

Full Length Research Paper

Effect of ripening on the composition and the suitability for jam processing of different varieties of mango (*Mangifera indica*)

Germain Kansci^{1*}, Benoit Bargui Koubala¹, Israel Mbome Lape²

¹University of Yaounde I, Department of Biochemistry, PO Box 812 Yaounde, Cameroon.

²Food and Nutrition Research Centre, Ministry of Scientific and Technical Research, Yaounde, Cameroon.

Accepted 22 August 2003

As part of an effort to solve the problem of post harvest losses of fruits, physicochemical characteristics of four mango varieties (Palmer, Améliorée, Mango and Keitt) were determined at two ripening stages. Their suitability for jam processing was also evaluated based on viscosity measurements. The pulps of pre-ripe mangoes were highly acidic (pH: 3.50 – 3.85), rich in starch (4.4 – 11.1 % w/w) as well as in dry matter. They contained less soluble sugars (4.04 – 7.56 g/100 g) and recorded lower viscosity values than those of the ripe mangoes. The pre-ripe Palmer and Améliorée mango varieties had high dry matter content, while the Mango and Améliorée varieties had higher soluble sugars contents. Due to their higher starch contents, all the jams prepared with pre-ripe mangoes were more viscous than the ripe mango preparations. Ripe Palmer and Améliorée varieties were the best for jam processing, based on their viscosity values. These results could help to improve the quality of mango jams.

Key words: Mango, proximate analysis, ripening stage, jam processing.

INTRODUCTION

Of the over 1,000 varieties of mango (*Mangifera indica*) existing in the world (Morton, 1987; Brossard, 1997), about 48 have been identified in Cameroon (IRAD, 1991). The annual world production is estimated to around 1.7 Million tons while that of Cameroon is estimated at 15,400 tons. Unfortunately, over 20% of this national production, which is mature for consumption only between the months of April and July, is lost mostly due to the high perishability of ripe mango fruits (Temple, 1999) and, to a lesser extent, to overloading of tree branches before total ripening of fruits (especially for the Améliorée and Mango varieties).

The feasibility of processing mango fruits into juice, jam or dried products has been demonstrated (Jiokap-Nono et al., 2001). This can ensure consumption of the fruits all-year round and good recovery of some important bio-constituents like vitamin A whose lack constitute a public health problem in Cameroon (Sibetcheu et al., 1999). The physico-chemical characteristics of fruits and the technological qualities of the products processed thereof vary with the variety of mango as some are more suitable than others for specific applications (Doreyappa and Ramanjaneya, 1995; Mercadante and Rodriguez, 1998).

Though mango fruits are much appreciated when harvested after full ripening, pre-ripe harvesting can be otherwise recommended. In general, the importance of state of ripening at harvest is primordial as notable changes occur in the fruit during ripening which improved its physico-chemical and sensory characteristics (appearance, smell and flavour). Amongst these are the

* Corresponding author; E-mail: gkansci2000@yahoo.fr, Fax: 00 33 (2) 40 67 50 84. Present address: INRA/LEIMA, B.P. 71627, F44316 Nantes cedex 03, France.

starch to soluble sugar inter-conversion, decrease in acidity, increase in β -carotene content, modification in texture and conversion of protopectin to pectin, (Cheffel and Cheffel, 1992; Kapse et al., 1995; Mercadante and Rodriguez, 1998). Processing of mango into jam would therefore give added value to the fruit, which could be consumed by indigenous populations, without further addition of pectin. This study was initiated to assess the suitability of different mango varieties for this product and to establish the relationship between fruit ripening on both its quality and that of the jam processed thereof.

MATERIALS AND METHODS

Four mango varieties (2 grafted: Palmer and Keitt; 2 ungrafted: Améliorée and Mango) at two stages of ripening were collected. The Palmer, Améliorée and Keitt were kindly offered from the orchard of the "Fruit and Legume Programme of the National Institute for Agricultural Research & Development (IRAD) in Yaounde Cameroon, while the Mango variety was harvested in a private orchard in the town of Yaounde. Two ripening stages were considered:

- The initial or pre-ripe state characterised by the firmness of the fruit (little or no depression when hand-pressed) and its green colour;
- The ripe state characterised by the absence of sap at the peduncle during harvest, a strong perfume, its lesser firmness and its orange/yellow colour.

After harvest, fruits were selected, cleaned and dipped in sodium bisulphite (1.8% w/v), and peeled. Pulp was removed, packaged in plastic bags and deep-frozen at -30°C .

The pH, dry matter, lipid, glucose and ash content of the pulps were determined using standard AOAC methods (1980, 1984). The total sugar and fructose contents of the pulp were determined using the Anthron and the Anthron/thiourea colorimetric methods, respectively (Montreuil et al., 1981). The pectin content was determined according to Dekker and Richards (1972). The protein content was estimated from the total nitrogen content (using the *Kjeldahl* method) of the dried pulp, using a conversion factor of 6.25 (Godon and Loisel, 1981). Starch and maltodextrin contents were determined after enzymatic hydrolysis; 0.9 was used as conversion factor. All reagents were of analytical grade.

To determine the viscosity of pulp/jam slurry, the latter was diluted to 10% dry matter content, transferred into a stainless steel cylinder and the whole thermostated at 30°C . The viscosity of the pulp and jam was measured by dipping vertically the rotating spindle of the viscotester (VT-02 Haake) into the slurry and reading its viscosity after 5 minutes.

RESULTS AND DISCUSSION

Composition of the fruits

The average weight of the fruit of the four mango varieties ranged from 240 to 630 g. The grafted mango varieties, Palmer and Keitt, were heavier, with respective unit masses of 630 ± 41 and 520 ± 49 g/fruit, than the

traditional Mango and Améliorée varieties (240 ± 25 g/fruit). These results compare favourably with those obtained on the hybrid variety Arka Aruna that has an average weight of 682 g and the Alphonso variety with 216 g (Doreyappa et al., 1994).

The peels represented 16 - 19% (w/w), the seeds 12 - 17% (w/w) and the pulp 65 - 72% (w/w) of the total weight of the fruits (Figure 1). The Keitt variety was much richer in pulp while the Mango variety was least. Elsewhere, the least amount of pulp (about 58 % w/w) has been obtained with the Alphonso mango variety (Doreyappa et al., 1994).

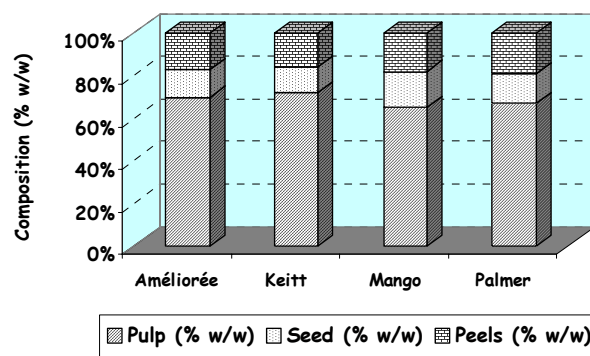


Figure 1. Composition by mass of fruits from different mango varieties.

Effect of mango variety and ripening on physical characteristics of pulp

As earlier indicated, three physical parameters of the slurry and jam were analysed, notably the dry matter content, the ash content and their viscosity (Figure 2).

In all the mangoes varieties, the dry matter content was significantly higher in the pre-ripe pulps than the ripe pulps. These effects were even more evident on the pulps of Keitt and Palmer mango varieties (Figure 2a), giving early indications that these later varieties could be most suitable for jam preparation.

Except for the case of the Keitt variety, the ash content was equally higher in the pre-ripe pulps (0.36 - 1.08% w/w) than the ripe ones (0.32 - 0.49) (Figure 2b), values that compare favourably with those of De Laroussilhe (1980) who obtained average values of about 0.3 % (w/w) for the ripe mango pulp.

Generally, ripe mangoes pulps were more viscous compared to pre-ripe ones (Figure 2c). However, the effect of mango variety was very evident here as the effect of ripening varied significantly with the mango variety under study. For the pre-ripe fruits, the local mango variety was most viscous while the Palmer was

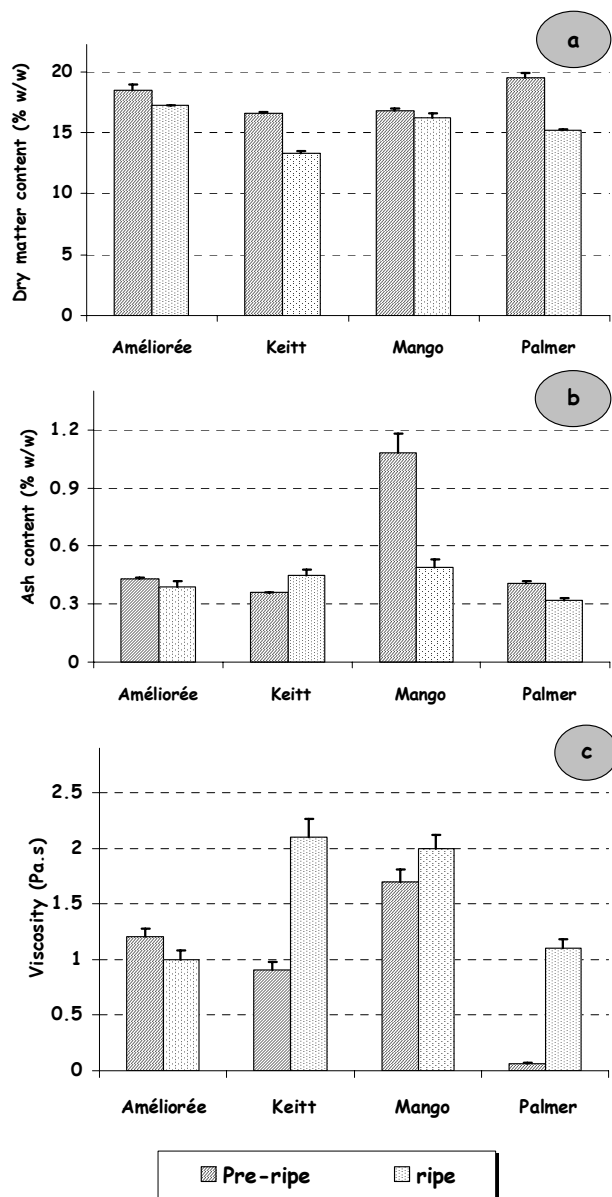


Figure 2. Physical properties of pulps obtained from different mango varieties. (a) Dry matter content, (b) ash content, and (c) viscosity of the slurry.

least. The Améliorée and Keitt gave intermediate values. However, for pulp obtained from the ripe fruits, the viscosity of the Keitt variety increased considerably, meeting up to that of the local mango variety. That of the Palmer variety also increased considerably to equal values obtained from the Améliorée variety. The increase in viscosity would be attributed to increase high fibre content, but most especially to the presence of pectin. In effect, the ripening process is naturally accompanied by the transformation of protopectin to pectin (Germain and Linden, 1981).

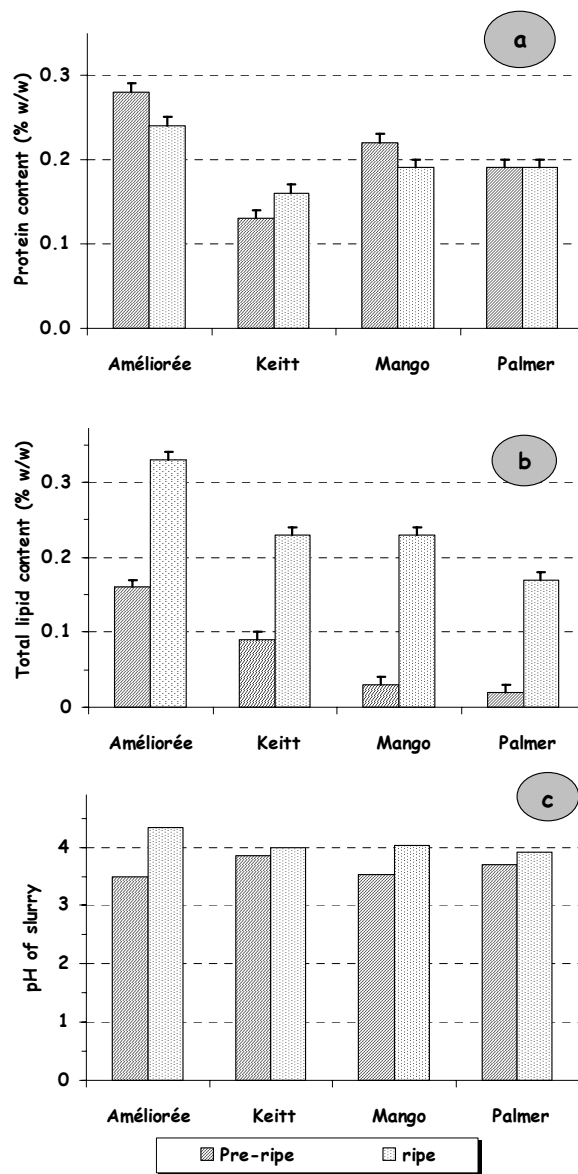


Figure 3. Chemical composition of pulps obtained from different mango varieties. (a) Total protein content, (b) total lipid content, and (c) pH of the slurry.

Effect of mango variety and state of ripening on pulp composition

No consistent observations could be made on the effect of the state of ripening on protein content of pulp as these varied significantly with the mango variety (Figure 3a). The Améliorée variety nonetheless recorded the highest protein content and the Keitt variety the least. The evolution in lipids content following ripening was much more consistent, increasing significantly for all mango varieties with ripening (Figure 3b). We observed,

Table 1. Chemical nutrient composition of the mangoes at the two stages of the ripening. Values are expressed in g/100 g fresh matter.

Varieties	Total sugar		Saccharose		Fructose		Glucose		Pectins		Starch/ Maltodextrin	
	Pre-ripe	ripe	Pre-ripe	ripe	Pre-ripe	ripe	Pre-ripe	ripe	Pre-ripe	ripe	Pre-ripe	ripe
Améliorée	7.6 f	15.2 a	2.8 e	4.5 b	4.0 b	9.4 a	0.55 g	1.4 d	2.2 b	1.7 fg	9.3 b	0.8 g
Keitt	4.0 h	9.4 e	0.7 i	1.7 h	2.4 h	6.4 d	0.55 g	1.5 c	1.8 e	1.6 g	4.4 d	0.0 j
Mango	5.3 g	14.0 a	1.8 g	4.7 a	3.4 f	8.1 b	0.10 i	0.8 f	2.0 c	2.4 a	8.3 c	1.1 f
Palmer	5.2 g	13.4 c	1.7 h	4.3 c	3.3 g	8.0 b	0.44 h	1.0 e	2.1 c	1.7 f	11.1 a	0.9 g

Values are means \pm standard deviation. In a same column for each parameter, values with different letters are significantly different ($p < 0.05$).

Table 2. Formulation of the different jams with different mango varieties at the two different ripening stages.

Varieties	Améliorée		Keitt		Mango		Palmer	
	Pre-ripe	ripe	Pre-ripe	ripe	Pre-ripe	ripe	Pre-ripe	ripe
Pulp (g)	156.05	153.60	152.37	146.51	152.77	151.71	157.82	149.81
Sugar (g)	241.89	244.27	244.74	250.14	244.80	246.54	239.96	246.99
Pectin (g)	2.06	2.13	2.89	3.35	2.43	1.75	2.22	3.20

nonetheless that the Améliorée variety was richest in lipids regardless of the state of ripening, whereas the Palmer variety was poorest.

A study of the acidity of the pulps indicated that pulp obtained from pre-ripe fruits were generally more acidic (pH 3.50 to 3.85) than those obtained from ripe fruits where the pH ranged between 3.91 and 4.35 (Figure 3c). The pulp of Améliorée and local Mango pre-ripe were most acidic and those of the Améliorée ripe, the least acidic. These pH values are close to those of Doreyappa and Ramanjanneya (1995) on the Alphonso variety (4.4) and the Totapuri variety (3.8).

Effect of mango variety and ripening stage on the Carbohydrates composition

The total sugar content of the ripe pulps of all the mangoes variety was significantly higher (9.4 - 15.2 % w/w) than that of the pre-ripe pulps (4.0 - 7.6 % w/w) (Table 1). The Améliorée mango was sweetest while the Keitt variety had the lowest total sugar content (14.3 g/100g). The high sugar content of pulps from ripe fruits as compared to those from pre-ripe fruits had earlier been attributed to the transformation of starch into soluble sugars under the action of phosphorylase enzyme during ripening (Germain and Linden, 1981).

About half of the soluble sugars of mango pulps are mainly composed of fructose, with about 30% sucrose

and 20% glucose, as previously indicated (Favier et al., 1993). The ripe pulps contained more soluble sugars than the unripe ones. The starch/maltodextrin content of the pre-ripe pulp varied from 4.4 to 11.1 g/100 g and was higher than the ripe pulps (0.8 - 1.1 % w/w). The pre-ripe mango from Palmer, Améliorée and Mango varieties were much richer in starch/maltodextrin compared to the Keitt variety. Surprisingly, there was no starch in the ripe Keitt mangoes, indicating total transformation into soluble sugars during ripening.

The pectin content of the pre-ripe pulps (1.7 and 2.2 % w/w) was in most cases higher than the ripe pulps, except for the ripe Mango variety that was very rich in pectin (2.4 % w/w). *Ceni* mango variety contains 5.8 % (w/w) pectin (Kratchanova et al., 1991). Positive correlation between the viscosity and pectin content of fruits has been evidenced by Nso et al. (1998). The high pectin content partly explains the relatively higher viscosity obtained with some pulps.

Viscosity of mango jams

Jams were formulated taking into account many factors such as the pH, dry matter, sugar and pectin contents of the different pulps and ingredients to obtain a final concentration of 1.25% pectin, 63% sugar and 68% dry matter (Table 2). Their viscosity were compared with those of 2 commercial popular mango jams named "TR"

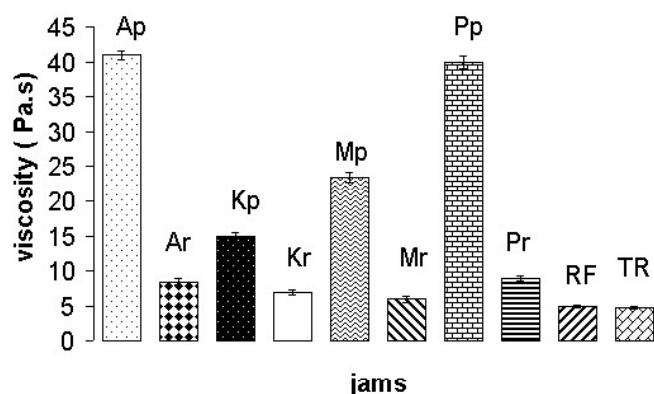


Figure 4. Viscosity of jams prepared with the different mango varieties at two ripening stages. A, K, M and P are Améliorée, Keitt, Mango and Palmer varieties, in the pre-ripe (p) or ripe stage (r). RF and TR are commercial jams from the market.

and “RF”, bought at the local market in Yaounde.

The viscosity of the jams varied considerably, from 6 - 41 Pa.s, with the most viscous being jams from pre-ripe pulps (15.0 to 41.0 Pa.s) and the less viscous were jams from ripe pulps, 6.0 - 9.0 Pa.s (Figure 4). The viscosity of the two locally marketed jam products were significantly lower ($p < 0.05$) than the viscosity of jams formulated with ripe mango fruits from the Keitt, Palmer, Améliorée and Mango varieties. Content and source of pectin used (Ralet et al., 1994) and the dry matter content of the commercial (only 50 - 60 g/100g) and experimental jams (68% w/w) may explain the difference observed. The most viscous jams were obtained from pre-ripe pulps of Améliorée and Palmer mango varieties, which coincidentally were richest in starch. The gelation property of starch/maltodextrin at temperature higher than 60°C in the presence of water has been shown (Alves et al., 1999) and could therefore influence the jam quality. These jams were very firm, with a more elastic texture, different from the gel formed due to the action of pectin. The jams prepared with ripe pulps of the Améliorée and Palmer mangoes were also more viscous than those prepared with other mangoes ripe pulps.

Conclusion

This work was initiated to characterise the pulp obtained from different varieties of the fruit from the mango tree, *Mangifera indica* and to establish the effect of state of ripening of the harvested fruit on its suitability for jam preparation. The ripening stage of mango influenced considerably the dry matter, soluble sugar, starch, pectin contents and the pH of the pulps. Due to their richness in dry matter and starch/maltodextrin, jams prepared from

ripe and pre-ripe pulps of Palmer and Améliorée mango varieties were much firmer. Sensorial analysis are needed to better establish the suitability of different mangoes for jam processing. A special emphasis will be further given to the molecular characterisation of pectin in different mango fruits as well as ascertain their gelling properties.

ACKNOWLEDGEMENT

We are grateful to the Fruit and Legume programme of IRAD (Yaounde - Cameroon) for providing us with the different mango varieties.

REFERENCES

- Alves RML, Grossmann MVE, Silva RSSF (1999). Gelling properties of extruded yam (*Dioscorea alata*) starch. *Food Chem.* 67: 123 – 127.
- AOAC (1980). Official Methods of Analysis, 13th ed. William Herwitz, Washington, pp. 130 – 131.
- AOAC (1984). Official Methods of Analysis, Centennial edition 1884 – 1984, 14th ed. Virginie USA.
- Brossard D (1997). Mémento Fruits et Légumes. *CTIFL*, 5^e ed., Tec. & Doc., Lavoisier Paris, pp. 91-94.
- Cheftel JC, Cheftel H (1992). Introduction à la Biochimie et à la Technologie des aliments. Tec. et Doc (ed.) Lavoisier Paris, 1 : pp. 147-241.
- De Laroussilhe F (1980). Le Manguier. Techniques Agricoles et productions tropicales, Maisonneuve & Larose (ed.), Paris, 312 p.
- Dekker RFH, Richards GN (1972). Determination of pectic substances in plant material. *J. Sci. Food. Agric.* 23 : 475 – 483.
- Doreyappa ING, Ramanjaneya KH (1995). Evaluation of some mango varieties for their suitability for canned mango juice. *J. Food Sci. Technol.* 32: 323 – 325.
- Doreyappa ING, Ramanjaneya KH, IYER CPA, Subramanyam MD, Dinesh MR (1994). Physicochemical and Processing quality of four new Mango hybrids in comparison to two commercial cultivars. *J. Food Sci. Technol.* 31: 385 – 388.
- Favier JC, Ireland –Ripeit J, Laussuc C, Feinberg M (1993). Répertoire général des aliments. Tome 3: Table de composition des fruits exotiques, fruits de cueillette d’Afrique. INRA (ed.), pp 55-59.
- Germain P, Linden G (1981). Activités enzymatiques. In : Deymier B, Multon JL, Simon D (eds) Analyse des constituants alimentaires. Techniques d’Analyse et de contrôle dans les industries agro-alimentaires, Tec. et Doc Lavoisier, Paris, 4 : pp. 211-244.
- Godon B, Loisel W (1981). Protéines. In : Deymier B, Multon JL, Simon D (eds) Analyse des constituants alimentaires. Techniques d’Analyse et de contrôle dans les industries agro-alimentaires, Tec. et Doc Lavoisier, Paris, 4 : pp. 187-205.
- IRAD, 1991. Fabrication de la confiture de mangue en utilisant un cuiseur à double parois chauffé au gaz et muni d’un agitateur – malaxeur. Fiche technique n° 07-06, IRA (ed.) MESIRES-Cameroon (Ed.), 6 p.
- Jiokap-Nono Y, Nuadje GB, Raoult-Wack AL, Giroux F (2001). Déshydratation-Imprégnation par immersion de rondelles de mangue (*Mangifera indica*) : influence de la température et de la concentration de la solution sur les cinétiques de certains éléments constitutifs du fruit. *Fruits* 56 : 169 – 177.
- Kapse BM, Rane DA, Salunkhe DK, Khedkar DM (1985). Sensory evaluation of different varieties of mango during storage. *Indian Food Packer* 39: 43- 48.
- Kratchanova M, Benemou C, Kratchanova C (1991). On the pectic substances of Mango fruits. *Carbohydrate Polymers* 15: 271 – 282.

- Mercadante AZ, Rodriguez-Amaya DB (1998). Effects of ripening, cultivar differences, and processing on the carotenoid composition of Mango. *J. Agric. Food Chem.* 46: 128 – 130.
- Montreuil J, Spik G, Fournet B, Tollier MT (1981). Dosage colorimétriques des glucides. In : Deymier B, Multon JL, Simon D (eds) *Analyse des constituants alimentaires. Techniques d'Analyse et de contrôle dans les industries Agroalimentaires, Tec. et Doc Lavoisier, Paris, 4: pp. 86-92.*
- Morton J (1987). *Mango. Fruits of warm climates.* Miami, Florida. Pp. 221 – 239.
- Nso EJ, Ndibewu P, Kayem GJ (1998). Reduction of viscosity of Guava pulps by treatment with pectinases. *Cam. Biosc. Proc.* 5: 412-420.
- Ralet MC, Monique AVA, Thibault JF (1994). Gelation properties of extruded lemon cell walls and their water-soluble pectins. *Carbohydr. Res.* 260: 271-282.
- Sibetcheu D, Nankap M, Kollo B (1999). La carence en vitamine A au Cameroun: épidémiologie, traitement et prévention. *Bull. liais. Doc. OCEAC* 32 (4): 17-22.
- Temple L (1999). *Le marché des fruits et légumes au Cameroun.* Bulletin technique. CIRAD – IRAD (Ed.) Yaoundé, Cameroun. 163 p.