The Effect of Ripening on the Nutrient Composition of Mature Locally Cultivated Pink Banana Cultivar (*Musa spp*) Peel and its Possible Uses.

Ayo, JA[1,2], Ochefu A[1] and Agbatutu A[1]

[1]*Dept. of Biological Sciences, Kwararafa University, Wukari, Nigeria*
[2]*Dept. of Food Science and Technology, Federal University Wukari, Wukari, Nigeria.*

***Corresponding Author:** jeromeayo@yahoo.com, jeromeayo@gmail.com

ABSTRACT

Background: *The stage of maturity of food plants greatly affects the concentrations of nutrients in them and lack of this information makes these plants to be highly underutilized.*

Material and Methods*: Matured unripe pink banana cultivar were collected from Ussa, Ussa LGA, and divided into two portions.One portion was covered with jut bag and kept in the dark under room temperature to ripen. The peel of the other portion (unripe) were immediatetly removed, cut into pieces, dried at 50°C, milled into powder and stored under referigeration temperature (10°C). The peel of the ripe pink banana cultiver were processed as the unripe peel.The chemical composition of the powdered bananas peels (unripe andripe) were determined using standard methods.*

Results*: The moisture, protein and carbohydrate content of the pink banana cultiver decreased from 8.82 to 7.83, 5.39 to 5.19 and 72.79%, respectively. While the ash, fats and fibre content increased from 4.66 to 5.34, 5.29 to 6.22 and 3.10 to 3.17%, respectively, on ripening.An increase in vitamin C (0.08 to 0.14mg/100g), vitamin E (92.0 to 113.10 mg/100g), and decrease in starch (1.13 to 0.92mg/100g) and lignin (5.22 to 5.11mg/100g)on ripening. The potassium and phosphorous content of the banana peels increased from 4.16 to 4.31 and 0.28 to 0.35mg/100g, repectively, on ripening.*

Conclusion*: Ripening has relatively improve the macronutrients and micronutrients of the unripe banana cultivar peels and could therefore be used in enrichment of food products.*

Keywords: Nutrient, Composition, Pink, Banana, Ripening, Peel

INTRODUCTION

Since the dawn of human civilization plants have made large contributions facilitating human health and well being[1]. The stage of maturity of food plants greatly affects the concentrations of nutrients in them[2], thus it is very important to choose a suitable stage of harvesting[3]. The major wastes of banana processing in Nigeria are their peels. Ripe banana is very perishable and subject to fast deterioration after harvesting, more susceptible to mechanical injuries thus causing spoilage and increasing the losses. In all stated uses, there is little or no account of reuse or recycling of the waste peels, except for some insignificant use as animal feed [4]. The none usage of peels could be due to poor scientific information as to the composition of varied species of banana peel at different stages of development particularly in the developing countries where the same fruit is been cultivated in abundance.

During the process of growth and development of fruit, series of developmental transitions normally occur. These processes involve coordinated changes in a number of catabolic and anabolic reactions[5], which lead to the synthesis or degradation of a wide range of bioactive compounds. Hence, fruits at varying maturity levels may possess vivid bioactive compounds, which need to be studied so as to provide maturity indices for its usage as a source of food or medicine.

In Nigeria, fruits can be harvested at all stages of development (from immature to overripe) and can be used as a source of food in one form or the other. Some fruits are picked when they are mature but not yet ripe.The stage of maturation at which any fruit is harvested also influences the fruit's green-life or its ability to be stored for long periods[6].

The peels of plantain can be dried and made into meal which can be used to substitute up to 70 – 80% of the grain in pig and dairy diets with little change in performance[7]. The meal is also used in poultry diets but when in high amount, it tends to depress growth and reduces feed efficiency.

Ripening is a natural process which involves series of biochemical changes that are responsible for the change of color, pigment formation, starch breakdown, textural changes, aroma development and abscission of fruits.Ripening in fruit is a process which makes them more palatable.In general, a fruit becomes sweeter, less green and softer as it ripens. Nutritional changes upon ripening are very complex and depend on a number of factors, including light and temperature. This knowledge is very important particularly in post handling and processing of fruits and by- products.Emaga et al., [11] observed that as banana fruit advances to maturation stage, the composition of both the pulp and peel changes significantly. Therefore, information on nutrient compositions of banana peels at different stages of maturity and ripening cannot be overemphersised.

Bananapeelhasbeen fairly researched into particularly its applications including: application in bread making[8], antioxidant source, production of cellulose nanofibers[9],adsorption of heavy metals from water[10] and production of cookies.

The peel of bananas constitutes 40% of the total weight of fresh bananas, and yet, it has been underutilized and discarded as waste. But these wastes are either uneconomically utilized or disposed of, thereby causing serious pollution problems. This may be due to the ignorance regarding the benefits of its possible commercial applications[12].

Peels are the major by-products of all fruits and vegetables obtained during processing; however, some studies show that these are good sources of polyphenols, carotenoids, and other bioactive compounds, which in turn, possess various beneficial effects on human health[13]. Banana peel extract contains higher antioxidant compounds and thus, promising a more intense utilization of the peels in food and nutraceuticals. However, potential application of the banana peel depends on its chemical composition as well as its physicochemical and functional properties[11].The aim of this study is to investigate the chemical composition of matured unripe and ripe locally cultivated pink banana cultivar peel.

MATERIALS AND METHODS

MATERIALS

Material Collection: Matured unripelocally cultivated pink banana cultivars used in this study were bought from Ussa, Ussa Local Government, Taraba State, Nigeria. The pink cultivar was identified as Dwarf Red/pink Banana using IPGRI[14] classification.

Material Preparation: The samples were cleaned and divided into two portions.One portion was wrapped in jute bag and stored at room temperature(38°C) to ripen. The other portion (unripe) wasimmediately washed, peeled(manuallyusing stainless knife). The peels were sliced and further reduced into smaller pieces to enhance drying, spread on wire gauze and dried (50°C using hot air oven). The dried unripe peels (pink) were milled using Kenwood Blender, packed in polyethylene) and stored in the refrigerator until use.The unripen portion was observed to ripen after four days of storage and was also peeledand processed as the unripe peel to produce flour.

METHODS

Determination of proximate composition: The sample were analyzed for proximate composition (moisture, ash, organic matter, crude protein, lipids, carbohydrate and crude fibre). The moisture content of the peel was determined by oven drying to a constant weigh at 105°C.The lipid was extracted with petroleum ether (40 – 60°C) using a soxhlet apparatus for six hours. The Micro-Kjedahl procedure was adopted for the determination of protein. Carbohydrate was determined by difference[15].

Determinationof Vitamins(B & E), starch and sugar: The Vitamin C& E content were determined Onwuka[16] methods, while the starch and sugar content was determined as described bySulfuric method[17].

Determination of mineral composition of bananapeels werecarried out using Atomic Absorption Spectrophotometry(AAS) as described by AOAC[15]. Two gram(2g) of fruit peels was dried in an air oven at 105°C for 3 hours. The dried sample was charred, ashed in a muffle furnace (at 550°C), treated with concentrated hydrochloric acid, submitted for atomic absorption spectrophotometry(AAS). For AAS, a SHIMADZU atomic absorption flame emission spectrophotometer model AA-670 IF with an air-acetylene flame, and wavelength respectively set to 422.7 nm for calcium, 279.5 nm for manganese, 248.3 nm for iron and 213.9 nm for zinc determination were used. Concentration of each mineral contained in test solutions was calculated from the standard curve prepared.

Determination of Phytochemical: Phenolics,carotenoids, flavonoids, steroids, tanincontent as described Folin-Ciocalteu [17].

Statistical Analysis

One-way Analysis of Variance(ANOVA) was conducted on each of the variables and the Least Ssignificant Difference(LSD) test at significant level p = 0.05 was performed using SPSS 23 version software for windows to compare the difference between treatment means. Results were expressed as the mean standard deviation.

RESULTS

Proximate composition of Ripe and Unripe Pink banana cultivar peel flour

The proximate compositions of the peels of unripe and ripe pink banana are shown in Table 1.The ripening effect is significant, p=0.5.The moisture, protein and carbohydrate content of the pink banana cultiver decreased from 8.82 to 7.83, 5.39 to 5.19 and 72.79%, respectively. While the ash, fats and fibre content increased from 4.66 to 5.34, 5.29 to 6.22 and 3.10 to 3.17%, respectively on ripening.

Table 1: Proximate composition of ripe and unripe pink banana cultivar peel flour

Table 1: Proximate composition of ripe and unripe pink banana cultivar peel flour

Sample	Moisture	Ash	Fats	Protein	Fibre	CHO*
URB**	8.82±0.02a	4.66±0.05d	5.29±0.02d	5.39±0.02b	3.10±0.01b	72.79±0.01b
RRB***	7.83±0.04d	5.34±0.03a	6.22±0.02a	5.19±0.02c	3.17±0.02a	72.22±0.04d

* CHO –Carbohydrate
** URB- Unripe pink banana peel flour
*** RRB- Ripe pink banana peel flour

Table 2: Vitamins and starch/sugar composition of ripe and unripe pink banana cultivar peel flour

Samples	Vitamin C (mg/100g)	Vitamin E (mg/100g)	Starch (%)	Sugar (%)	Lignin (%)
URB*	0.14±0.01a	92.00±.0.17c	1.13±0.01a	0.92±0.00c	5.11±0.4
RRB**	0.08±0.01b	113.10±0.95a	0.92±0.00d	1.23±0.17a	4.79±0.4

* URB- Unripe pink banana peel flour
** RRB- Ripe pink banana peel flour

Table 3: Mineral composition of ripe and unripe pink banana peel flour (mg/100g)

Samples	Calcium	Magnesium	Potassium	Phosphorous	Iron	Zinc
URB*	0.66±0.02a	0.35±0.01a	4.31±0.07a	0.28±0.03b	0.25±0.01a	0.04±.00b
RRB**	0.54±0.01b	0.33±0.01b	4.16±0.06b	0.35±0.01a	0.15±0.01b	0.10±.00a

* URB- Unripe pink banana peel flour
** RRB- Ripe pink banana peel flour

Vitamins and starch/sugar composition of ripe and unripe pink banana peel flour

The effect of ripening of the peel of the pink banana cultivars on the vitamins(A and C), carbohydrate (starch and sugar) and lignin are shown in Table 2. The observed results for pink cultivar showed a decrease in vitamin C(0.14 to 0.08mg/100g), starch(1.13 to 0.92mg/100g) and lignin (5.11 – 4.79mg/100g), with increcrease in the sugar (0.92 to 1.23mg/100g) and Vitamin E (92.0 to 113.10 mg/100g) content, on ripening. The observed effects were significant, p=0.05. Generally, the matured unripe pink cultivar was observed to have relatively higher vitamin C, starch and lignin content.

Mineral composition ripe and unripe pink banana peel flour

The result of the effects of ripening on the mineral composition of peel flour of the pink banana cultivar is shown in Table 3.Calcium, magnesium, potsium and iron of the unripen pink banana peel decreased from 0.66 to 0.54, 0.35 to0.33, 4.31 to 4.16 and 0.25 to 0.15mg/100g, respectively, while the phosphorous and the zinc content decreased from 0.28 to 0.35 and 0.04 to 0.10mg/100g, respectively, on ripening.

Phytochemical compositionof ripe and unripepink banana peel flour

The phytochemical composition of peel flour of pink cultivar of banana is summarizedin Figure 2. Ripening decreased the quantity of phenol, flavonoid, carotenoid, sterol and tannin content from 0.55 to 0.37, 0.97 to 0.64, 3.08 to 2.91, 0.08 to 0.06 and 0.17 to 0.18mg/g, respectively, for the pink banana cultivar peels.

DISCUSSION

Proximate Composition of unripe and ripe pink banana peel

The decrease in the moisture content with ripening as observed agreed with the findings of Khawa *et al*.,[18]. The decrease in moisture content could be attributed to the movement of moisture from the peel to the pulp during ripening. Also the utilization of carbohydrates

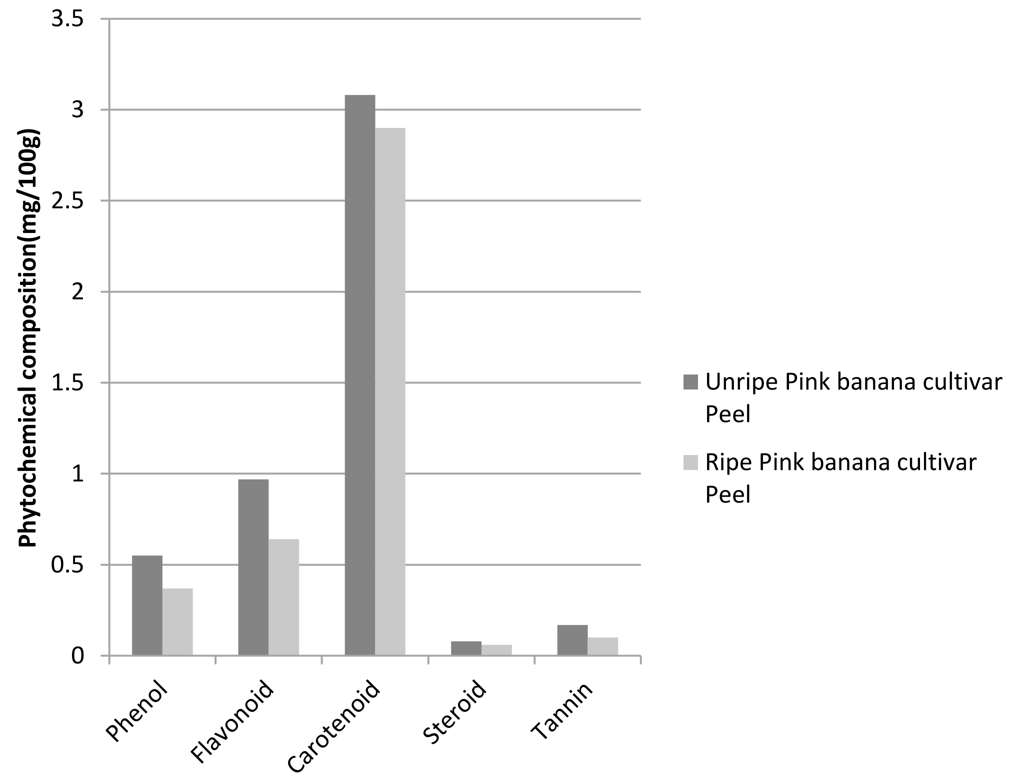

Figure 1: Phytochemical composition of Pink unreipe/Ripe Banana cultivar Peel

during breathing and osmotic transfer from the peel to pulp has been found to increase the water content of ripen banana peel pulp[19][11]. The relative low moisture content of the ripen peels flour coud be an advantage in the storage of the same and also in the texture development of food products where hydration is of importance.

The decrease in protein content agreed with the findings of Adamu*et al.,*[20]. The proteins in the banana peel are enzymes involved in the maturation of the fruit[21]. A slight decrease in the protein content at stage of ripening could be attributed to the utilization of proteins in the gluconeogenesis[22].

The significant increase in crude fat content in the peel of the pink banana cultivar could be due to the continuous synthesis of fatty acids during metabolism which could increase the crude fat concentration with fruit development[23] and at ripening.

The increase in the soluble crude fibre in pink banana peel during fruit ripening agreed with the findings of [8] and Happi-Emaga *et al*.,[11]. The increase could be due to biochemical break down of the carbohydrate during ripening. Zhang *et al*.,[13] reported that peels of banana and plantain could be a good source of dietary fibre of low cost for use in foods[8]. The values of crude fiber found in the present study is on the higher side which suggests that the culinary banana peel can be a good source of fiber and can help in alleviating digestion problems (constipation)[24].

The amount of the ash content in the peel of culinary bananas varied with growth and maturity[13].These studies showed an increase in the ash content of the peels of pink (4.66 to 5.34%) cultivar. The matured unripe pinkcolored cultivar had a higher level of ash content.Ash content, which is generally an inorganic material, is directly or indirectly associated with the absorption capacity of mineral salts at different developmental stages. The ash content in present study is comparatively less than the values reported (12.8%) by Emaga *et al*.,[11]this may correlate to the absorption rate of mineral salt by the plant and soil condition.

The ripening process decreased the carbohydrate content of the peel of the pink(72.79 to 72.22%) banana cultivar. This variation might be due to the degradation of starch at different developmental stages[23]. The carbohydrate content in the present study is comparatively higher as compared to 59% carbohydrates present in the *Musa sapientunm*peel[24]and this variation may be attributed to the variety used in the present study.

Starch, sugar and Vitamins(C and E)of unripe and ripe pink banana peel

The starch of pink banana cultivar peel decreased on ripening(Table 2). The decreasing trend of starch of banana peel with advancement in maturity has also been reported by Emaga *et al*.,[11] which could be correlated to the accumulation of carbohydrates during maturation which causes the hydrolysis of starch and sugar storage during maturation and ripening. The onset of ripening was attended with a pronounced decrease in the starch as observed by Raji et al.,[25].

Peels of banana and plantain could be a good source of dietry fibre of low cost for use in foods, but the characterization of fiber components from green banana and plantain peels should be determined[8]. Green banana peels contain much less starch (about 15%) when green than plantain peels, while ripe banana peels contain up to 30% free sugars[26].

The suger content of the unripe pink banana cultivar peel increased on ripening. The increasing trend of sugars content for the cultivar onripening agreed with the report of Adisa and Okey [27]. The increase in the sugar content could be due to the degradation of starch to sugar with maturity[28]. According to the reports of Emaga *et al.,*[11], the major total soluble solids found in the peel of bananas are mainly glucose and fructose with a slight amount of sucrose. In the present study, the amount of sugar of ripen peel studied was higher than the unripe peel.

Lignin content of the peel of the banana cultivar in these studies decreased from 5.11 to 4.79% during ripening. The decreased observed agreed with Happi-Emaga *et al*.,[8]. This decrease trend of lignin may correlate to the lignifications of cell wall constituents which result in decrease in other dietary fiber fractions[28].

Banana fruits contain various antioxidant compounds in both pulp and peel tissues, such as vitamin C, vitamin E, β-carotene and flavonoids. The pink cultivar contain relatively higher Vitamin C content. The vitamin C content of the pink peel banana cultivar increased from 0.08 to 0.14mg/100g on ripening. Osman *et al*.,[29] obtained increasing ascorbic acid content with ripening, with highest level at the fully ripened stage, as similarly obtained in the present study.

The increase in ascorbic acid content with ripening has been attributed to the increase in lipid peroxidation considering that fruit ripening which is an oxidative phenomenon requires turnover of active oxygen species[30]. The vitamin E increased from 92.00 to 113.10mg/100g for the matured pink banana cultivars on ripening. The findings agreed with recent works that antioxidant compounds including ascorbic acid and vitamin E usually increased during ripening [31].

Minerals content of unripe and ripe pink banana peel

The study indicates insignificant decrease of calcium(Ca),potassium(K), zinc(Zn) and magnesium(Mg) as unripe banana ripens.Minerals play a key role in various physiological functions of the body, especially in the building and regulation processes. Fruits are considered as a good source of dietary minerals[32]. Calcium is an important constituent of bones and teeth and it is actively involved in the regulation of nerve and muscle functions[33]. According to Leterme *et al.,*[34], several factors like variety, state of ripeness, soil type, soil condition, and irrigation regime may cause variation in the mineral and trace elemental contents in different types of fruits as well as within different parts of the same fruit.

The calcium content of the pink banana peel decreased from 0.66 to 0.54mg/100g (Table 3) on ripening of the cultivars. The observed decrease of calcium content in this study agreed with the findings of O'Conell[35]. Thus the relatively high amounts of calcium in the peel of unripe banana as observed in this study, suggest its importance to diabetics. Calcium is an important component of intracellular processes that occur within insulin responsive tissues like skeletal muscle and adipose tissue. Alteration in calcium flux can have adverse effects on insulin secretion which is a calcium-dependent process[35].The study showed that unripe banana peels contain significantly higher amounts of Mg than ripe plantain peels for pinkcultivars under study. Magnesium is a cofactor of hexokinase and pyruvate kinase and it also modulates glucose transport across cell membranes[35].

The high amount of K in the peel samples investigated (4.16 – 4.31mg/100g) could be considered of comparative advantage. Intake of diets with higher Na to K(Sodium to Potassium) ratio has been related to the incidence of hypertension[36]. The relative high phosphorous content (0.28 - 0.37mg/100g) of the banana cultivars could be advantageous to consumers. Phosphorus is involved in several biological processes such as: bone mineralization, energy production, cell signaling and regulation of acid-base homeostasis[35].

Findings from this study showed that matured unripe plantain peel contains higher quantities of Zn (0.04 to 0.10mg/g). Zinc plays a key role in the regulation of insulin production by pancreatic tissues and glucose utilization by muscles and fat cells[37]. Zinc is particularly necessary in cellular replication and the development of the immune response and also plays an important role in growth; it has a recognized action on more than 300 enzymes by providing functional face for formation of their structure or in their catalytic and regulatory actions[38].

The large variation in all of the micronutrients observed during fruit development may be attributed to preferential or selective absorbance, and this may be due to the cultivar and/or soil, climate, agricultural practice, and the quality of water for irrigation[39]. The results revealed that the unripe banana peel contains a higher amount of mineral salts which agreed with the finding of Adisa and Okey[27] which could be said to improve the mineral intake of theconsumer.

Phytochemical composition of unripe and ripen pink banana peel

Generally, a higher phytochemical content were observed for the pink banana cultivar at unripe stage. The decrease in the phenol content of the pinkbanana cultivar agreed with findings of Someya *et al.,*[40].In humans, phenolic compounds have been reported to exhibit a wide range of biological effects including anti-bacterial, anti-inflammatory and antioxidant properties[41].In general, phenolic content, particularly tannins which are responsible for astringency taste of unripe fruits, decreased with ripening mainly due to polymerization rendering them insoluble and undetectable to taste[41].

Theplausible explanation behind this variation has been explained by Kiyoshi and Wahachiro[42] that during the early ripening stage, 60% of the polyphenolic compounds have a molecular weight above 2×10^5. With advancement in ripening, this higher molecular weight disappears slowly, resulting in a decrease in astringent property. On further ripening, only those 40% of polyphenols with a molecular weight below 2×10^5 remain, and the polyphenols content decreased which are in line with the results of this work. The decreasing trend of polyphenols in the banana peel with growth and ripening has also been reported by Ham *et al.,* [41].

The culinary banana peel could be anexcellent source of polyphenols which may be involved in defense against radiation or aggression by pathogens[43] and also form an important group of antioxidants, having the ability to absorb free radicals[44].

The decrease in the flavonoid content of the pink(0.97 to 0.64mg/100g) banana cultivar peel agreed with the finding of Flavonoids, the most potent anti oxidative compounds of the plant phenolics, which potentially occurred during the early stages of the culinary banana peel development[45]. The maximum amount gradually decreased with a minimum value at ripening[45]. Many flavonoids are found to have strong antioxidants and are capable of effectively scavenging the reactive oxygen species (AOS)[44].

The decrease in the tannin content with the advancement of growth reduces the astringency property and this property is related to insolubilization and polymerization of polyphenols with other constituents of pulp[44]. The tannins content of the peel, which act against the availability of proteins in the rum, decreases with ripening as a consequence of a migration of the polyphenols from the peel toward the pulp and the phenolic oxidative degradation by polyphenol oxidases and peroxidases[46].

CONCLUSION

Ripening of matured pink banana cultivar peel has been found to relatively improve the nutrient(fats, sugar, vitamin E) quality and lower the anti nutrient compounds of the product.Banan peel flour could be a source of nutritional and bioactive compounds for fortification and enrchment of food products.

REFERENCES

1. Singh, R; Dar SA and Sharma P (2012). Antibacterial activity and toxicologicalevaluation of semi purified hexane extract of Urtica dioica leaves. *Res. Journal of Medicinal Plant*, 66: 123-135.
2. Izonfuo WAL and Omuaru VOT (1998)," Effect of Ripening on the Chemical Composition of Plantain Peels and Pulps (Musa paradisiaca)", *Journal of theScience of Food and Agriculture* 45:333-336.
3. Yu, P; Christensen, D.A and Mckinion, J.J (2004). In situ rumen degradation kinetics of timothy and alfalfa as affected by cultivar and stage of maturity*Canadian Journal of Animal Science,* 84: 255- 263.
4. Babayemi, O.J; Khadijah, T.D; Abideen, A.K and Davies, O.N (2009). Determination of potash alkali and metal Contents of ashes obtained from peels of some varieties of Nigeria grown Musa species. *Bioresources* 5: 1384-1392.
5. Duhan,A; Chauhan, B.M and Punia, D (1992). Nutritional value of some non-conventional plant food of India, *Plant Foods Human Nutrition*, 42: 193- 200.
6. Chanda, S; Kaneria, M and Nair, R (2011). Antibacterial activity of Psoralea corylifolia L. seed and aerial parts with various extraction methods, *Res. Journal of Microbiology*, 60: 124-131.
7. Sharrock, S (1997). Uses of Musa in: International Networks for Improvement ofBanana and Plantain, *INIBAP annual report* (INIBAP: Montpellier France) pg. 42-44.
8. Happi-Emaga, T; Herinavalona-Adrianaivo, R; Wathelet, B; TchangoTchango, Jand Paquot, M (2007). Effects of the stage of maturation and varieties on the chemical composition of banana and plantain peels. *Food Chemistry*, 103:590–600.
9. Annadurai, T; Muralidharan, A.R; Joseph, T; Hsu, M.J; Thomas, P.A andGeraldine, P (2012). Antihyperglycemic and antioxidant effects of a flavanone, naringenin, in streptozotocin-nicotinamide-induced experimental diabetic rats. *J Physiol Biochem*. 68:307–318.
10. Essien, J.P; Akpan, E.J and Essien, EP (2005). Studies on Mould Growth andBiomass Production Using Waste Banana Peel. *Bioresource Technology*, 96(13): 1451–1455.
11. Emaga, T.H; Andrianaivo, R.H; Watheletet, B; Tahnago, J.T and Paquot, M (2007). Effects of the Stage of Maturation and Varieties on the Chemical Composition of Banana and Plantain Peels. *Food Chemistry* 103(2): 590– 600.
12. Khawas, P; Dash, K.K; Das, A.J and Deka, S.C (2015). Drying Characteristics

and Assessment of Physicochemical and Microstructural Properties of DriedCulinary Banana Slices. *International Journal of Food Engineering,* 11(5), 667–678.
13. Zhang, P; Whistler, R.L; BeMiller, J.N and Hamake, B.R (2005). Banana starch:Production, physicochemical properties, and digestibility – A review. *Carbohydrate Poly.* 96(13): 1451–1455
14. IPGRI (1996). Descriptors for banana (Musa spp.).Documentation and Information management, International plant genetics Researches Institute, IPGRI, Rome (ITA). Pg. 55.
15. AOAC (Association of Official Analytical Chemists) (2012). Official Methods of Analysis of the Association of Official Analytical Chemists 17th Ed. Published by the Association of Official Analytical ChemistsInternational, Suite 400 2200 Wilson Boulevard, Arlington, Virginia USA
16. Onwuka, G.I.(2005). Food analysis and instrumentation: theory and practice. Naphathali prints, Nigeria, 95-96.
17. Trease, G.E and Evans, W.C (1996). Pharm acognosy . Macmillan publishers ltd.Pp 213.
18. Khawas, P; Das, A.J; Sit, N; Badwaik, L.S and Deka, S.C (2014). NutritionalComposition Of Culinary *Musa* ABB At Different Stages Of Development.*American Journal of Food Science and Technology*, 2(3), 80–87.
19. Fernandes, K.M; Carvalho, V.D and Cal-Vidal, J (1979). Physical Changes During Ripening Of Silver Banana. *Journal of Food Science*, 44(4), 1254–1255.
20. Adamu, A.S; Ojo, I.O and Oyetunde, J.G (2017). Evaluation of Nutritional values of ripe, unripe, boiled and roasted plantain pulp and peel. *European Journal of Basic and Applied Sciences*. Vol.4 (1): 9-12.
21. Zhang, L.L; Feng, R.J and Zhang, Y.D (2012). Evaluation of different methods ofprotein extraction and identification of differentially expressed proteins uponethylene-induced early-ripening in banana peels. *Journal of the Science ofFood and Agriculture*, 92, 2106– 2115.
22. Goswami, B and Borthakur, A (1996). Chemical And Biochemical Aspects of Developing Culinary Banana (*Musa* ABB *Kachkal*. *Food Chemistry*,55(2):169–172.
23. Siddika, A.M; Khatun, S; Khan, M.M.H and Pervin. F (2013). Changes In: Contents Of Some Chemical Compositions And Activities Of HydrolyticAnd Oxidative Enzymes Of *Coccinia Cordifolia* L. Fruits. *Journal of Bioscience*, 21, 35–41.
24. Anhwange, B.A (2008). Chemical Composition of *Musa Sapientum* (Banana)Peels. *Journal of Food Technology* 6(6): 263–266.
25. Raji, K; LalMeera, G and Krishna, P.S (1974). Biochemical aspects of the developing and ripening banana. Phytochemistry (13)11:2365-2370.
26. Happi Emaga, T; Bindelle, J; Agneesens, R; Buldgen, A; Wathelet, B and Paquot,M (2011). Ripening influences banana and plantain peels composition andenergy content. *Trop. Anim. Health Prod.*, 43 (1): 171-177.
27. Adisa, V.A and Okey, E.N(1987). Carbohydrate And Protein Composition Of Banana Pulp And Peel As Influenced By Ripening And Mold Contamination. *Food Chemistry*, 25(2), 85–91.
28. Porcher, M.H and Barlow, S (2002), Sorting Musa names, The University of Melbourne.
29. Osman, A; Syafirin, N; Saad, N and Mohamed, S (1998). Comparing the physico-chemical characteristics of Mas, Rasthali and Berangan bananas at 3 stagesof maturity. First National Banana Seminar, Awana Genting, UPM, Serdang(MYS).
30. Jimenez, A., Cressen, G., Kular, B., Firmin, J., Robinson, S., Verhoeyen, (2002). Changes in oxidative process and components of the antioxidant system during tomato fruit ripening. Journal of Planta 214: 751– 758.
31. Mosa, Z.M and Khalil, A.F (2015). The effect of banana peels supplemented dietThe Chemistry of Components, 2nd Edn. Royal Society of Chemistry.
32. Ismail F, Anjum MR, Mamon AN and Kazi T G (2011). Trace metal contents of vegetables and fruits of Hyderabad retail market, *Pakistan Journal of Nutrition*, 10, 365– 372.
33. Soetan K.O; Olaiya C.O and Oyewole O.E. (2010).The importance of mineral

elements for humans, domestic animals and plants: A review African Journal of Food Science Vol. 4(5) pp. 200-222, May 2010

34. Leterme P; Buldgen A; Estrada F and Londono AM (2006). Mineral content oftropical fruits and unconventional foods of the Andes and the rain forest of Colombia, *Food Chemistry,* 95, 644-652.
35. O'Conell, B (2001). Select vitamins and minerals in the management of diabetes, *Diabetes Spectrum,* 14: 133-148.
36. Chen, X.H; Xia, L.X; Zhou, H.B and Qiu, G.Z (2010). Chemical composition and antioxidant activities of Russula griseocarnosa sp. . *J Agric Food Chem* 58: 6966-6971.
37. Eleazu, C.O; Iroaganachi, M and Eleazu, K.C(2013). Ameliorative potentials of cocoyam (*Colocasia esculenta* L.) and unripe plantain (*Musa paradisiaca* L.) on the relative tissue weights of streptozotocin-induced diabetic rats. J. Diabetes Res., 10:11,55.
38. Salgueiro, M.J; Zubillaga, M.B; Lysionek, A.E; Caro, R.A; Weill, R and Boccio,J.R.(2002). The role of zinc in the growth and development of children, *Nutrition,* 18: 510-519.
39. Rop, O; Sochor, J; Jurikova, T; Zitka, O; Skutkova, H; Mlcek, J; Salas, P; Krska, B; Babula, P; Adam, V; Kramarova, D; Beklova, M; Provaznik, I and Kizek, R (2010). Effect of Five Different Stages of Ripening on Chemical Compounds in Medlar (*Mespilus Germanica L.*) *Molecules,* 16(1), 74–9.
40. Someya, S;Yoshiki, Y andOkubo, K (2002). Antioxidant compounds from bananas (MusaCavendish). *Food Chemistry*, 79:351–354.
41. Han, X; Shen, T and Lou, H (2007). Dietary polyphenols and their biologicalsignificance, *International Journal of Molecular Science*, 8: 950-988
42. Kiyoshi, M and Wahachiro, T. (2003). Food Preservation Sci, 29(6), 347-351.
43. Ashraf, A.M; Maah, J.M; Yusoff, I; Mahmood, K and Wajid A(2011). Study of Antioxidant Potential of Tropical Fruits. International *Journal of Bioscience, Biochemistry and Bioinformatics,* 1(1), 53–57.
44. Daniels, J (2016). Constituents of six Malaysian medicinal plants. *Journal ofMedicinal Plant resources*, 3 (2): 67-72.
45. Choi, S.H; Ahn, J.B; Kim, H.J; Im, N.K; Kozukue, N; Levin, C.E and Friedman, M (2012,). Changes in Free Amino Acid, Protein, and Flavonoid Content in Jujube (*Ziziphus Jujube*) Fruit During Eight Stages of Growth and Antioxidative and Cancer Cell Inhibitory Effects by Extracts. *Journal of Agricultural and Food Chemistry* 60:10245–10255.
46. Bugaud, C; Alter, P;Daribo, M.O and Brioullet, J.M (2009).Comparison of thePhysicochemical Characteristics of a New Triploid Banana Hybrid, FLHORBAN 920, and the Cavendish Variety. *Journal of the Science of Food and Agriculture*, 89, 407–413.