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Evaluation of Selected Mango Varieties for Fruit Powder Production In Ghana

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Abstract

Mango is an important fruit, which receives high patronage in Ghana. However, the highly seasonal and perishable nature of the crop, besides being a constraint to both farmers and processors, also deny consumers the opportunity to enjoy the fruit all year round. Use of the stable powder form of mango can serve to fill the gap during the mango off-season. This study evaluated the fruits of four major mango varieties ("Keitt", "Kent", "Palmer" and a local variety*)* grown in Ghana for their suitability for fruit powder production. The fresh fruit pulp and reconstituted freeze-dried powder of the varieties were analyzed for physicochemical characteristics. The study revealed that "Keitt", "Kent" and "Palmer", which are the exotic varieties, had significantly ($p \leq 0.05$) high pulp content of 68%, 66% and 63% respectively indicating potential for high fruit powder yield. Acceptable levels of total soluble solids, titratable acidity, ascorbic acid and beta-carotene contents were observed in the fresh fruit and the freeze-dried powders of the varieties. There was no significant ($p \leq 0.05$) difference in Yellowness Index between fresh fruit pulp of "Keitt", "Kent" and "Palmer" and their respective reconstituted freeze-dried powders. These three mango varieties exhibited considerably good quality in terms of physical and chemical characteristics for processing and utilization as fruit powder. The production of high quality mango powder from these varieties could therefore serve as substitutes in the off-season and also reduce postharvest loss.

Keywords: pulp content, off-season, freeze-dried, substitute, postharvest loss.

Introduction

Mango (*Mangifera indica* L.) is one of the nutritionally important specialty fruits with an appreciable source of vitamins A, B, C and minerals (Nigam et al., 2007). The crop has comparative advantage of two production seasons in the Coastal Savannah zone, is considered a high value export commodity and has received considerable attention in Ghana. Major mango varieties grown include "Keitt", "Kent", "Palmer", "Haden" and "Erwin". Annual national production between 2013 and 2015 was around 70,000 metric tonnes (Broek et al., 2016).

Mango fruits are available in Ghana as seasonal surpluses during certain parts of the year in different growing areas. Postharvest losses of between 20% and 50%, mostly in the main season, were reported by Zakari (2012), while Gaveh (2016), observed 36% fruit loss across the growing regions in Ghana. The highly seasonal nature of mango fruits remains a major a constraint to processors and also denies consumers the opportunity to enjoy the crop all-year-round. There is therefore the need to preserve the seasonal mango fruit surplus to a more stable powder form that can be utilized whenever mango fruits are not available.

The processing of mango fruits into the more stable powder form will enable availability through extended storage life, easy widespread distribution and utilization in the mango off-seasons. New products can also be created using the mango fruit powder as raw material in diverse applications for food-based, pharmaceutical and cosmetic industries. According to Rajkumar et al. (2007), mango powders have innovative opportunities for applications in various formulations to manufacture assorted products like dry health drinks, beverage mixes, sauces, baby foods, confections, nutrition leathers and bars, ice cream and yogurt. This study, therefore, evaluated some major mango varieties cultivated in Ghana by assessing the physico-chemical characteristics of the fruits and the respective fruit powders.

Materials and Methods

Determination of Physical Characteristics Of Fruits And Fruit Powder

Fruits of the mango varieties: "Keitt", "Kent", "Palmer" and Local, at green matured stage, were obtained from a commercial farm in Yilo Krobo District in the Eastern Region and transported to the Biotechnology Centre, University of Ghana. The fruits were allowed to ripen naturally under ambient conditions. Fruits without blemish were selected, washed in tap water to remove dirt; surface sterilized with sodium hypochlorite (200ppm) solution and blotted-dry with paper towel. Thirty (30) fruits in three sets (replicates) of 10 fruits per set were selected for each of the four varieties. The average weight of each variety was determined by weighing the individual fruits on an electronic balance. The peel, pulp and seed weights of each variety were also determined by carefully separating them from the whole fruit using a sharp knife. The weights obtained were expressed as a percentage of the whole fruit. Data collected were subjected to ANOVA and mean differences among varieties tested using LSD at 5%.

Homogenized fruit pulp using a household blender was analyzed for color characteristics on a CIE L*a*b* chromatic space using FRU-WR10QC colorimeter (Shenzhen Wave Optoelectronics, China). Yellowness index (YI) which is used to express the level of yellow coloration in carotenoid rich materials (Pathare et al., 2013) was determined for the fresh pulp and reconstituted powder using the equation:

$YI = (142.86 \times b^*)/L^*$

Where:

YI = Yellowness Index

b^* = yellowness

L^* = luminosity (brightness)

A '*t*' test was performed to ascertain the difference. The total difference (ΔE) indicating the magnitude of the change in the color parameters in the fruit pulp and reconstituted powder were calculated using the equation (Commission International de l'Eclairage, 2004)

$\Delta E^* = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$

Where:

ΔE^* = Total color difference

ΔL^* = change in luminosity (Lightness)

Δa^* = change in greenness or redness

Δb^* = change in blueness or yellowness

Determination of Chemical Characteristics of Fruits and Fruit Powders

Homogenized fruit pulp was analyzed for the following characteristics: moisture content (AOAC 1990), total soluble solids (TSS) and titratable acidity (TA) using refractometer, ascorbic acid (Indophenol method) and beta-carotene contents (Nagata & Yamashita, 1992; Barros, et al., 2007). The homogenized pulp was freeze-dried at freezing and subliming temperatures of -35°C and 30°C respectively under a pressure of <500mTorr using a freeze dryer (Harvestright®, USA). It was followed by size reduction using a pulverizer (Mitsui, Japan). The mango pulp powder was reconstituted by adding water to achieve similar solid contents as the fruit pulp. The reconstituted pulp powder was then analyzed for colour, total soluble solids, titratable acidity, ascorbic acid content and carotenoid content. The chemical analysis was performed in three replicate samples. Data collected were subjected to ANOVA and mean differences among varieties tested using LSD at 5%.

Results and Discussion

Mango Fruit Weight

Fruit weight ranged from 220 g (local variety) to 607 g ("Keitt") and there were significant ($p \leq 0.05$) differences among the mango varieties (Figure 1). In a similar study by Abu (2010) in "Keitt", "Kent", "Palmer" and Haden varieties, the highest fruit weight was observed in the "Keitt". Differences in fruit weight have been reported to be as a result of genetic variation among the various varieties, growing conditions, cultural practices and age of the tree crop (Jilani et al., 2010; Kuar et al., 2014). Weight of fruit is an important parameter for measuring yield, which directly translates into economic value of the crop. That is, in mango, the fruit size and weight are major quality indices. Small to medium sizes are ideal for the fresh market while in the processing sector, large fruits are always preferred. The comparatively large fruit weight of the "Keitt" indicated suitability in terms of fruit weight for processing and therefore appropriate for mango fruit powder production. "Kent" and "Palmer" may be good substitutes in the absence of "Keitt" for high powder yield.

Peel, Pulp And Seed Weight

Sunburst chart of the morphological sections of the mango fruits with the outer, middle and inner rings representing peel, pulp and seed respectively is shown in Figure 2. Peel weight ranged between 20.4% and 23.3% with significant ($p \leq 0.05$) differences between "Keitt" and "Kent", but not "Palmer" and the local variety. Pulp weight contributed highest to the fruit morphological sections in all the varieties. The exotic varieties ("Keitt", "Kent" and "Palmer") had high pulp weight of 68%, 66% and 63% respectively compared to the local variety (57%). For seed weight, the local variety had the highest value of 20%, which was significantly different from "Keitt", "Kent" and "Palmer". However, there were no significant differences in seed weight among the exotic varieties. The pulp contribution to the fruit weight was found to be highest followed by the peel and seed in all the four varieties. Similar findings were reported by Pleguezuelo et al. (2012), in Spain, where several mango varieties were compared. The exotic varieties ("Keitt", "Kent" and "Palmer") had considerably high pulp content indicating a greater potential to yield large volumes of fruit powder.

Pulp To Seed Ratio

The pulp-to-seed ratio varied significantly ($p \leq 0.05$) among all mango varieties assessed (Figure 3). The ratios recorded for "Keitt", "Kent", "Palmer" and Local were 5.7, 5.0, 4.7, and 2.8 respectively. High pulp to seed ratio is a desirable fruit quality parameter in processing. It gives an indication of high pulp yield in a given mango fruit variety. Pleguezuelo et al. (2012), stated that high pulp to seed ratio could be considered commercially valuable mango fruit characteristic. Mitra and Mitra (2001), also found differences in pulp to seed ratio in mango varieties and established that a high pulp to seed ratio signifies suitability of a given cultivar for fruit processing. In this study, the high pulp to seed ratio observed in "Keitt" suggests an excellent processing potential for high powder yield while "Kent" and "Palmer" also have considerable high pulp content.

Colour Characteristics of Mango Fruit Pulp And The Reconstituted Powder

Generally, luminosity or brightness (L*) values were low in the fresh pulp than the corresponding reconstituted fruit powder in all the varieties. "Palmer" had the least L* value of 46.46 while the Local variety had the highest of 53.04. On the other hand, the redness (a*) and yellowness (b*) values in fresh pulp were comparatively higher than the reconstituted powder. The total colour differences (ΔE) ranged between 0.68 ("Palmer") to 4.9 (the local variety)

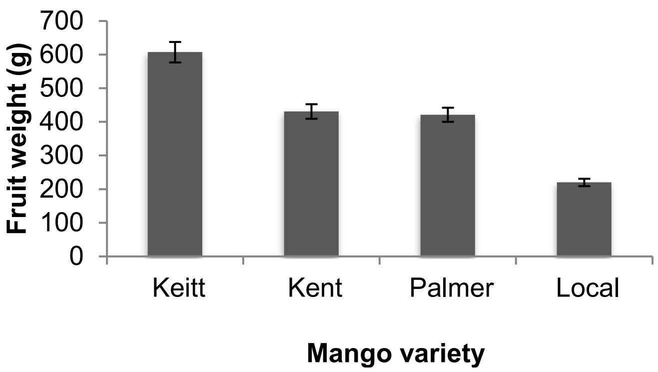

Figure 1. Fruit weight of the four mango varieties

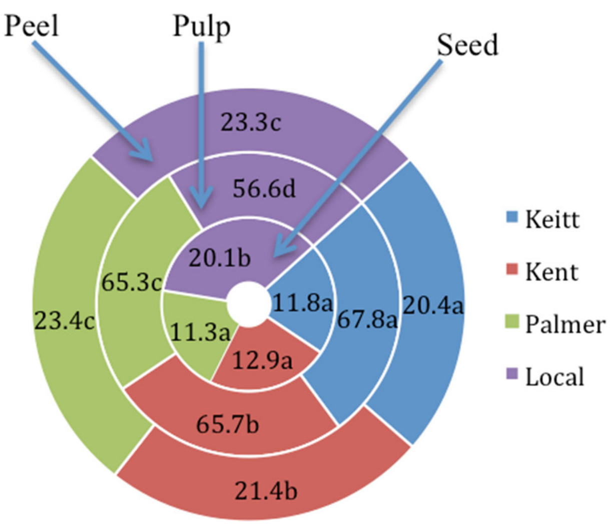

Figure 2. Percentage weight of pulp, seed and peel of four mango varieties. Means with the same letter within the mango varieties are not significantly different (p>0.05)

Table 1. Tristimulus colour values L* a* and b* and total colour difference (ΔE) of fresh fruit pulp and reconstituted freeze-dried powder of four mango varieties.

Variety	Fresh mango pulp			Reconstituted fruit powder			ΔE
	L*	a*	b*	L*	a*	b*	
"Keitt"	49.79±0.09	1.36±0.02	24.78±0.09	50.50±0.19	0.95±0.14	24.87±0.04	0.83
"Kent"	47.46±1.00	3.87±0.14	25.51±1.86	50.01±0.17	3.31±0.07	24.65±0.18	3.03
"Palmer"	46.68±0.40	4.32±0.16	24.79±0.45	46.80±0.03	4.33±0.08	24.29±0.06	0.68
Local	53.04±0.44	1.62±0.21	31.51±0.41	54.54±0.07	0.57±0.05	26.97±0.09	4.90

± =Standard deviation of the mean

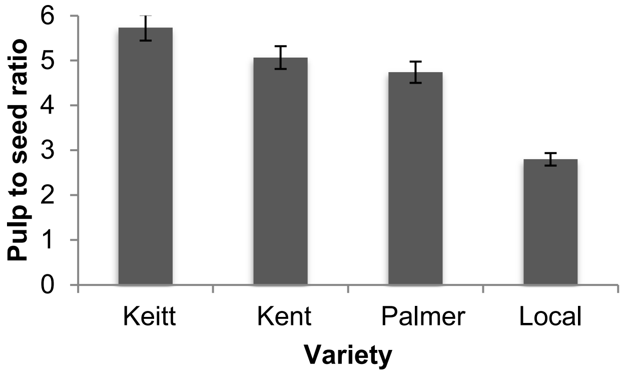

Figure 3. Pulp to seed ratio of the four mango varieties

for the four varieties tested. Colour difference was more pronounced in the Local variety. The more the colour difference (ΔE) values between two objects approach zero, the more the objects are perceived to be similar. Low ΔE value therefore depicts possibility of substituting one for the other. "Palmer" (0.68) and "Keitt" (0.83) reconstituted powders therefore had closest semblance to their respective fresh fruit pulp (Table 1).

Yellowness Index

The yellowness index ranged between 71-84 in the fruit pulp and 70-74 in the reconstituted powder (Table 2). There were no significant ($p<0.05$) differences between the fruit pulp and the respective reconstituted powders of "Keitt", "Kent" and "Palmer" varieties. This indicates a minimal effect of the freeze-drying process on the fresh mango pulp. However, a significant difference in the yellowness index was observed in the local variety. The subjective visual color observation of the fruit pulp and the corresponding reconstituted powder showed no distinct appearance in color, a promising indication for product substitution (Figure 4).

Total Soluble Solid and Titratable Acidity of the Fresh Mango Fruits

Generally, there were significant differences in the chemical characteristics of the mango fruits among the varieties (Table 3). Moisture content ranged between 81- 84%. Abu (2010), reported a similar moisture content range of 82-84% in "Keitt", "Kent", "Palmer" and Haden varieties. "Keitt" had significantly ($p<0.5$) high total soluble solids (TSS) and titratable

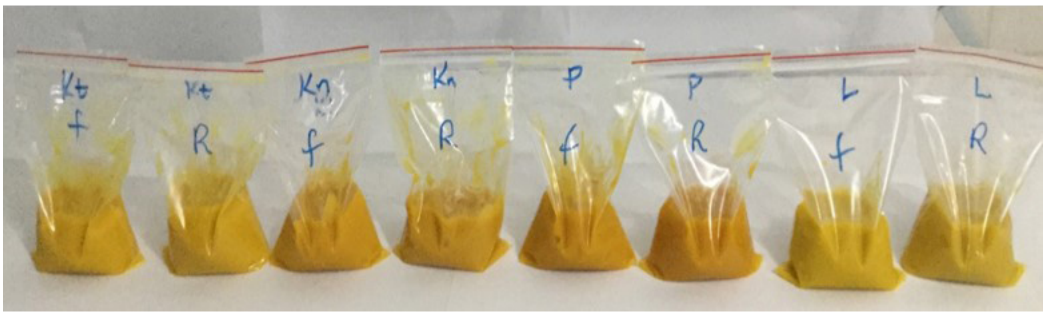

Figure 4. Appearance of fruit pulp and reconstituted fruit powder of four mango varieties: Kt= "Keitt", Kn= "Kent", P="Palmer", L= the local mango variety, F = fruit pulp, R = reconstituted powder.

Table 2. Yellowness index of fresh pulp and reconstituted powder of four mango varieties

Variety	Fruit pulp	Reconstituted powder	*p*-value
“Keitt”	71.10 ± 0.27	70.36 ± 0.34	0.11
“Kent”	76.79 ± 1.65	70.41 ± 0.28	0.21
“Palmer”	75.86 ± 1.43	74.15 ± 0.20	0.15
Local	84.87 ± 1.43	70.66 ± 0.18	0.02*

*Significant at p<0.05

Table 3. Chemical characteristics of fruits of four mango varieties

Variety	Moisture content (%)	TSS (%)	TA %)	AsA (mg/100g)	Beta-carotene (mg/100g)
“Keitt”	83.73^{a}	18.47^{a}	1.05^{a}	9.64^{a}	5.00^{a}
“Kent”	83.80^{a}	13.80^{b}	0.41^{b}	13.80^{b}	21.00^{b}
“Palmer”	84.08^{b}	16.13^{c}	0.55^{c}	19.01^{c}	28.04^{c}
Local	81.33^{c}	17.43^{d}	0.87^{d}	16.15^{d}	20.04^{d}

Note: TSS = total soluble solid; TA = titratable acidity; AsA= ascorbic acid.

Table 4. Chemical characteristics of the fruit powders of four mango varieties

Variety	Moisture content (%)	TSS (%)	TA (%)	AsA (mg/100g)	Beta-carotene (g/100g)
“Keitt”	5.45a	18.13a	1.10a	5.99a	3.78a
“Kent”	5.47a	17.27b	0.58b	6.51a	13.84b
“Palmer”	3.68b	18.07a	0.53b	12.76b	18.06c
Local	5.62a	16.53b	0.78a	10.94c	13.97b

Note: TSS = total soluble solid; TA = titratable acidity; AsA= ascorbic acid.

acidity (TA) than the rest of the varieties. It was also observed that high TSS corresponded to high TA and vice versa in all the mango varieties. Compared to the work done by Abu (2010), on ripe fruits, significant differences were reported in the TSS component of 17% for “Keitt”, 17.5% for “Kent” and 19.1% for “Palmer” while Appiah et al. (2011), reported 15.95% in fully ripe “Keitt” variety. In this study, the TSS values were 18.5%, 13.8%, 16.1% and 17.4 for “Keitt”, “Kent”, “Palmer” and Local respectively. The TSS in fruits may differ according to the variety and field conditions during growth and development and ripening stage (Kinhal, 2019). As stated by Okoth et al. (2013), TSS of 15% and above at the ripe stage is appropriate for processing products like fruit juices, nectar, jam and powder products. The TSS content observed in this study for “Keitt”, “Palmer” and Local varieties could be described as excellent for both fresh market and processing while that of “Kent” appeared satisfactory. Titratable acidity (TA) positively corresponded with TSS and the highest and the lowest values were observed in “Keitt” and “Kent” varieties, respectively. A contrasting observation was reported by Pleguezuelo et al. (2012), where no correlating pattern was observed in several mango varieties studied in Spain.

Ascorbic Acid And Beta-Carotene Content In Fruit Pulp

Ascorbic acid (AA) and beta-carotene contents in the fruits were significantly (p<0.05) different among the varieties (Table 3). “Palmer” had the highest AA content of 19.01 mg/100 g fresh fruit while “Keitt” had the lowest of 9.64 mg/100 g fresh fruit. Similarly, a high AA was reported in “Palmer” variety by Abu (2010), among “Keitt”, “Kent”, “Palmer” and Haden mango varieties. Beta-carotene content was significantly different in all the varieties ranging from 5 mg/100 g to 28 mg/100 g of the pulp. “Palmer” had the highest (28 mg/100 g) and “Keitt” the lowest (5 mg/100 g). A low amount of 4.76 mg/100 g puree was reported in the “Chokanan” variety (Johar et al., 2008).

Moisture Content, Total Soluble Solid and Titratable Acidity of The Mango Fruit Powders

Significant differences in chemical characteristics of the reconstituted fruit powders were observed among the varieties (Table 2). The moisture content (MC) in the powders ranged between 3.68 and 5.62%. Caparino (2012), obtained 2.3% moisture content of freeze-dried Carabao mango variety. High moisture in horticultural crops imposes susceptibility to chemical and enzymatic reactions as well as microbial decay leading to spoilage and food safety concerns. Reducing the moisture content or water activity can help reduce spoilage. The moisture content of 84% in the fresh pulp was reduced to less than 6% after freeze-drying and this can greatly enhance storability. TSS and TA values ranged between 16-18% and 0.53-1.10% respectively. Meanwhile, Mahendran (2008), examined Tommy Atkins mango fruit powder and obtained 9.5% for TSS and 0.49% for TA. The TSS and TA values in the fruit powders in this study were comparable to their corresponding fresh fruits. Similar findings were made by Mawilai et al. (2019), in TSS and TA values in the fruit powders and fresh fruits of the Mahachanok variety.

Ascorbic Acid And Beta-Carotene Content Of The Fruit Powders

Generally, the AA in the fruit powder was lower ($p<0.05$) than that of the fresh fruits (Table 4). The AA content in “Keitt” and “Kent” were significantly different from “Palmer” and Local. “Palmer” fruit powder had the highest AA of 12.76 mg/100 g while “Keitt” had the lowest of 5.99 mg/100 g. The AA was considerably retained after freeze-drying and pulverization. The retention proportions were 62%, 47%, 67% and 68% in the “Keitt”, “Kent”, “Palmer” and the the local variety, respectively. The higher retention proportions of 83% AA were reported by Ceballos et al. (2012), in freeze-dried soursop pulp. Nevertheless, the amount reported in this study could be deemed as a good source of vitamin C for juices, yoghurts and ice cream, among others. According to Lee and Kader (2000), chemical and enzymatic oxidations occur in AA during the heating stages of processing thereby resulting in losses. Retention could be improved further with incorporation of acceptable AA stabilizers such as citric acid before freeze-drying in the development of the fruit powders.

The beta-carotene content was significantly different among the varieties with “Palmer” having the highest of 18.06 mg/100 g fruit while “Keitt” had the lowest of 3.78 mg/100 g fruit (Table 4). The beta-carotene content in the fruit powder was lower as compared to the fruit pulp in all the mango varieties. Similar results were obtained by Yano et al. (2005), in fresh and dried mangoes. This may be attributed to the effects of the processing and light, which might have degraded the pigment.

Conclusion

The fruit pulp and fruit powder of the four major mango varieties evaluated exhibited various physico-chemical characteristics that were of considerably good quality. Fruits of “Keitt”, “Kent” and “Palmer” had greater potential for high pulp powder yield. Their reconstituted fruit powders were also comparable in quality to the fresh pulp in terms of color, sugar content as well as the levels of ascorbic acid and beta-carotene. “Keitt”, “Kent” and “Palmer” mango varieties, therefore, have great potential for fruit powder processing and utilization as substitutes in the mango off-seasons in Ghana.

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