B, Dongowsky G, Gebhardt E, Habel A (2005) The composition of dietary fibre-rich extrudates from oat affects bile acid binding and fermentation *in vitro*. *Food Chemistry* **90**, 181-192

Femenia A, Lefèvre C, Thebaudin Y, Robertson J, Bourgeois C (1997) Physical and sensory properties of model foods supplemented with cauliflower fiber. *Journal of Food Science* **62**, 635-639

Figuerola F, Hurtado ML, Estévez AM, Chiffelle I, Asenjo F (2005) Fibre concentrates from apple pomace and citrus peel as potential fibre sources for food enrichment. *Food Chemistry* **91**, 395-401

French D (1984) Organization of starch granules. In: Whistler RL, BeMiller JN, Paschall EF (Eds) *Starch: Chemistry and Technology*, Academic Press, New York, pp 183-247

Fuchs Y, Pesis E, Zauberman G (1980) Changes in amylase activity, starch and sugars contents in mango fruit pulp. *Scientia Horticulturae* **13**, 155-160

Gallaher D, Schneeman BO (2001) Dietary fiber. In Bowman B, Russel R (Eds) *Present Knowledge in Nutrition* (8th Edn) ILSI Press, Washington, DC, pp 87-97

Gomez-Lim MA (1997) Postharvest physiology. In: Litz RE (Ed) *The Mango: Botany, Production and Uses*, CAB International, Wallingford, UK, pp 425-445

Infoagro.com Online: www.infoagro.com/frutas/frutas_tropicales/mango.htm

Jaime L, Mollá E, Fernandez A, Martin-Cabrejas M, López AF, Esteban R (2002) Structural carbohydrates differences and potential source of dietary fiber of onion (*Alliun cepa* L.) tissues. *Journal of Agricultural and Food Chemistry* **50**, 122-128

Jiménez-Escrig A, Rincón M, Pulido R, Saura-Calixto F (2001) Guava fruit (*Psidium guajava* L.) as a new source of antioxidant dietary fiber. *Journal of Agricultural and Food Chemistry* **49**, 5489-5493

Kansci G, Bargui-Koubala B, Mbome-Lape I (2003) Effect of ripening on the composition and suitability for jam processing of different varieties of mango (*Mangifera indica*). *African Journal of Biotechnology* **2**, 301-306

Ketsa S, Chidtragool S, Klein JD, Lurie S (1999) Firmness, pectin components and cell wall hydrolases of mango fruit following low-temperature stress. *Journal of Horticultural Science and Biotechnology* **74**, 685-689

Larrauri JA, Rupérez P, Borroto B, Saura-Calixto F (1996) Mango peels as a new tropical fibre: preparation and characterization. *Lebensmittel-Wissenschaft und Technologie* **29**, 729-733

Lalel HJD, Singh Z, Chye-Tan S (2003) Aroma volatiles production during fruit ripening of Kensington Pride mango. *Postharvest Biology and Technology* **27**, 323-336

Lalel HJD, Singh Z (2004) Biosynthesis of aroma volatile compounds and fatty acids in Kensington Pride mangoes after storage in a controlled atmosphere at different oxygen and carbon dioxide concentrations. *Journal of Horticultural Science and Biotechnology* **79**, 343-353

Limonta-Carvalho CR, Roseto CJ, Bassi-Mantovani DM, Morgano MA, Vidigal de Castro J, Bartoletto N (2004) Avaliação de cultibares de mangueira selecionadas pelo Instituto Agronômico de Campina comparadas a outras de importância comercial. *Revista Brasileira de Fruticultura, Jaboticabal-SP* **26**, 264-271

Malik AU, Zingh Z (2006) Improved fruit retention, yield and fruit quqlity in mango with exogenus application of polyamines. *Scientia Horticulturae* **110**, 167-174

Maninder Kaur, Narpinder Singh, Kawaljit Singh Sandhu, Harmeet Singh Guraya (2004) Physicochemical, morphological, thermal and rheological properties of starches separated from kernels of some Indian mango cultivars (*Mangifera indica* L.) *Food Chemistry* **85**, 131-140

Morga NS, Lustre AO, Tunac MM, Balagot AH, Soriano MR (1979) Physico-chemical changes in Philippine *Carabao* mangoes during ripening. *Food Chemistry* **64**, 225-234

Pino JA, Mesa J (2006) Contribution of volatile compounds to mango (*Mangifera indica* L.) aroma. *Flavour and Fragrance Journal* **21**, 207-213

Saura-Calixto F (1998) Antioxidant dietary fiber product: A new concept and a potential food ingredient. *Journal of Agricultural and Food Chemistry* **46**, 4303-4306

Schneeman BO (1987) Soluble vs insoluble fiber-different physiological responses. *Food Technology* **47**, 81-82

Tharanathan RN, Yashoda HM, Prabha TN (2006) Mango (*Mangifera indica* L.) The King of Fruits – an overview. *Food Reviews International* **22**, 95-123

Thebaudin J, Lefèvre AC (1997) Dietary fibre: Natural and technological interest. *Trends in Food Science and Technology* **8**, 41-48

Ubando J, Navarro A, Valdivia MA (2005) Mexican lime peel: Comparative study on contents of dietary fibre and associated antioxidant activity. *Food Chemistry* **89**, 57-61

Ollé D, Lozano FY, Brillouet JM (1996) Isolation and characterization of soluble polysaccharides and insoluble cell wall material of the pulp from four mango (*Mangifera indica* L.) cultivars. *Journal of Agricultural and Food Chemistry* **44**, 2658-2662

Sreenath HK, Nanjundaswamy AM, Sreekantaiah KR (1987) Effect of various cellulases and pectinases on viscosity reduction of mango pulp. *Journal of Food Science* **52**, 230-231

Vergara-Valencia N, Granados-Pérez E, Agama-Acevedo E, Tovar J, Ruales J, Bello-Pérez LA (2007) Fibre concentrate from mango fruit: Characterization, associated antioxidant capacity and application as a bakery product ingredient. *Lebensmittel-Wissenschaft und Technologie* **40**, 722-729

Wu JSB, Chen H, Fang T (1993) Mango juice. In: Nagy S, Chen CS, Shaw PE (Eds) *Fruit Juice Processing Technology*, Agscience, Auburdale, pp 533-594