

Composition and chemical characteristics of mangoes (*Mangifera indica* L.) for animal feeding in Nayarit, Mexico

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An experiment was designed to study the composition and chemical characteristics of Mexican mangoes (*Mangifera indica* L.) of Nayarit, mature and without application for human intake. During the first experimental stage, the influence of the harvest beginning and ending (June and August) on the shell, seed and pulp of four representative samples from 96 mature fruits reduced to twelve per season was assessed. The mangoes were from the Tommy Atkins variety, randomly collected the same day in two markets and two allotments (twelve fruits/place). In the second, a factorial scheme 2 x 3 was used to study the effect of season and components on the mangoes' chemical characteristics. There was no season effect either on the fresh weight of the fruits (417 and 454 g) or the pulp percent (76.1 and 75.8 %). However, the shell and seed proportion increased and diminished lightly ($P < 0.05$) in August compared with June. There was no significant effect on the interaction season x component in the chemical indexes. The season did not influence on the DM content of the fruit (average, 26.4 %), but did on the NDF and N content, which tended to increase ($P < 0.05$) in August in respect to June. The NDF content was different ($P < 0.05$) in shell, seed and pulp (40.1, 56.5 and 66.6 %). The N level was lower ($P < 0.05$) in shell (0.48 %) than in seed and pulp (1.2 % in both cases), and was always low. It is suggested that the mango parts, considered as waste in the industry (shell and seed) can be a good resource for ruminants' feeding. There are no evidences that the beginning and ending of harvest influence on the chemical and chemical characteristics of the fruits.

Key words: *mango, animal feeding, physico-chemical composition.*

In the last years, the mango (*Mangifera indica* L.) crop has increased its production. Mexico occupies the fourth place of the world production of this fruit and the first exporting it. The Pacific-Central region, of which Nayarit State is part, is one of the most important areas exporting Mexican mangoes. It has more than 49 000 cultivated hectares and 48 packers. The predominant cultivated variety is Tommy Atkins. This area of Mexico produces annually 485 000 t, out of which 71 % are addressed to exportation (SAGARPA 201). In this context, the mango processing industry generates important amounts of wastes or residues. It has been reported that 28 to 43 % of the total of mangoes managed as residues mainly constituted by shell and seeds are discarded during the process (Filho *et al.* 2006).

Searching for feeding alternatives considering the use of locally available resources is an important element to create proper production ways for the tropical environment. For this purpose, the agroindustrial by-products contribute with the use of potentially polluting materials in animal feeding (Olivera *et al.* 2006).

The objective of this study was to assess, according to the harvest season, the physical and chemical characteristics of Mexican mangoes of Nayarit, not used for human consumption.

Materials and Methods

This study was conducted in the facilities of the Academic Unit of Agriculture, belonging to the Autonomous University of Nayarit, in the animal nutrition laboratory. The unit is located in the km 9 of the Tepic-Compostela road, in the Jalisco municipality,

Nayarit, Mexico. The geographical location is 21° 25' 40.88" north latitude and 104° 53' 29.54" west longitude.

The physical and chemical composition of Mexican mangoes (*Mangifera indica* L.) of Nayarit, mature and not used for human consumption was studied. The influence of the harvest beginning and ending (June and August) on the proportion of shell, seed and pulp was assessed in a year considered typical due to the harvest volume and fruits yield (SAGARPA 2011). A total of 96 mature mangos of the Tommy Atkins variety, randomly selected the same day in two markets and two allotments of Nayarit were used. The same proportion per recollection place was applied. Half of the mangoes were collected at the beginning of the season, June 2009, and the other at the end of the season, August of the same year. Four samples were formed in each season, obtained from a paddock sampling and with three fruits each, when randomly reducing the population from 48 to 24, and later to 12 mangoes. In the second study stage, a factorial scheme 2 x 3 was used to analyze the season effect (June and August) and the fruit components (shell, seed and pulp) on the chemical characteristics of mangoes, in which the physical composition was assessed.

The mangoes were mature, proved by touching and appearance of the fruit. This is commonly used resource by the consumers of the local market. The physical separation of the mango parts was manually, with the help of a sharp knife. The three parts each was divided into were: shell or exocarp, pulp or mesocarp and seed or endocarp. The parts were fresh weighed in a digital balance with one gram appreciation.

Out of each part, representative samples were taken after being ground in a hammer mill and manually homogenized to determine the DM content. The samples were dried in an oven at 60 °C to be later reduced to meal. The ash and N content were determined by duplicate in the dried samples by the methods recommended according to AOAC (1990). The same procedure was used with the determination of the plant cell walls, ADF, NDF and hemicellulose, conducted according to van Soest and Robertson (1985). The OM content was defined as the difference 100–percent of ash.

The means were contrasted by the analysis of variance technique (Steel *et al.* 1997) and, when necessary, they were separated by the Tukey's test. In addition, the regression analysis was used and the Pearson's correlation matrix was made when considered. The statistical software SAS (2003) was used for processing the data.

Results

Table 1 shows the values obtained for the physical composition of the mangoes examined. There was no significant effect of season either on the fresh weight of the fruits (417 and 454 g) or on the percent of shell and seed (23.8 and 24.0 %).

Certain interdependence degree was found between the different mangoes components. The result of the Pearson's correlation matrix is shown in table 2. While the seed percentage was not significantly correlated with other mean indexes, the interdependence between the shell and pulp, or between the shell and the shell plus the seed, were strongly correlated ($P < 0.001$), inversely with the first and directly with the second. The shell percent was also inversely correlated ($P < 0.05$) with that of the seed.

From the chemical composition point of view, there was no significant interaction season x fruit component in any of the assessed indexes. The season effect appears in table 3. There was no season effect either on the DM and OM content of the fruit (average, 26.4 and 99.0 %) or in the concentration of NDF, ADF, hemicellulose and N.

Table 4 shows the information corresponding to the fruit component effect. The chemical composition results of the three fruits components showed that the shell had significantly the lowest values ($P < 0.05$) of N, NDF, ADF and hemicellulose, compared with the other two components of the fruit. In general, all the components of the mangoes assessed were rich in cell wall and poor in nitrogen compounds and minerals.

Table 1. Season effect on the physical composition of mangoes from Nayarit

	June	August	SE ±
n	4 ¹	4	-
Composition, g			
Shell	57.1	69.3	2.31*
Seed	42.1	39.1	2.12
Shell and seed	99.2	108.4	5.85
Pulp	318.7	345.5	13.35
Total	417.9	454.2	16.34
Composition, %			
Shell	13.7	15.5	0.45
Seed	10.1	8.5	0.37
Shell and seed	23.8	24.0	0.50
Pulp	76.1	75.8	0.44
Total	100.0	100.0	-

¹Each replicate is composed of three fruits. All the data are expressed in in natura

* $P < 0.05$

Table 2. Interdependence between different components of mangoes from Nayarit¹

Indicator	Shell	Seed	Shell and seed
Seed	-0.447		
Shell and seed	0.663	0.372	
Pulp	-0.662	0.372	-0.999

¹All the measurements are expressed in percent of the total in fresh basis
 $P < 0.05$ for $r < 0.400$

Table 3. Chemical composition of mangoes from Nayarit. Season effect (percent in dry basis of the whole fruit)

Indicator	June	August	SE ±
DM	27.6	25.2	2.28
Ash	1.02	0.90	0.19
Organic matter	98.98	99.10	0.13
NDF	52.3	56.5	2.71
ADF	24.2	25.7	1.78
Hemicellulose	28.17	30.80	1.62
Nx6.25	0.61	1.30	0.33

* P < 0.05

Table 4. Chemical composition of mangoes from Nayarit. Effect of the fruit component (percent in dry basis)

Indicator	Shell	Seed	Pulp	SE ±
DM	21.9 ^b	40.8 ^a	16.4 ^c	0.80*
Ash	0.50 ^b	2.13 ^a	0.25 ^c	0.18*
Organic matter	99.5 ^b	98.7 ^a	98.7 ^a	0.12*
NDF	40.1 ^c	56.7 ^b	66.6 ^a	1.4*
ADF	17.4 ^c	24.1 ^b	33.3 ^a	1.1*
Hemicellulose	22.6 ^b	32.5 ^a	33.3 ^a	1.1*
Nx6.25	0.48 ^b	1.20 ^a	1.20 ^a	0.12*

^{abc} Means without common letter in the same row differ significantly (P < 0.05).

* P < 0.05

Discussion

The information related with the characteristics of the physical components and nutrients content of mangoes, influenced by the season, is scarce, probably because the harvest period of the fruit is relatively short in the tropical world (Siller *et al.* 2009). In the case of Nayarit, the mangoes collecting and processing comprises three months, from June to August. Evidences, although light, of the presence of variations on the fruits characteristics were found in this research. Maybe they are more or less important, depending on the destination of the fruits not suitable for human intake or according to the mangoes industrial by-products.

The data presented in this study are analyzed in respect to the previous reports from other mango producer regions. This obeys to the low availability of information in Nayarit on this topic (Siller *et al.* 1009), although the mango products have been used in animal feeding in Mexico (Scotillo 1984 and Aguilera *et al.* 1997).

The data of Indian mangoes suggest that the seeds proportion and that of the endosperm may vary considerably (Ramteke *et al.* 1999). It has been suggested that seeds may constitute between 10 and 25 % of the fruit weight, according to the variety considered (Hemawathy *et al.* 1988). This variability in the mangoes seeds proportion has been referred by Wu *et al.* (1993), who recommended that the seeds percentage of mangoes could be between 9 and 40 %.

According to the results of this study, the seeds of the cultivated variety Tommy Atkins little contribute to the total weight of the fruit, and are actually below the values indicated in studies of Hemawathy *et al.* (1988) and Wu *et al.* (1993).

According to Wu *et al.* (1993), in respect to the whole fruit, the mango shells seem to represent between 7-24 %. However, according to Beerh *et al.* (1976), the shells may contribute with 15-20 % of the fruit. The results of this study agree with those reported by other Brazilian authors (Brito *et al.* 2003, Pereira da Silva *et al.* 2009 and Siller *et al.* 2009). This could indicate that the mango fruit used in this research was within the standards reported for its physical components. Table 5 presents a summary of the available information about the physical composition of Tommy Atkins variety.

The results obtained in this experiment, from the Pearson's correlation matrix, suggest the possibility of approaching to the knowledge of non-edible residue content of the mangoes from the percent of the fruits' shell. This would be given by the following expression:

$$y = 14.63 + 0.64 x \quad (r, 0.663; P < 0.001)$$

where:

y - percent of shell

x - percent of shell plus seed, both in fresh basis

The mango shell and seed are very fibrous, with low content of mineral and nitrogen elements (Göhl 1982). In respect to the seeds, the data on the chemical

Table 5. Components of Tommy Atkins mangoes

Weight, g	Components, % <i>in natura</i>			Reference
	Shell	Seed	Pulp	
-	-	11.4	-	Nunes <i>et al.</i> (1991)
450	10.0	11.0	79.0	Brito <i>et al.</i> (2003)
375	14.0	10.0	76.0	Siller <i>et al.</i> (2009)
521.1	14.4	10.6	75.0	Pereira da Silva <i>et al.</i> (2009)
436.1	13.7-15.5	8.5-10.1	75.8-76.1	This experiment

composition of their endosperm or kernel are not scarce, compared with the seed as such (Díaz and Cobo 1983, Odunsi 2005 and Abdalla *et al.* 2007).

Agreeing with Madhukara *et al.* (1993), the mango shell or skin has, as average, 32 % of reducer sugars, while cellulose, lignin and pectin are among the fibrous components with 13, 13 and 7 % in dry basis, respectively. In agreement with Madhukara *et al.* (1993), the shells have few protein, only 4 %, or 1.76 -2.05 % in the varieties Raspuri and Badami (Ajila *et al.* 2007). These results agree with those of this experiment, although Ajila *et al.* (2007) found higher values in shell protein of the variety they assessed.

According to the results of this experiment, there are no evidences that the harvest beginning and ending influence considerably on the physical and chemical characteristics of the fruits. It is suggested that the mango parts considered as industrial waste (shell and seed) may be a good feeding resource for ruminants, due to the characteristics of its chemical composition.

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Received: January 5, 2011