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Effect of maturity stages on nutritive quality and sensory properties of Fig fruits

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ABSTRACT
This study was conducted in a completely randomized design to evaluate the physical character, proximate composition, minerals (Fe, Zn, Ca and P) and sensory properties of early, mid and late maturity stages of *Ficus sur* fruits (FSF) collected from five trees. The physical parameters were determined at the sample collection site. Fresh fruit samples collected were used for sensory evaluation. The other sub-sample was dried at 65°C for 48 h to constant weight and stored in a sealed plastic bag at refrigeration temperature (5°C) for nutrient content analysis. The early maturity stages of FSF was most preferred except for its taste in which the late maturity stage was the best accepted fruits. The early maturity stage attained the highest fruits size, crude fat, crude protein and aril weight. The late maturity stage attained the highest dry matter, crude fiber and total carbohydrate. Iron and zinc contents were high for late maturity stages while calcium and phosphorus contents were high at early stages. The condensed tannin contents were not significantly different among the three maturity stages. The study showed that harvesting FSF at early maturity stage would be best for most sensory preferences and physical characteristics while late maturity stage is better for most of the nutrient contents analyzed.

Keywords *Ficus sur* fruits, Maturity stages, Nutrient contents, Physical parameters, Sensory evaluation

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INTRODUCTION

Fig (*Ficus sur* Forssk, Moraceae) fruits (vernacular name, harbuu) are important wild fruits widely available in Ethiopia and consumed by human for centuries (Molla et al., 2011). The fruits are also sold by households to earn money for purchasing of items such as salt, sugar, soaps and stationery materials particularly during peak fruits ripening period. A *F. sur* tree can produce up to 1-2 tonnes fruits (personal *observation*) annually even though exact yield estimation per tree could be complicated due to different factors such as at early fruit maturity stage, consumption by birds, apes and monkeys. At mid and late stages, fruits naturally fall down to the ground and are eaten by wild animals like pigs and bushbucks, different species of livestock and pet animals.

Different fruits have different periods as optimum maturity stages. Some researchers (Jan et al., 2012) identified different ripening/maturity periods for apple cultivars as early, mid and late stages. Parker and Maalekuu (2013) noted four stages of ripeness for four tomato cultivars. Like many other fruits, *Ficus sur* fruits (FSF) have different stages of maturity that dictates its harvest time. Crisosto et al. (2010) noted two maturity stages for *Ficus carica* fruits, and also reported the presence of variations in sensory property of four fig cultivars harvested at the two maturity stages. Variation in fruits maturity stages brings about differences in color, taste, flavor, texture, fleshiness and other sensory properties. Mahmood et al. (2012) noted that sensory quality is affected by sugar concentration that was varied with the fruits ripening stages.

Maturity at harvest determines final fruit quality. Immature fruits are bitter, have inferior quality and when ripe and dried are more prone to shriveling (wrinkling) and mechanical damage (Kader, 1999). Overripe fruits are likely to become soft and mealy with insipid flavor soon after harvest. Any fruit picked either too early or too late in its season is more susceptible to physiological disorders and has a short storage-life than fruits picked at the proper maturity stage.

Various approaches of testing fruits quality are available, for example, Biospeckle optical technique (Zdunek et al., 2014); color measurements (Londhe et al., 2013); near infrared spectroscopy (NIR) (Cortés et al., 2016) and physicochemical methods (Magwaza and Opara, 2015). However, most of these methods are instrumental and do not involve human sense organs to determine palatability of the food items.

Sensory evaluation, among others, is the best way to identify consumer acceptability and preference for food items. Yet no eating quality documents are available for fig fruits consumed in Ethiopia. Nutrient contents data for wild edible fruits of Ethiopia are limited (Molla et al., 2011) to substantiate their future sustainable production to support nutrition and food security of the country. Information on the nutrient contents, sensory properties and effects of varying ripening stages of FSF is absent. In view of this, in the present work the sensory preference, physical, proximate and mineral nutrient contents of FSF at three maturity stages are reported.

MATERIAL AND METHODS

Study site and fruits sample collection

The FSF were collected from Horro District of Oromiya National Regional State of Ethiopia located about 11 km from Shambu College of Agriculture (9º34´N latitude and 37º06´E longitude) which is about 315 km from Addis Ababa. The three fruit maturity stages (early, mid and late) were differentiated based on the traditional experience on sensory and visual appearance of the fruits. The three stages are edible but vary in the ripening phase and are locally called *boodhee*, *cooligaa* and *qoortoo* for early, mid and late stages of maturity, respectively. They have distinct color, taste, flavor and texture. The fruits still attached to the tree were picked and collected into clean plastic bags by members of local community.

About two kg fruits samples from each maturity stages were taken from randomly selected five fig trees located at an arbitrary determined distances of one to 10 km from each other in the same locality. The three maturity stages were separately collected for a single tree. After collection, the physical parameters were determined at the collection site, while other sub-samples were immediately taken to Shambu College of Agriculture, Food Science and Postharvest Technology Laboratory for sensory evaluation and chemical analysis. Sensory evaluation was made immediately after collection while the sample was fresh. The sub-sample left was further trimmed to remove inedible parts and the inner seeds to simulate how locals process and consume the fruits. The aril part (fleshy fruit part consumed) of the fruits for each maturity stage was dried in a forced air draft drying oven at 65°C for 48 h and ground to pass 1mm sieve size. The dried ground sample were then stored at refrigeration temperature (5°C) in sealed plastic bags pending chemical analysis. The chemical analysis were conducted by taking the dried sample to the Food Science and Postharvest Technology laboratory of Haramaya University (located at 9º26'N latitude and 42º3'E longitude), Ethiopia.

Treatments

Based on local knowledge, the three natural ripening stages of FSF were categorized into maturity stages as: early (orange red, yellowish red colors with turgid - moisture full fruits), mid (brown and slightly brown color with moderate moisture content and moderate soft texture) and late (pale brown and nearly straw colored with least moisture content and rough texture) (Figure 1).

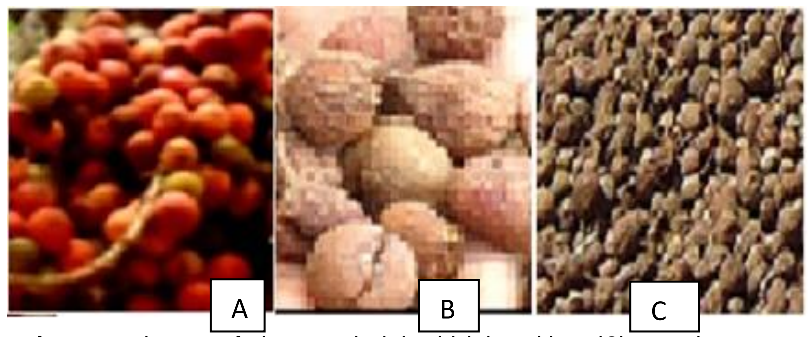

Figure 1. Ficus sur fruits at early (A) mid (B) and late (C) maturity stages (photo by researchers)

Sensory evaluation

The FSF collected from five trees of the same maturity stage were pooled together and uniformly mixed. Fifty consumer panelists (female 18 and male 32), with most of them (70%) aged from 25 to 40 years (students and staff of the College) were approached randomly but finally selected based on their consent for participation. All the panelists selected had experience of consuming fig fruits and had different life background before they were enrolled to the College. Training was given to the panelists to familiarize them with sensory evaluation procedures. Cup of water was provided to cleanse their mouth in between tasting to avoid residual after-taste from influencing the following decision. The fruits samples were presented fresh without processing in white and clean ceramic dishes to consumer panelists. Descriptive sensory scores were collected for FSF color, taste, flavor and fleshiness/tenderness after setting a range of relevant vocabulary (Valentin et al., 2012) and data were presented as percentage. Sensory acceptability for color, flavor/aroma, taste, fleshiness, texture, fruits size and overall acceptability variations were evaluated on a 1 to 9 hedonic scales (9=like extremely, 8=like moderately, 7=like, 6=like slightly, 5=neither like nor dislike, 4=dislike slightly, 3=dislike, 2=dislike moderately, 1=dislike extremely) (Resurreccion, 1998).

Physical parameters of fruits at maturity stages

Single fruit weight (g) was determined after the inedible parts (like twigs) were removed and determining mean weight of twenty randomly selected fruits.

Twenty fruits weight (g) were determined as twenty fruits aril parts mass after carefully removing thin outer stalk and inner seeds using fork and small spoon. Aril and seed weight (g). The seed is located in the inner part of the fruits and the smallest size is comparable to teff grain (*Eragrostis tef*) size. Aril and seed weight were determined by randomly taking twenty fruits after removal of thin outer inedible stalks and separating the aril from the seed using a fork. The seed was then washed in clean water to remove adhered soluble materials and sun dried for one h. Weights for the aril and seed were measured on mass balance (±0.01g) (model TP-3002 Denver Instrument, Germany).

Fruits diameter (cm) were determined on twenty randomly selected fruits by vertically dividing each fruit into two at the middle and measuring diameter for both halves of the fruit. Both halves were measured two times (horizontally across the thickness and vertically along its length) and average was taken as fruit diameter.

Fruits length (cm) was measured on twenty randomly selected fruits and dividing each fruit vertically (along its length) at the middle and determining the mean length of both halves.

Chemical analysis

Dry matter, ash, crude fiber, and crude fat contents of the samples were determined according to AOAC (1995). The crude protein content (CP % = N % x 6.25) was determined by determining N content using micro-Kjeldahl method and urea as a control. The total carbohydrate content was determined by difference as 100-(% ash + % CP + % CF + % crude fat).

The Fe, Zn, and Ca contents were analyzed by atomic absorption spectrophotometer (Model 210 VGP spectrophotometer, Buck Scientific, East Norwalk, CT, USA) using air-acetylene as a source of energy for atomization after dry digestion of about 10g sample (AACC, 2000). For iron content determination, absorbance was measured at 248.3nm and iron content was estimated from a standard calibration curve (3-8µg Fe/mL) prepared from analytical grade iron wire. For zinc content determination, absorbance was measured at 213.8nm and zinc content was estimated from a standard calibration curve (0.1-1.0µg Zn/mL) prepared from ZnO. For calcium content determination, absorbance was measured at 422.7 nm after addition of 1% lanthanum (i.e., 1mL La solution/5mL) to sample to suppress interferences. Calcium content was then estimated from standard solution (0.1-1.0µg Ca/mL) prepared from $CaCO_3$.

Phosphorus content was determined after digestion of about 15 mg sample by measuring the absorbance of blue color of phosphomolybdate developed at 822 nm using UV-Vis Spectrophotometer (Model 6505, Genway, U.K) (Morrison, 1964). Phosphorus content was estimated from a standard (0.2-1.2 µg P/mL) calibration curve prepared from K_2HPO_4.

Condensed tannin contents were determined using Vanillin-HCl method (Price, 1978) by blank subtraction for the extracted color after vortex (REAX top, Germany) mix extraction (20 min) of sample (200 mg) with 10 mL absolute methanol maintaining water bath (GLS 400 water bath, England) temperature at 30°C for extraction and incubation. Vanillin reagent (0.5% in methanol, w/v and 4% HCl in methanol), 5 mL was mixed with 1 mL extract and for blank 5 mL of 4% HCl in methanol was mixed with 1 mL extract. Absorbance was measured at 500 nm with UV–VIS spectrophotometer (Model 6505; Jenway, Chelmsford, UK), and CT contents were estimated from catechin (CE) standard curve as catechin equivalent (% DM).

Statistical analysis

The physical and nutrient composition data were analyzed using general linear model procedure of SAS (SAS, 2008). The sensory evaluation data was analyzed using the mixed model of the same statistical package. The maturity stages of the fruits were taken as fixed effects and the response from sensory evaluations were taken as random effects. Where the ANOVA resulted in a significant differences among the treatments, means were separated using Tukey honestly significant difference ($p < 0.05$).

The model used is described as:

$Y_{ijr} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \varepsilon_{ijr}$, where, μ is grand mean; α_i is the 1-3rd level fixed effect of the FSF maturity stages; β_j is the 1-50th level random effect of assessors and $\alpha\beta_{ij}$ the 1-3rd fixed effects of maturity stage and 1-50th random effects of assessors interactions. The interaction effect was not significant, hence only the main effects were presented in the result.

RESULTS

Effect of maturity stages of FSF on descriptive consumer sensory judges

The sensory response for FSF maturity stages are given in Table 1. There were variations in color, taste, flavor, texture, fleshiness and fruits sizes among FSF fruits for different maturity stages. The color of early maturity (*boodhee*) fruits was observed as red, the mid maturity (*cooligaa*) as brown and the late maturity (*qoortoo*) as pale brown. The panelists described fruits taste as slightly sweet for early maturity stage and sweet for both mid and late stages. The flavor of the fruits was judged as fruity by most of panelists while others described it as aromatic for all the three ripening stages. The fruitiness score for the early stage was higher than for both the mid and late maturity stages. The fleshiness of the fruits was categorized as very soft, slightly soft and sticky for early, mid and late fruit maturity stages, respectively.

Table 1. Descriptive sensory scores of *Ficus sur* fruits for early, mid and late maturity stages

Fruit maturity stages	Color -percent							
	Light yellow	Yellow	Slight pink	Light red	Red	Brown	Pale brown	Others
Early (Boodhee)	8	10	6	22	54	0	0	0
Mid (Cooligaa)	2	0	0	8	2	52	36	0(0)-
Late (Qoortoo)	0	0	0	0	0	44	56	0(0)-
	Taste - percent							
	Slightly sweet	Sweet	Intense sweet	Sour	Bitter	Salty	Others	
Early (Boodhee)	56	32	0	6	4	2	0	
Mid (Cooligaa)	30	46	4	10	8	2	0	
Late (Qoortoo)	18	62	10	4	4	0	2	
	Flavor – percent							
	Earthy	Spicy	Woody	Aromatic	Fruity	Smoke y	Blending	Other type
Early (Boodhee)	0	6	4	30	54	0	4	2
Mid (Cooligaa)	4	8	2	34	46	0	2	4
Late (Qoortoo)	4	4	4	38	42	2	4	0
	Fleshiness/tenderness- percent							
	Very soft	Soft	Slightly soft	Chewy	Sticky	Others	-	-
Early (Boodhee)	58	28	12	2	0	0	-	-
Mid (Cooligaa)	16	26	44	12	2	0	-	-
Late (Qoortoo)	0	2	6	38	52	2	-	-

Effect of Ficus sur fruits maturity stages on consumer sensory preference

The sensory preference for early, mid and late maturity stages of FSF are given in Table 2. All the sensory parameters significantly differed ($p<0.0001$) with ripening stages. The preference score for color, flavor, texture, fleshiness and fruit size consistently decreased from early to late stages of ripening. However, the preference for the taste followed the opposite trend.

Table 2. Effect of maturity stages on sensory preference of *Ficus sur* fruits evaluated on 1-9 hedonic scales

Sensory category	Fruits maturity stages: Early	Mid	Late	±SEM	P level
Color	7.59^{a}	5.79^{b}	5.31^{b}	0.228	<0.001
Taste	4.52^{c}	6.05^{b}	7.61^{a}	0.225	<0.001
Flavor	7.80^{a}	6.31^{b}	4.63^{c}	0.238	<0.001
Texture	7.20^{a}	5.80^{b}	4.65^{c}	0.186	<0.001
Fleshiness	7.71^{a}	6.06^{b}	3.50^{c}	0.191	<0.001
Fruit size	8.02^{a}	5.81^{b}	3.87^{c}	0.09	<0.001

The mean scores in a row with different superscript letters are significantly different at $P<0.0001$; SEM= standard error of the mean

The physical characteristics for FSF are given in Table 3. All the parameters significantly ($p<0.0001$) decreased as the ripening stage advances. The effect of maturity stages on proximate composition and minerals contents are given in Table 4. The dry matter (DM) and total carbohydrate contents significantly increased ($p<0.0001$) with maturity stages. Though not significant, ash and crude fiber (CF) contents also followed the same trend as that of DM while crude fat and crude protein (CP) contents significantly decreased ($P<0.05$) with progress in maturity stages.
The iron ($P<0.001$) and zinc ($p<0.01$) contents of FSF increased from early to late stages of maturity, whereas calcium ($P<0.001$) and phosphorus ($P<0.05$) trends were in reverse. The condensed tannin content of the fruits did not significantly differ ($P>0.05$) on maturity stage variations but the mean values decreased with the ripening progress to the late stage.

DISCUSSION

Effect of maturity stages on consumer sensory preferences of FSF

Maturity indices are important for deciding when to harvest the fruits to provide some marketing flexibility and to ensure the attainment of acceptable eating quality to the consumer (Kader, 1999). The FSF color appearance for different maturity stages has shown clear demarcation of the stages. Except for the red color of early stage, all the color descriptions made for FSF by the panelists were not in agreement with the colors reported for other fig (*Ficus carica*) fruits as white, green, black, red, wine, and purple (Crisosto et al., 2010).

Table 3: Physical characteristics of *Ficus sur* fruits at early, mid and late maturity stages

	FSF Maturity Stages				
Physical parameters	Early	Mid	Late	±SEM	SL
Single fruits wt (g)	11.6^{a}	8.10^{b}	6.01^{c}	0.048	<0.001
Aril wt (g)	8.48^{a}	5.90^{b}	4.20^{c}	0.029	<0.001
Seed wt (g)	3.11^{a}	2.20^{b}	1.82^{c}	0.022	<0.001
Twenty fruits wt (g)	232.2^{a}	162.0^{b}	120.0^{c}	0.476	<0.001
Fruits diameter (cm)	2.93^{a}	2.58^{b}	2.27^{c}	0.024	<0.001
Fruits length (cm)	3.11^{a}	2.68^{b}	2.48^{c}	0.036	<0.001

Means with different superscripts in the same row are significantly different; SEM= Standard error of the mean; SL= significant level

Table 4: Proximate composition (% of dry matter) and some mineral contents of FSF at different stages of fruits maturity

	Fruits maturity stages				
Nutrients	Early	Mid	Late	±SEM	SL
Dry matter (%)	44.5^{c}	65.5^{b}	87.6^{a}	0.524	***
Ash	6.59	6.69	7.01	0.094	ns
Crude fiber	8.03	8.24	8.35	0.082	ns
Crude fat	6.54^{a}	6.33^{b}	6.15^{b}	0.047	*
Total carbohydrate	70.3^{b}	70.8^{a}	71.0^{a}	0.097	**
Crude protein	8.23^{a}	8.01^{ab}	7.80^{b}	0.056	*
Minerals (mg/kg)					
Iron	46.6^{c}	54.6^{b}	59.8^{a}	0.311	***
Zinc	4.30^{c}	4.52^{b}	4.72^{a}	0.003	**
Calcium	125.2^{a}	120.1^{b}	115.9^{b}	1.141	***
Phosphorus	66.8^{a}	63.6^{b}	61.0^{b}	0.718	*
CT (% DM)	1.29	1.27	1.25	0.061	ns

Means with different superscripts in the same row are significantly different; CT = condensed tannins; SEM= Standard error of the mean; SL= significant level; ns = non-significant. *= P<0.05; **= P<0.01; ***=P<0.001.

The color of early matured (*boodhee*) fruits is distinct but is somewhat similar to the ripe fruit color reported for other figs (*Ficus racemosa* and *Ficus benghalensis*) from India (Borges et al., 2011). Such color variations is an attribute of variety differences. For mature litchi fruits full-red colors were described (Finger et al., 1997) as good quality standard with better fruity characteristics whereas intense pericarp (fruit wall) browning indicates excessive maturity of overripe. The color of fruits change with change in stage of maturity and this change in color is also positively associated with composition of secondary metabolites that affect nutritional value and flavor acceptance of the fruits (Borges et al., 2011). The color preference of consumers for early stages FSF (Table 2) indicated that they were interested in red to light red color fruits as compared to brown color for mid and pale brown for late maturity stages (Table 1).

The panelists judged the taste of the fruits to be best in late stage than the preceding maturity stages. This could be due to increased concentration of sugars in the late stage as ripening of fruits progress. Similarly it was reported by Crisosto et al., (2010) where soluble solids, including sugar components, increased from 0.7 to 3.2% for different fig cultivars as the ripening stage advanced from commercial maturity to advanced maturity stage. Similar increases in sugars, total soluble solids and sweetness with an increased ripening stages were reported for strawberry, sweet cherry, and mulberry fruits by Mahmood et al. (2012) and for pomegranate by Fawole and Opara (2013).

The highest inclination of panelists for flavor of FSF in the early stage was similar with flavor score earned by fully matured strawberry, long mulberry and small mulberry fruits reported by Mahmood et al. (2012). Obenland et al. (2012) stated that as fruits ripening advanced beyond full maturity, the volatiles like aldehydes, ketones, alcohols and esters most associated with flavor declined in abundance hence reduces the sensory perception of flavor in the fruits. Volatile organic compounds of fruity flavor were reported to be abundant at ripening for other fig species (*F. racemosa* and *F. benghalensis*) (Borges et al., 2011). Thus, the best flavor preference of the panelists at early stage of FSF maturity was in agreement with fig species reported above. Even though, there was no documentation on the respiration pattern (whether it is climacteric or non- climacteric fruits) for the FSF, our experience with these fruits was that it is consumed by humans only after it is matured and fully ripened (i.e. from early maturity stages) on the plant. Fruits not consumed at that stage could be further ripened to mid and late stages while on or detached from plant and this process is accompanied by decrease in moisture contents. If picked from trees just before fully ripened, the fruits are not readily accepted by humans. Thus, FSF ripening process follows the respiration pattern of fruits with climacteric characteristics. Borges et al. (2011) had also reported similar respiration pattern for other fig species (*F. racemosa* and *F. benghalensis*).

The highest textural preference for early maturity FSF was mainly based on its softness on pressing between the teeth. The texture of FSF with progress in ripening was in reverse character to that reported for olive (*Olea europaea*) fruits by Mafra et al. (2001) in that the firm texture in the later, was shifted to softness with advancing maturity. This means that the early stage FSF was the most fleshy-type and such fleshiness decreased as ripening advanced towards late stage because of moisture decrease on drying.

The highest preference for fruits size in early stage of FSF was mainly due to highest moisture content that enhanced turgidity of the early stage in relation to the flaccid nature of mid-stage and relatively dryness of the late stages. Generally, except for the taste of the fruits, the rest of the sensory parameters were scored favorably for the early mature FSF, indicating preferential use of the fruit at this maturity stage. Nevertheless, the least preference for taste of fruits in their early stages negatively affects diet choices, palatability and intake. If properly dried and preserved, the mid and late maturity ripening stages, could have an attractive aroma and taste with potential use as food ingredient with bioactive constituents in products such as cookies, pastries, sauces, jams and other confections similar to other Figs (*Ficus carica* L.) fruits (Haug et al., 2013).

Effect of fruits maturity stages on physical characteristics of FSF

The heavier weight of single fruit in the early stage of maturity was mainly due to the high moisture content that enhanced turgidity and thereby fresh weight. This contradicts the review report (Fawole and Opara, 2013) on pomegranate fruits where weight increased with progress in maturity stages. The weights of single or twenty fruits determines the selling price per kg of fresh FSF. Thus early mature fruits are expected to fetch a better price. However, this contradicts traditional marketing of FSF in the study area whereby the late maturing fruits are commonly traded because of ease of handling, sweet taste and their longer shelf life, all of which were attributed to low moisture and better sugar content (Crisosto et al., 2010; Mahmood et al., 2012). The high preference rate given to the early stage FSF, which are recommended for fresh consumption need improved storage conditions to maintain its keeping quality from deterioration due to its high moisture content.

The heavier weight of aril and the least weight of seed for early stage FSF indicated that this stage contain the highest fraction of edible flesh component which was another aspect of quality for the early stage FSF. The fruits diameter and length described the size of the fruits in relation to the space it occupies and thereby estimate the physical volume of production and storage demand. Therefore, the differences in physical characteristics of FSF at different maturity stages affects storage requirements by producers and the prices of the fruits at these stages.

Effect of FSF maturity stages on proximate, minerals and condensed tannin contents

The lower dry matter content of FSF at early stage is attributed to its high moisture contents. Other researchers indicated the early maturing fruits have more than threefold (44.5%) dry matter content than in ripe papaya fruits (Maisarah et al., 2014), two fold for apple, Ngowe and Kent mango varieties (Okoth et al, 2013). Absence of differences between maturity stages with regard to ash contents (6.59-7.01%) indicated that the three stages had similar potential of providing mineral nutrients.

The crude fiber content (8.03-8.35%) of FSF was higher than that of matured dragon fruits (1.5%) (Jaafar et al., 2009) and ripe papaya fruits (7.6%) (Maisarah et al., 2014). The daily recommended fiber intake by IOM (2016) for human of one year to 50 years of age for both sexes is 19-38 g. This could be achieved if one consumed 236.6-373.6g of early stage FSF per day either in two or three meals. This showed FSF had a potential to supply dietary fiber requirements for low income rural households. Moreover, the buffering and laxative effects of such fibers in the diet could aid normal gastro-intestinal tract health, prevent obesity and diabetes developments (Tungland and Meyer, 2002). The crude fat content in FSF was slightly less than that of matured dragon fruits (8.5%) (Jaafar et al., 2009) but higher than of apple, Ngowe and Kent mango varieties at different stages of ripeness (Okoth et al., 2013). The decreasing trend in crude protein content of FSF with increase in ripening stages was due to catabolic effect on proteins. Even though the decrease in protein content of FSF with progress in ripening was small, similar observations were reported for Musa ABB (protein content of 10.56% for early stage to 2.01% at late stage) (Khawas et al., 2014) and African pear pulp (CP from 14.5 to 9.7%) (Hez et al., 2009).

The iron content in the present study showed an increasing trend and a similar trend was also reported by Fawole and Opara (2013) for pomegranate fruits. According to IOM (2016) for greater than 9 years old humans, the recommended dietary allowance for iron was in the range of 8 to 18 mg per day, and at pregnancy was 27 mg per day. If the iron in the FSF was assumed to be 100% bioavailable, to get 18 mg iron per day, one needed 386.3 g of early stage or 300 g of late stage daily, but pregnant women needed 579 g or 450 g per day intake of early or late stage FSF, respectively. Even though, FSF could contribute towards iron nutrition, iron from plant sources were only about 10% bio-available. Also FSF availability is seasonal and consumption of meat products or other iron sources is essential to meet the iron requirements. Zinc contents of FSF showed subtle increase with maturity stages and similar obseveration were reported for pomegranate (Fawole and Opara, 2013), medlar (*Mespilus germanica* L.) (Rop et al., 2011) and Musa ABB fruits (Khawas et al., 2014). The FSF have also the potential to contribute toward the recommended dietary allowance for zinc which was in the range 8 to 12 mg per day (IOM, 2016). The calcium and phosphorus contents showed a decreasing trend with progress in maturity. With progressing maturity, a decrease in the calcium content was also observed for pomegranate fruits and attributed to its translocation into the seed than in the arils (Fawole and Opara, 2013). Calcium and phosphorus contents of the FSF were less than the contents reported for medlar fruits (Rop et al., 2011) but were higher than for *Cola parchycarpa* (K. Schum) fruits (Nwiisuator et al., 2012).

In the present study no difference was observed in the condensed tannin contents among the three FSF maturity stages while, a decreasing trend with maturity increasing was reported for culinary banana (Musa ABB) fruit by Khawas et al. (2014). Dietary condensed tannin levels in the food in excess of 3% was reported as fatal (Chung et al., 1998) and the same authors noting that rats could tolerate up to 5% condensed tannins mixed in their ration, with higher levels depressing growth. The condensed tannins found in FSF could not be regarded as deleterious (1.25-1.29%), but could contribute toward anti-oxidant activities.

CONCLUSIONS

The early maturity FSF was the most preferred stage on the basis of fruit color, flavor, texture, fruit size and tenderness while the late stage was best preferred for taste. The early maturity stage also attained highest physical measurement values such as fruit weight, aril weight, seed weight, fruit diameter and length. The late stage contained the highest dry matter, crude fiber and total carbohydrate, while crude fat and crude protein were higher in fruits harvested during early maturity. High iron and zinc contents were best obtained in fruits at late stages while calcium and phosphorus were high at early maturity stages. In all stages of the fruits, condensed tannin content was similar and its concentration could not be considered deleterious. Therefore, harvesting FSF at early stage would be best on the basis of fruits sensory preference and physical characteristics while the late stage is superior in its nutrient concentration and sweet taste. If properly managed, dried and preserved, the FSF has a potential to be used as food ingredients in various food products such as cookies, pastries, sauces, jams and other confection products. Further characterization and product development from sole FSF or its combination with other ingredients is warranted.

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Conflict of interest

None

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