

Chemical and Technological Studies on Sapote Sapodilla (*Manilkara zapota*) and White Sapote (*Casimiroa edulis*) Products

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ABSTRACT

This study intended to evaluate the physical and chemical properties of two sapota fruit cultivars namely: sapodilla (*Manilkara zapota*) and white sapote (*Casimiroa edulis*). The investigation also, included and assessment products created from these fruits like sapodilla compote and irradiated dried rolls made from white sapota besides, puree made from white sapota and guava and stored for 12 weeks in polyethylene bags at ambient temperature ($28\pm 2^\circ\text{C}$), microbiological tests were conducted every 3, 6, 9, and 12 weeks during the storage period. The physico-chemical properties of moisture, protein, crude fiber, ash, fat, total carbohydrates, total acidity, total soluble solid contents, T.S.S., vitamin C, vitamin A, total sugars, reducing sugars and non-reducing sugars, and mineral contents of white sapote fruits and sapodilla fruits were determined. Meanwhile, the results recorded for total antioxidant activity (TA) of 88.01%, total phenolics (TP) of 46.73 mg/100g, and total flavonoids of (TF) 22.33 mg/100g, respectively, for sapota fruit, and 77.34%, 40.28 mg/100g, and 20.66 mg/100g, respectively, for sapodilla fruit. Physicochemical properties non-significant effects of gamma rays on sapota rolls. While sensory evaluation showed a slight decrease in color score when treated with radiation for sapota rolls, while the irradiated sapota rolls there were decreases in vitamin C and vitamin A it was 2.6 and 4.25 mg/100g for un-irradiated rolls and 1.97 and 3.88 mg/100 g for irradiated rolls respectively. On the other hand, total antioxidant activity increased from 80.21% for the un-irradiated rolls to 91.64% for the irradiated rolls by 2 kGy; total phenol content (TPC) was 40.29 mg/100g for the un-irradiated rolls, while the irradiated rolls were 58.78 mg/100 g; and total flavonoid content (TFC) was 21.85 mg/100 g for the un-irradiated rolls and 45.98 g for the irradiated rolls. Moreover, the gamma rays measured a 2 kGy showed decrease in the total bacterial count and total mold and yeast of sapota rolls, which also increased the shelf-life of sapota rolls.

1. Introduction

Sapodilla (*Manilkara zapota*) and White sapote (*Casimiroa edulis*) commonly alluded to as "Sapota" (Mexico), chiku (India), and nispero (Puerto Rico), is an evergreen tree local to the Southern districts of Mexico Northern Guatemala. It is broadly conveyed, especially in Central and South America. It is broadly developed for commercial purposes, particularly within

The Philippines, Indonesia, Vietnam, Malaysia, India, and Thailand (Kishore and Mahanti 2016). It is additionally copiously developed in Bangladesh, Cambodia, Sri Lanka, and Pakistan (Siddiqui et al., 2014 and Punia et al., 2022) Sapodilla and White sapote has a place to the (*Sapotaceous*) family, in conjunction with blossoming species, and is known for its quality wood, therapeutic properties,

Tulloch et al., 2020 and Mehnaz and Bilal 2017). sapota could be a that can reach a tallness of 25–45 m, with a normal breadth of 1.5 m (Bashir, 2019). Beneath tropical conditions, it bears white, bell-like blossoms completely different flushes (June–July, September–October, and March–April). The natural product may be circular, oblate, or oval; ranges from 5 to 9 cm in breadth and weighs (70–300 g) (Siddiqui et al., 2014). sapodilla it features a brown unpleasant and dirty peel surface. It features a beefy and succulent mash with a characteristic reddish-brown color. When youthful, is difficult, exceedingly astringent, (Alrashood et al., 2020) and (De Souza Freitas et al., 2017). Ordinarily, 1–5 dark sparkly seeds can be found inside. The pulp, peel, and seed represent 79, 15, and 5% of the total fruit weight, respectively. Moisture content of the entire fruit was estimated at 78%, similar to pulp (80%) (Mehnaz and Bilal 2017). The edible portion is about 70%, whereas the non-edible portion accounts for approximately 30% of the total weight ((Alrashood et al., 2020). The flavor is sweet when mature and resembles the taste profile of pears (Yahia and Gutierrez-Orozco 2011). Traditionally, it has been used to treat cough, diarrhea ulcers, hemorrhage, muscle spasms, pain, pulmonary diseases, and nervous system disorders, among other medical conditions (Bashir, 2019). White sapote the fruit is a round or oval, of smooth and grainy texture with a sweet flavor due to the presence of fructose and sucrose. White sapote fruits are eatable and have nutritional value, which provides the minerals sodium, potassium, magnesium, iron, calcium, and phosphorous. The fruit is rich in vitamins A and C (180 and 800 mg/kg), wet weight, respectively), and it possesses a high content of carbohydrates (160g/kg) (Mehnaz and Bilal 2017). They provide fibers that prevent constipation. The higher carbohydrate content of white sapote than any other fruit suggests that they are a good ready-to-eat source of energy. The fruits are reported to have an energy level higher than apples, bananas, mangoes, and guavas, and a higher quantum of ash than apples (Abdalahy, 2017). The high ash content of the fruit indicates a good mineral source, which is veritably important for the

metabolism. A calcium content of 9.9mg/100 g of white sapote was reported, which is higher than banana and apple and equal to mango (Ahlawat et al., 2016) The phosphorous content of (20.4mg/100g) was reported in sapota fruit, which is higher than apples, mangoes, and nearly all bananas. Iron content (0.33mg/100g) was also reported to be higher in sapota fruit than in apples, mangoes, bananas, and guavas. In terms of vitamins, thiamine content is lower in the sapota fruit (Ahlawat et al., 2016).

One of the major postharvest issues is the quick growth and briskness of comestible, edible, ripe fruit. The storehouse life of sapota fruit is exceptionally short-lived and can only be stored for 7–8 days under ordinary conditions after the crop (Reddy, 2018). The shelf life of sapota fruits could be conceivably extended by reducing the rate of respiration, loss of water through transpiration, and microbial infection, which is substantially caused by the species *Botryodiplodia*, *Pestalotiopsis*, *Phytophthora*, and *Phomopsis* (Siddiqui and Dhua, 2010; Siddiqui et al., 2013). According to (Gadgile et al., 2010), postharvest fungal conditions of sapota are black mold spoilage (*Aspergillus niger*), green mold spoilage (*Penicillium spp.*), and Rhizopus rot (*Rhizopus oryzae*). As soon as the fruits reach their climacteric peak, the shelf life of the sapota fruit deteriorates. Heavy post-harvest losses to the extent of 20–30 percent were suffered by sapota in India (Salunkhe and Desai, 1984). Khurana and Kanawjia (2006) stated that due to the short shelf-life of sapota fruits, about 30–35 percent of fruits corrupt as post-harvest losses during harvesting, storehouse, grading, transportation, packaging, and distribution, therefore incurring a precious loss in India. (Yadav et al., 2013) observed that treating the sapota fruits with gamma irradiation with a combination of different factory growth controllers increases the shelf life of the fruits. They also reported that these treatments help in lowering physiological weight loss and maintaining maximum firmness during storage. It was also found that there is an increase in total soluble solids, sugars, and acidity. Food irradiation involves a physical, non-thermal treatment where food is exposed to either non-ionizing radiation or

ionizing radiation (the more prevalent choice). This method has been substantiated to yield favorable outcomes by targeting disease-causing microorganisms and spoilage agents, all the while upholding the integrity of the product's quality and nutritional attributes. Furthermore, it stands as an effective approach for impeding microbial growth and enhancing the caliber of both fresh and dehydrated commodities while leaving their chemical, physical, and nutritional properties unscathed. Given these considerations, bolstering public trust in food irradiation as a secure means of preserving both food and nutrients, thereby curtailing the prevalence of foodborne illnesses, remains of paramount importance (Abdelaleem and Elbassiony, 2020; Bisht et al., 2021). (Elshiemy et al., 2019) reported that gamma-irradiated red beet leaves and roots exhibited heightened total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity in comparison to other dosages. The impact of radiation treatments on antioxidant content in fresh plant produce has been observed to yield variable outcomes, including heightened antioxidant capacity and activity interconnected with total phenolic content and antibacterial activity following plant irradiation. Several reports highlight that radiation-induced effects on chemical bonds can lead to the liberation of low-molecular-weight fragments. This outcome is linked to the activation of phenylalanine ammonia-lyase (PAL) biosynthesis, which consequently promotes phenolic compound synthesis, aiding radiation-induced depolymerization of polysaccharides and thereby facilitating the release of phenols (Hidar et al., 2021). The utilization of gamma-ray irradiation in the preservation of food products emerged as a technology in the latter part of the 20th century and has since become a widely adopted strategy for enhancing microbiological safety and extending the shelf life of edibles. This method is known for its safety, efficacy, environmentally conscious nature, and energy efficiency, making it particularly significant in the field of industrial food preservation. Applying gamma irradiation to safeguard dried foods like fruits, herbs, spices, and nuts, using doses ranging from 3 to 10 kGy, provides a

valuable alternative to using microbicidal gases for fumigation. In certain instances, doses exceeding 20 kGy have also been applied to reduce microbial populations in dehydrated foods. Typically, when subjected to gamma radiation doses ranging from 1 to 10 kGy, food products experience negligible losses in nutritional value because this irradiation treatment does not raise the temperature of the food (Shahbaz et al., 2014). The cultivation of sapota trees began in Egypt in 2010, as Egypt's climate became suitable for growing types of tropical plants. Sapota was planted in many of Egypt's governorates, including Giza, Dakahlia, Arish, and others. It is considered a summer fruit, and its trees are abundant in fruit, as the fruits are collected in the month of June. There are many nurseries in Egypt that provide seedlings to farmers. (Fayek et al., 2012). During peak harvesting seasons, the loss is 30–50%, and, hence, the fruits are vended at low prices as a consequence of inadequate preservation methods (Getachew, 2018). Therefore, value-added processing is necessary to contribute towards the expansion of nutritional input and the request for white sapote fruit to be harvested during off-seasons (Zeru, 2018; Abo-Taleb and Abdul-Latif 2023). The aim of the present study was to investigate the importance of those fruits by identifying the physical and chemical properties of fresh white sapote and sapodilla fruits. And also, we used gamma irradiation for preserving fruit and its components, which can be used dried rolls in preparing natural and healthy juice, to increase the total phenolic content, total flavonoid content, and antioxidant activity of compote.

2. Materials and Methods

Materials

Raw materials

Sapodilla (*Manilkara zapota*) and white sapote (*Casimiroa edulis*) fruits were purchased from a private the village of Mit Al-Ezz, Dakahlia, Governorate. Guava (*Psidium guajava L.*) was purchased from one of the markets near Food Technology Research Institute Giza, Government, ripe, healthy, disease-free fruits were also used to produce puree.

Methods

Irradiation treatment

After manufacturing white sapota rolls, were irradiated with gamma irradiation at doses of 0 and 2 kGy using an experimental ⁶⁰Co Russian Gamma chamber (dose rate 323.5 Gy/h), Cyclotron Project, Nuclear Research Center, Egyptian Atomic Energy Authority, Egypt.

Sample preparation

Processing of the Compotes

Initially, about one kilogram of sapodilla is washed well, peeled, cut into pieces of appropriate size, then placed in a bowl containing a liter of water, the sugar (30 %) is dissolved in water and is in a moderate proportion. Citric acid 1-2 gm is also placed to preserve the color of the fruit. The fruit is left in this bowl until the boiling point, for 10 minutes. He raises the bowl pot from the heat, leave it to cool, then fill it in clean, sterilized jars and sealed (Mendonca et al., 2001)

Preparation of fresh (white sapota and guava) puree for manufacturing dried sapota rolls

Because the guava fruit has the same structure and color, the guava fruit was chosen to be added with the sapota fruit when making the rolls. The fruit is washed with water off washed with running water under the tap, it is peeled, and the internal seeds and cut the fruits, is the puree were extracted mechanically by beating the fruit in a blender (Type: Moulinex MFP626 – 220V – 50-60Hz – 1000W – 250 ml France) and then filtering to obtain a fine puree (Hashim and Ismail 2022)

four sapota puree formulas are made:

F1= The first formula is the control (a liter of sapota puree only).

F2= The second formula (sapota puree 75% + guava puree 25%)

F3= The third formula (sapota puree 50% + guava puree 50%)

F4= The fourth formula (sapota puree 25% + guava puree 75%)

Manufacturing dried sapota rolls

Add to every liter of formula puree 2 gm sodium

meta bisulfite, 2 gm sodium bicarbonate and 1gm Pectin. Formulas were poured into aluminum trays (smeared with paraffin oil) in a thin layer (5–8 mm) and dried at 50-55°C for 24 hours in an air oven (Type: VENTICELL55- Artikel Nr: 000721/10000 - Temp. Berech: 250°C – Anschlub:230V AC 50/60Hz – Leistungaufn :1250W Germany). (Genanew et al., 2022).

Methods of analysis

The proximate analysis of fruits, which included moisture content, ash, crude protein, fat and crude fiber, were determined according to the methods set forth by the Association of Analytical Chemists (A.O.A.C. 2000). The percentage of carbohydrate content was determined by the following formula. % Carbohydrate = 100- (% ash+ % fat 1% protein+ % fiber content)

Determination of Vitamin C and A

The Association of Official Analytical Chemists (A.O.A.C. 2003) determined limited range of possible procedures, based essentially on the chemical reactions of ascorbic acid. Also, The Association of Chemists explained Official Analytical Chemists (A.O.A.C. 2006). Vitamin A (Retinol) in medical and nutritional products.

Determination of minerals

Mineral content iron (Fe), zinc (Zn), calcium (Ca), potassium (K), sodium (Na) and phosphorus (Mg) were determined using by Agilent Technologies (model 4210 MPAES), atomic absorption spectrophotometer according to the method of (A.O.A.C. 2007)

Determination of sugars

Extraction and determination of total water-soluble sugar, reducing sugar, were carried by (A.O.A.C. 2011) methods. The non-reducing sugar was obtained by subtraction of reducing sugar from total water-soluble sugar.

Titrateable acidity content

Titrateable acidity was determined according to (A.O.A.C. 2012)

Determination of pH

pH value was determined with a (Jenway3510 pH meter). The pH meter is calibrated using the

buffer solution before collecting the pH reading of the sample tested (A.O.A.C. 2012).

Total soluble solids (T.S.S.) analysis

Brix value was determined to check evaporation and concentration in order to assess the firmness of the products. It is based on the principle that light entering a prism has a unique characteristic. This feature is represented by a value on a scale in units known as °Brix, determined with a Hand Refractometer (ATAGO Type 500 cat. No. 2340). (A.O.A.C. 2016)

Total Antioxidant Activity

Total antioxidant content (TA) was estimated by using 2,2-diphenyl-1-picrylhydrazil (DPPH) assay to measure the free radical scavenging capacity. The assessment of samples' radical scavenging exertion was conducted through the application of DPPH (2,2-diphenyl-1-picrylhydrazyl), in agreement with the system outlined by (Brand-Williams et al., 1995). The computation of the DPPH scavenging chance for the samples was performed using the following formula:

$$DPPH \% = \frac{Abs\ control - Abs\ sample}{Abs\ control} \times 100$$

Total phenolic content

TP was determined following the method of (Singh et al., 2015). Sample extract (100 liter) was diluted to 4.8 ml by distilled water and (300 liter) of Folin–Ciocalteu reagent was added. 20% sodium carbonate (900 liter) was added with mixing after 8 min. and the solution was left at 40 °C for 30 min. before taking its absorbance at 765 nm. on a spectrophotometer. Gallic acid was used as a standard and the results were reported as mg GAE (gallic acid equivalents)/100 g.

Total flavonoid content

TF of the fruits and vegetables was determined by the method of (Heimler et al., 2005) Quercetin was used as a standard, and results were expressed as mg QE (quercetin equivalents)/100g (Singh et al., 2016)

Microbiological analysis

Microbiological analysis Microbiological status

of arranged tests detailing rolls 10 gm of test was exchanged with a sterile pipette to the carafe containing 90 ml of ordinary saline to form 10⁻¹ weakening. In such a way, weakening up to 10⁻⁷ was made. 1 ml of each weakening was equitably spread on the supplement agar medium and hatched at 37°C for 24 hours. Yeasts and molds: the methods of were taken after for the assurance of yeast and shape tallies utilizing potato-dextrose agar medium. The plates were hatched at 20°C - 25°C for 5 days. Colonies were tallied after 3 and 5 days, and detailed as yeasts and molds number per gram. (Rahman et al., 2011)

Sensory evaluation

The sensitive parcels of white sapota juice and sapodilla compote were estimated. The color, taste, appearance, agreeableness, general adequacy, texture, size, shape, and evaluation were carried out by 10 Food Tech judges. Rec. Using a 10-point pleasure scale. Samples with an overall quality score of 7 or over were considered palatable. According to the system of (Singh et al., 2020),

Statistical analysis

All the results from chemical analysis, physical analysis, and sensory evaluation were analyzed using ANOVA with a multiple range significant difference (LSD) test. Standard error was determined (SE) (p < 0.05) using SPSS according to (Zainol et al., 2018).

3. Results and Discussions

Chemical characterization of cultivars sapote fruits

The chemical properties of sapota fruits cultivars were recorded in Table 1. noticed a high moisture in both cultivars of sapota, the percentage was higher in white sapota (78.61%) than in sapodilla (76.71%). Similarly, percentage of carbohydrates was also higher in white sapota (96.23%) than in sapodilla (90.44%). The high amount of carbohydrate in white sapota fruit is a good indication that these are good sources of ready energy, on the other hand higher percentage of fiber was recorded in sapodilla than in white sapota. While vitamin A levels was higher in sapodilla (46.70%)

than in white sapota (5.37%). Total sugars and reducing sugar recorded a high percentage of white sapota (4.48%) and (12.38%), while non-reducing sugar were the highest in sapodilla (3.20%), total soluble solid T.S. S (17.44°Brix) in white sapota percentage was higher than sapodilla. From the re-

sults recorded in Table 1., it is noted that the two types of sapota contain a high nutritional value, therefore, they can be used in food industries, these results are in symmetry with (Hashim et al., 2021) and (Muralidhara et al., 2023)

Table 1. Physicochemical properties, vitamins and total sugar sapota fruit cultivars

Parameter	Concentration	
	White sapote	Sapodilla
Moisture (%)	1.06 ± 78.61	1.50 ± 76.71
Protein (%)	0.31 ± 1.09	0.02 ± 0.43
Crude fiber (%)	0.32 ± 1.14	0.44 ± 5.80
Ash (%)	1.02 ± 1.42	0.04 ± 0.54
Fat (%)	0.03 ± 0.42	0.46 ± 1.37
Carbohydrates (%)	1.10 ± 96.23	2.10 ± 90.44
Vitamin C (mg/ 100 gm.)	0.10 ± 3.14	1.50 ± 7.87
Vitamin A (mg/ 100 gm.)	1.11 ± 5.37	1.34 ± 46.70
Total sugar (%)	0.75 ± 14.48	0.95 ± 11.50
Reducing sugar (%)	0.77 ± 12.38	0.90 ± 8.30
Non reducing sugar (%)	0.41 ± 2.10	1.00 ± 3.20
pH value	0.07 ± 5.73	0.06 ± 5.30
Total acidity (%citric acid)	0.01 ± 0.15	0.10 ± 0.12
T.S.S °Brix	1.86 ± 17.44	0.90 ± 14.30

a) Mean ± SD.

b) Carbohydrates was calculated by difference {100- (Protein+ Fats +Ash and Crude fiber)}

c) T.S.S. Total soluble solid

Antioxidant activity, total phenolic and total flavonoids contents

Sapota fruit cultivars are considered good sources of antioxidants, as noted in Table 2. The white sapota recorded a higher level of TA (88.01%) than the sapodilla, while the percentages of TP and TF were convergent: the white sapota (46.73 gallic acid mg/100 g) and the sapodilla

(40.28 gallic acid mg/100 g) and (20.66 quercetin mg/100 g), respectively. According to the findings, sapota fruit cultivars contain a high percentage of antioxidants, so they are considered beneficial for human health and the prevention of many diseases. These results are in harmony with (Tulloch et al., 2020 and Elkady et al., 2017).

Table 2. Determination of total antioxidant activity (TA), total phenolic (TP), total flavonoids (TF) cultivars sapota

Properties	Average	
	White sapote	Sapodilla
TA (%)	1.56 ± 88.01 ^a	0.96 ± 77.34 ^a
TP (Gallic acid) mg/100 g	1.84 ± 46.73 ^b	1.14 ± 40.28 ^b
TF (Quercetin) mg/100 g	1.50 ± 22.33 ^c	1.06 ± 20.66 ^c

Mean ± SD; with different superscripts in a row differ significantly (p < 0.05).

Values ± SE; in the same column with different letters are significantly different at P < 0.05.

Mineral elements content

Sapota assortments contain a tall rate of minerals, as appeared in Table 3. take note higher levels

of minerals in white sapota, Whereas the rate of K (192.87 mg/100g) recorded higher in sapodilla. It moreover contained the slightest sum of minerals,

Zn (0.13 mg/100 g), Mn (0.15 mg/100 g), and Fe (0.84 mg/100g), separately. It is obvious from the table of minerals that the cultivars of sapota natural product contain a changing sum of minerals, which increment in one cultivar and diminish within the other, but they are critical and useful components for human wellbeing, people and other vertebrates require huge sums of calcium for development and upkeep of bone and ordinary work of nerves and

muscles. Ruddy blood cells cannot work legitimately without press in hemoglobin, the oxygen-carrying shade of ruddy blood cells. Magnesium, copper, selenium, zinc, iron, manganese and molybdenum are imperative co-factors found within the structure of certain chemicals and are crucial in various biochemical pathways (Moura et al., 2019 and Budiarto et al., 2023)

Table 3. Mineral contents of white sapota and sapodilla

Mineral (mg/100g)	Concentration	
	White sapote	Sapodilla
Ca	0.77±38.65 ^d	1.54±21.37 ^b
K	1.55±73.67 ^a	2.50±192.87 ^a
Mg	1.01±55.03 ^b	1.48±13.51 ^c
Na	1.46±52.16 ^c	1.57±12.48 ^d
Zn	0.95±6.15 ^f	0.30±0.13 ^g
Mn	1.56±17.69 ^e	0.10±0.15 ^f
Fe	0.36±3.12 ^g	0.04±0.84 ^e

Mean ± SD; with different superscripts in a row differ significantly ($p < 0.05$).

Values ±SE; in the same column with different letters are significantly different at $P < 0.05$

Sensory evaluation of formulated white sapota puree

Results for sensory attributes are shown in Table 4. three types of formulated white sapota puree supplemented with different levels of guava puree fruit. The control F1 recorded the highest score of sensory characteristics values, while it had the lowest formula, F4. Although there were no significant differences between the formulas, the low sensory evaluation rate for Formula F4 is due to the fact that guava juice predominates in this formula, while formula F2 is closest to the control due to the high percent-

age of sapota puree. Sensory evaluation of food products, especially fruits and vegetables, serves as the first impression and is typically one of the primary indicators of perceived quality (Naser, 2021) and (Budiarto et al., 2023). Although there were no significant differences between the formulas, The hedonic test, which assesses consumers' acceptance or preference, is a discriminative analysis in which the panelists are required to give numerical scores to describe the extent of their likes and dislikes of the sensory characteristics of foods according to the scale provided in the questionnaires.

Table 4. Sensory evaluation of white sapota puree with different levels of guava puree fruit

Characteristics (10)	F1	F2	F3	F4
Color	0.05± 7.51 ^a	0.76±7.41 ^b	0.36±7.35 ^c	0.03±7.27 ^d
Oder	0.02± 8.88 ^a	0.15±8.71 ^b	0.30±8.46 ^c	0.12±8.30 ^d
Taste	0.07± 8.48 ^a	0.09±8.21 ^b	0.15±7.87 ^c	0.11±7.13 ^d
Texture	0.01± 8.86 ^a	0.03±8.63 ^b	0.02±7.53 ^c	0.15±7.13 ^d
Over palatability	0.10±9.40 ^a	0.15± 9.11 ^b	0.02±8.15 ^c	0.10±7.79 ^d

a) Mean ± SD; with different superscripts in a row differ significantly ($p < 0.05$)

b) Values ±SE; in the same column with different letters are significantly different at $P < 0.05$

The pH, TAc (titratable acidity), T.S.S (total soluble solids) and Viscosity in formulated puree

May notice in a Table 5. In this experiment, the pH of the control F1 (pure puree) was 5.9, while the pH was lowest in the puree formula F3, where it was less than the pH value of pure white sapota puree. The total acidity percentage is higher in Formula F3 than in the control (pure puree). The total soluble solid content of the pure white sapota puree was 17.50 °Brix, whereas the formula for F3 puree was 22.42 °Brix. Total soluble solids are expressed

in the °Brix value, which represents the percent weight of sucrose in sucrose solution. As for viscosity, it was higher in control (pure puree), while it was lower in F3 (154.33 cP). You may notice that the closest formula to the control is F1. The pH value (5.9) of white sapota fruit contents and total acidity (0.16%) make it very appropriate for food fortification, especially in foods with mild acidity. (Khalil et al., 2022) said that fruits with citric acid levels ranging from 0.08% to 1.95%, which can be classified as mild in favor, are well-accepted by consumers.

Table 5. pH, TAc (titratable acidity), T.S.S (total soluble solids) and viscosity contents of white sapota puree supplemented with different levels of guava puree fruit

Sapota puree	pH	TAc (%citric acid)	T.S.S (°Brix)	Viscosity (cP)
F1	5.9±0.10 ^a	0.16±0.12 ^d	17.50±0.11 ^d	225.8±0.14 ^a
F1	4.8±0.01 ^b	0.18±0.03 ^c	19.30±0.10 ^c	199.50±0.11 ^b
F2	4.7±0.12 ^c	0.22±0.10 ^b	20.40±0.13 ^b	161.40±0.10 ^c
F3	4.6±0.015 ^d	0.24±0.13 ^a	22.42±0.11 ^a	154.33±1.52 ^d

a) Mean ± SD; with different superscripts in a row differ significantly ($p < 0.05$).

b) Values ±SE; in the same column with different letters are significantly different at $P < 0.05$.

Physicochemical properties of white sapota rolls

The mean values and the standard deviation of the moisture, ash, fat, crude protein, crude fiber, carbohydrate, total sugar, and vitamins content of white sapota rolls shown in Table 6. According to the results, there was a decrease in Moisture where registered (20.63%), on the other hand there was an increase in ash, fat, fiber, protein, total sugars, reducing sugar and non-reducing sugar (2.82, 1.12, 3.57, 2.40, 54.26, 40.34 and 13.92%), respectively. While both decreased carbohydrates (90.07%) and vitamins vit. C (2.60 mg/ 100 gm.) and vit. A (4.25 mg/ 100 gm.), respectively. These results agreement with (Abo-Taleb and Abdul-Latif, 2023). While, the irradiated sample showed decrease vitamin C and vitamin A were 1.97 and 3.88 respectively. These findings align with (Salleh et al., 2016 and De-Figueiredo et al., 2014) they reported a significantly lower vitamin C. content in irradiated samples compared to non-irradiated ones. It is noteworthy that vitamin C. plays a pivotal role in metabolic processes and serves as a scavenger of reactive oxygen spe-

cies within biological systems. Additionally, it contributes to metabolism, growth regulation, cell division. Furthermore, (Lim et al., 2018) observed that there was no notable disparity in the ascorbic acid content between non-irradiated and irradiated samples, even though the ascorbic acid content in the irradiated samples was slightly ($p \geq .05$) lower immediately after the treatment in comparison to the control samples.

Antioxidants activity, total phenolic, total flavonoid content of white sapote rolls

The content of total phenols, total flavonoids, and antioxidant activity in white sapote rolls is presented in Table 7. and the results recorded that A decrease in the percentages of antioxidants (80.21%), phenols (40.29 Gallic acid mg/100 g) and flavonoids (21.85 Quercetin mg/100 g) because of drying. Irradiated rolls showed an increase of antioxidant activity, total phenolic (Gallic acid) and total flavonoids (Quercetin) were 91.64%, 58.78 and 45.98 mg/100g respectively. The findings from this study agree with those presented by (Elshiemy et al., 2019 and Abdelaleem and Elbassiony 2020)

they noted that irradiated samples showed a higher content of total phenols than other non-irradiated samples. The impact of radiation treatments on antioxidant content in fresh plant produce depends on factors such as administered dose, duration of exposure, and the specific raw material used. (Hamza et

al., 2022) noted that syrup treated with doses of 1 and 2 kGy exhibited an increase in total phenolic content compared to non-irradiated syrup. It's worth noting that the overall phenolic content depends on the phenolic composition in the extract and the magnitude of the radiation dose.

Table 6. Physicochemical properties of white sapota rolls.

Parameter	White sapote rolls	Irradiated by 2 kGy
Moisture (%)	20.63±0.02	21.71±0.02
Ash (%)	2.82±0.03	2.84±0.03
fat (%)	1.12±0.14	1.16±0.14
Crude fiber (%)	3.57±0.15	3.51±0.15
protein (%)	2.40±0.10	2.48±0.10
Carbohydrates (%)	90.07±0.16	90.02±0.16
Total sugar (%)	54.26±0.02	55.05±0.02
Reducing sugar	40.34±0.03	41.78±0.03
Non reducing sugar (%)	13.92±0.21	13.74±0.21
Vitamin C (mg/ 100 gm.)	2.60±0.43	1.47±0.43
Vitamin A (mg/ 100 gm.)	4.25±0.01	3.54±0.01

Mean ± SD; with different superscripts in a row differ significantly ($p < 0.05$).

Values ±SE; in the same column with different letters are significantly different at $P < 0.05$.

Table 7. Determination of antioxidant activity (TA), total phenolic, (TP) total flavonoids (TF) white sapota rolls.

Properties	white sapote rolls	irradiated white sapote 2 kGy
TA (%)	80.21±0.82 ^a	91.64±0.69 ^a
TP (Gallic acid) mg/100 g	40.29±0.86 ^b	58.78±0.78 ^b
TF (Quercetin) mg/100 g	21.85±1.43 ^c	45.98±1.6 ^c

Mean ± SD; with different superscripts in a row differ significantly ($p < 0.05$).

Values ±SE; in the same column with different letters are significantly different at $P < 0.05$.

Sensory evaluation of sapodilla compote

The results of the sensitive analysis are presented in Table 8. A sensitive evaluation is a combination of the external appearance and taste rates, with the ultimate having a lesser significance for the final score. Fruit size influences the opinions of buyers and consumers, and the larger the fruit size, Fruit color, together with fruit size, contributes to fruit attractiveness. Judging by the scores given for fruit coloration, taste rates combine the scores given for texture, taste, aroma, and agreeableness. Generally, well-informed buyers pay great attention to taste rates along with the external appearance of fruits. From the results of this study, it's clear that sapodilla compote entered the loftiest standing from the judges (9.59) in terms of overall acceptability, as it

is considered a well-accepted product among consumers (Bozhkova, 2014)

Table 8. Sensory evaluation of sapodilla compote

Measurement	Sapodilla compote
Fruit size	8.67±0.15
Fruit shape	8.55±0.05
Color	9.16±0.10
Odor	9.11±0.09
Taste	8.23±0.01
Sweetness	8.17±0.11
Appearance	8.63±0.30
Overall acceptability	9.59±0.51

Total bacterial count and total mold and yeasts

The data in Figures 1 and 2 showed that there was a decrease in total bacterial count, mold, and

yeast for irradiated sapota rolls during the storage period. The observed data showed that the microbiological result for total aerobic bacteria was less than 10 CFU/g at zero time for the irradiated sample. during storage the total bacterial count were increased for all of samples after 6 weeks', while after 9 weeks there has been remark-abled very slight increase of total count bacteria as in the first 6 weeks of the storage period this decrease because decrease the nutrients supporting, also due to decrease of moisture content for the samples, meanwhile the irradiated sample by 2 kGy decreased of total count bacteria this results agreed with founding (Yadav et al., 2012; Yadav et al., 2013 and Srinu et al., 2015) they found increase of shelf-life of irradiated sapota fruit. The total molds and yeast

have no count at zero time, that's due to the molds more effectively inherence by antimicrobial bioactivity of sapota was attributed to flavonoids and phenolic components, also by effect of sodium meta bisulfite as an inhibitor material, antifungal activity is probably due to the presence of terpenoids, flavonoids, and glycosides (Osman et al., 2011). During storage increased the count of molds and yeasts for all samples the figure showed the gamma irradiated samples by 2 kGy decreased of total count bacteria more than control sample these results agreed with (Yadav et al., 2013; Srinu et al., 2015 and Santos and de Aquino 2019) they indicated that gamma radiation effective to decrease the mold and yeast count for sapota fruits.

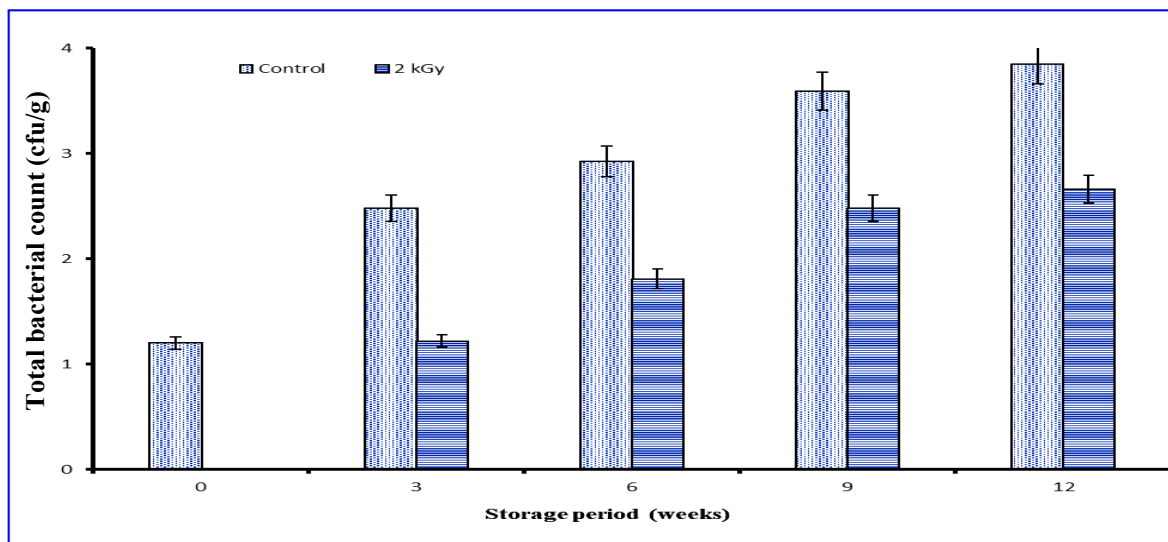


Figure 1. Total bacterial count of sapota rolls

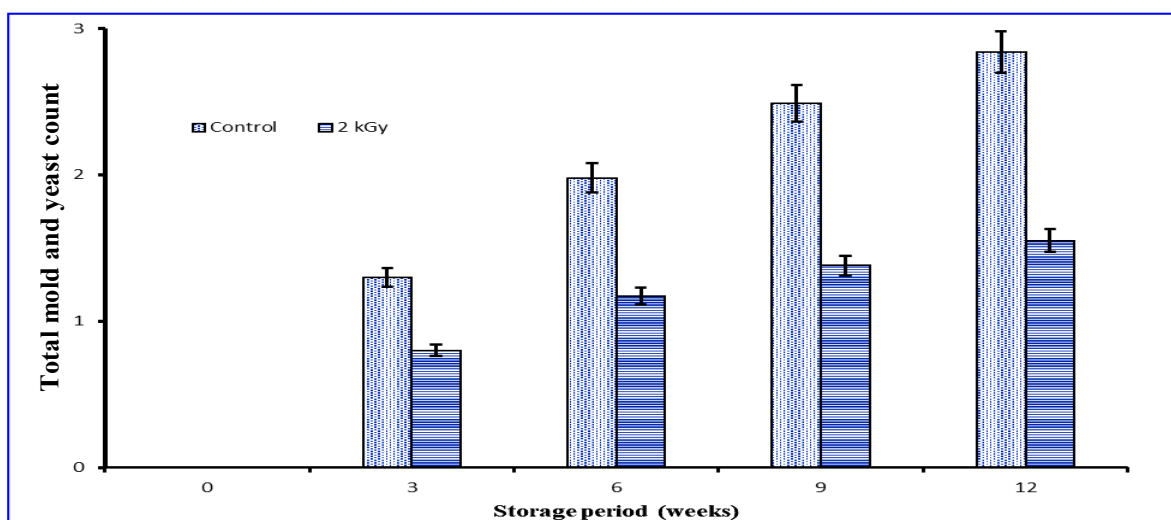


Figure 2. Total molds and yeast count of sapota rolls

4. Conclusion

Sapota is one of the important fruit crops that act as a strong antioxidant. Therefore, recommended agriculture of that fruit to develop functional and healthy products. Furthermore, radiation treatment has limited effects on certain physicochemical properties of sapota. However, irradiation at 2 kGy appears to be optimal for enhancing phenolic and flavonoid compounds in sapota rolls. In this study and future studies, the product market will be developed with functional and healthy fruit. Also suitable for all age groups alike. Sapota cultivation has succeeded in Egypt as a result of climate change, so it is recommended to expand its cultivation in various governorates of Egypt due to its high nutritional value. Finally, it could be clearly concluded through this study that sapota is promising crop.

References

- A.O.A.C. (2000). Method 920.182. in: Association of Official Analytical, 17th edn Gaithersburg, MD, Association of Official Methods of Analysis. 14th ed., Arlington, VA, U. S. A.
- A.O.A.C. (2003). Association of official analytical chemists, Official methods of analysis 17th ed., Arlington, Virginia.
- A.O.A.C. (2006). Association official analytical chemists. Official methods of analysis 02. Gaithersburg, MD.
- A.O.A.C. (2007). Official; method of Analysis. 16th ed. Vol. N. AOAC official 92:111 Arlington, VA: Association of Official Analytical Chemists
- A.O.A.C. (2011). Association of Official Analytical Chemists. Official Methods of Analysis. 18th Arlington, Ed, U. S. A.
- A.O.A.C. (2012). Association of Official Analytical Chemists. Official Methods of Analysis. 14th ed., Arlington, VA, U. S. A.
- A.O.A.C. (2012). Association of Official Analytical Chemists. Official Methods of Analysis. 14th ed., Arlington, VA, U. S. A.
- A.O.A.C. (2016). Official Methods of Food Analysis. Association of Official Analytical Chemists, Washington, DC, USA, 20th edition.
- Abdalahy M.R.A. (2017). In vitro plant regeneration from alginate encapsulated shoot tips of *Casimiroa edulis* L, Egyptian J. Desert Res., 67(2):315-325.
- Abdelaleem, M.A., and Elbassiony, K.R.A. (2020). Evaluation of phytochemicals and antioxidant activity of gamma irradiated quinoa (*Chenopodium quinoa*). Brazilian Journal of Biology, 81, 806-813.
- Abo-Taleb H.M. and Abdul-Latif M.M. (2023). Evaluation of Physical and Chemical Properties of White Sapote (*Casimiroa Edulis*) Fruits and Powder. Food Technology Research Journal, 1 (1): 42-52.
- Ahlawat T.R., Patel N.L., Patel C.R. and Ag-nihotri R. (2016). White Sapote (*Casimiroa edulis* Llave and Lex). In book: Underutilized Fruit Crops: Importance and Cultivation, Edition: 1st, Chapter, 65: 1353-1367.
- Alrashood S.T., al-Asmari A.K., Alotaibi A.K., Manthiri R.A., Rafatullah S. and Hasanato R.M. (2020). Protective effect of lyophilized sapodilla (*Manilkara zapota*) fruit extract against CCl₄-induced liver damage in rats. J Biol Sci., 27:2373–9.
- Bashir S. (2019). Pharmacological importance of *Manilkara zapota* and its bioactive constituents. Bol. Latinoam. Caribe Plantas Med. Aromát., 18:347–58.
- Bisht, B., Bhatnagar, P., Gururani, P., Kumar, V., Tomar, M.S., Sinhmar, R., Rathi, N. and Kumar, S., (2021). Food irradiation: effect of ionizing and non-ionizing radiations on preservation of fruits and vegetables—a review. Trends Food Sci. Technol. 114, 372–385.
- Bozhkova V. (2014). Chemical Composition and Sensory Evaluation of Plum Fruits. Trakya Uni J Nat Sci, 15(1): 31-35.
- Brand-Williams W., Cuvelier M.E. and Berset C. (1995). Use of a free radical method to evaluate antioxidant activity. LWT Food Sci. Technol., 28: 25-30.
- Budiarto R., Dwinanda S.R., Pakpahan H.A. and Komala M. Y. (2023). A review of sapodilla beneficial use, production status, and propagation technique in Indonesia. Journal

- Kultivasi, 22 (2) 192-199.
- De Souza Freitas W.E., Almeida M.L.B., De Morais P.L.D., Da Curnha Moura A.K. and Sales R. (2017). Potassium permanganate effects on the quality and post-harvest conservation of sapodilla (*Manilkara zapota* (L.) P. Royen) fruits under modified atmosphere. *Acta Agron.*, 66:331-37.
- De-Figueiredo, S. G., Silva-Sena, G. G., de-Santana, E. N., dos-Santos, R. G., Neto, J. O., & de-Oliveira, C. A. (2014). Effect of gamma irradiation on carotenoids and vitamin C contents of papaya fruit (*Carica papaya* L.) cv. golden. *Journal of Food Processing & Technology*, 5(6):1-10.
- Elkady W. M., Ibrahim E.A., Gonaid M.H., El Baz F.K. (2017). Chemical Profile and Biological Activity of *Casimiroa Edulis* Non-Edible Fruit's Parts. *Advanced Pharmaceutical Bulletin*, 7(4): 655-660.
- Elshiemy, S. M., Soliman, I. A., Abdelaleem, M. A. and Elbassiony, K. R. A. (2019). Antioxidant and Antibacterial Activity of Gamma Irradiated Red Beet (*Beta Vulgaris* L.) Leaves and Roots. *Journal of Nuclear Technology in applied science*, 7, 33-50.
- Fayek N.M., Abdel Abdel-Monem A. R., Mossa M. Y., Meselhy M.R. and Shazly A.H. (2012). Chemical and biological study of *Manilkara zapota* (L.) Van Royen leaves (Sapotaceae) cultivated in Egypt. *Pharmacognosy Research*, 4:85-92.
- Gadgile D.P., Kakde R.B., Rathod G.M., Chavan A.M. (2010) Postharvest fungal diseases of some tropical fruits. *Biosci. Disc.* 2010; 1(1):7-10.
- Genanew T.Z., Zegeye A. and Biniyam T. B. (2022). Characterization and optimization of (*Casimiroa Edulis*) fruit juice using Response Surface Methodology (RSM) *Int J Agric Sc Food Technol* 8(2): 090-100.
- Getachew, N. (2018). Modelling of microenvironment inside evaporatively and cool bot cooled stores using computational fluid dynamics models and changes in quality of stored tomatoes. Ph. D. in Agricultural Engineering, University of KwaZulu-Natal, Pietermaritzburg, South Africa.
- Hamza, H. Miloud, N. B. Jemni, M. Sleil, A. Mbarak, S. (2022). Gamma irradiated date syrup for sucrose substitution in yogurt: effect on physicochemical properties, antioxidant capacity and sensory evaluation. *Journal of Food Science and Technology*, 59(1):192-201.
- Hashim M.S. and Ismail F.A. (2022). Proximate and physicochemical analysis of pink guava juice fortified with vitamin E. *Journal of Academia*, 9: 21 – 29.
- Hashim N.H., Mohd Z. Z., Zamri A.I., Rusli, N.D., Smedley, K.L. and Zainol M.K. (2021). Physicochemical properties and sensory characteristics of chiku fruit (*Manilkara zapota*) pastilles. *Food Research*, 5 (2):164 – 172.
- Heimler, D., Vignolini, P., Dini, M.G. and Romani, A. (2005). Rapid Tests to Assess the Antioxidant Activity of *Phaseolus vulgaris* L. *Journal of Agricultural and Food Chemistry*, 53: 3053-3056.
- Hidar N., Noufid A., Mourjan A., El Adnany E.M., Mghazli S., Mouhib M., Jaouad A., Mahrouz M. (2021). Effect of preservation methods on physicochemical quality, phenolic content, and antioxidant activity of stevia leaves. *J Food Qual* 2021:10.
- Khalil O.S.F., Ismail, H.A. and Elkot W.F. (2022). Physicochemical, functional and sensory properties of probiotic yoghurt flavored with white sapote fruit (*Casimiroa edulis*). *J. Food Sci. Technol.*, 59(9):3700-3710.
- Khurana H.K. and Kanawjia S.K. (2006). Application of manothermosonication in food processing. *Packaging Indi*, 39(3):9-20.
- Kishore K. and Mahanti K.K. (2016). Codification and description of phenological growth stages of sapota (*Manilkara zapota*) according to the extended BBCH scale. *Sci Hort.*, 211:431-439.
- Kishore K., Samant D., Singh H.S. and Behera S. (2017). Studies on the reproductive strategies of sapota (*Manilkara zapota*). *J Environ Biol*. 37:291-5.

- Lim, W.S., Rabeta, M.S. and Uthumporn, U. (2018). Development of functional beverage from Sapodilla (*Manilkara Zapota L.*) fruit. *Food Research*, 2 (2):163 – 170.
- Mehnaz B. and Bilal A. (2017). *Manilkara zapota (L.) P. Royen (Sapodilla): A Review Related papers Manilkara zapota (L.) P. Royen (Sapodilla): a review. Int J Adv Res.*, 3:1364–71.
- Mendonca C.R., Zambiasi R. and Granada G.G. (2001). Partial Substitution of Sugars by the Low-Calorie Sweetener Sucralose in Peach Compote. *Journal of Food Science*, 66 (8):1195 -1200.
- Moura B. I. V., Araújo B. P. L., Sá R. D. and Randau K. P. (2019). Pharmacobotanical study of *Manilkara zapota (L.) P. Royen (Sapotaceae)*. *Braz. J. Pharm. Sci.*, 55: 1-10.
- Muralidhara B. M., Rajendiran S.1., Madhu G. S., Rani A.T., Deekshith D. and Mithun P. M. (2023). Effect of pre-sowing treatments on germination, growth and vigour attributes of white sapote (*Casimiroa edulis*). *Indian Journal of Agricultural Sciences*, 93 (6): 664–667.
- Nasr, W. I. A. (2021). Making Ice Cream Fortified with Sapota Fruit Pulp as a Functional Dairy Product. *J. of Food and Dairy Sci.*, Mansoura Univ., 12 (2): 37 – 41.
- Osman M.A., Aziz M.A., Habib M.R. and Karim M.R. (2011). Antimicrobial Investigation on *Manilkara zapota (L.) P. Royen*. *Int J Drug Dev Res*,3(1):185-190.
- Punia B.S., Sharma N., Kaur H., Kaur M., Sandhu K.S. and Maqsood S. (2022). A review of Sapodilla (*Manilkara zapota*) in human nutrition, health, and industrial applications. *Trends Food Sci Technol.*, 127:319–34.
- Rahman T., Hasan S. and Noor R. (2011). An Assessment of Microbiological Quality of Some Commercially Packed and Fresh Fruit Juice Available in Dhaka City: A Comparative Study. *Stamford Journal of Microbiology*,1 (1):13-18.
- Reddy J. (2018). Sapota Cultivation Project Report (Chiku), Farming Guide. Retrieved from Agri. Farming: <https://www.agrifarming.in/sapota-cultivation-project-report-chiku-farming-guide>.
- Salleh R.M., Ying T.L. and Mousavi L. (2016). Development of fruit bar using sapodilla (*Manilkara zapota L.*). *Journal of Food Processing and Preservation*, 1-7.
- Salunkhe D.K. and Desai B. (1984). Postharvest biotechnology of fruits, 1:168. CRC presses florida, U.S.A, 1984.
- Santos T.R.J., de Aquino S. L.C.L. (2019). Antimicrobial potential of exotic fruits residues. *South African Journal of Botany* 124, 338–344.
- Shahbaz H., Ahn J., Akrama K., Kim H., Park E. and Kwon, J. (2014). Chemical and sensory quality of fresh pomegranate fruits exposed to gamma radiation as quarantine treatment. *Food Chem.*, 145: 312–318
- Siddiqui M.W. and Dhua R.S. (2010). Eating artificially ripened fruits is harmful. *Curr Sci.*, 99 (12):1664-1668.
- Siddiqui M.W., Dutta P., Dhua R.S. and Dey A. (2013). Changes in biochemical composition of mango in response to pre-harvest gibberellic acid spray. *Agriculturae Conspectus Scientificus (ACS)*. 78(4):331-335.
- Siddiqui M.W., Longkumer M., Ahmad M.S., Barman K., Thakur P.K. and , Kabir J. (2014). Postharvest biology and technology of sapota: a concise review. *Acta Physiol Plant.*, 36:3115 –22.
- Singh J.P., Kaur A., Shevkani k. and Singh N. (2016). Composition, bioactive compounds and antioxidant activity of common Indian fruits and vegetables. *J Food Sci Technol*, 53 (11):4056–4066.
- Singh J.P., Kaur A., Shevkani K. and Singh N. (2015). Influence of jambolana (*Syzygium cumini*) and xanthan gum incorporation on the physicochemical, antioxidant and sensory properties of glutenfree eggless rice muffins. *Int J Food Sci Technol* 50:1190–1197.
- Singh S.N., Burbade R.G., Sanchavat H. and Pandit P.S. (2020). Physico Chemical Characteristics of Sapota (Chikoo) Powder based Value

- Added Pasta Product using Semolina (Suji) and Maida. *Journal of Agri. Search* 7(4):223-227.
- Srinu B., Bhagwan A., Babu J.D. (2015). Effect of combination of polypropylene packaging and irradiation on shelf life of sapota fruit stored at low temperature. *Environments and ecology*. 2015; 33:1672-1675.
- Tulloch A., Goldson-Barnaby A., Bailey D. and Gupte S. (2020). *Manilkara zapota* (Naseberry): medicinal properties and food applications. *Int J Fruit Sci.*, 20: S1–7.
- Yadav N.K.K., Bharathi N., Goud P.V. (2012). Combined effect of growth regulators and irradiation on shelf life of sapota (*Manilkara achras* (Mill.) Fosberg) cv. Kalipatti. *Plant Arch.* 2012; 13(2):1039-1042.
- Yadav N.K.K., Bharathi N. and Goud P.V. (2013). Effect of irradiation on quality of sapota (*Manilkara achras*) cv. Kalipatti. *Inter. J Applied Agri. & Horti. Sci.* 2013 b; 3(6):713-715.
- Yahia E.M. and Gutierrez-Orozco F. (2011.). Sapodilla (*Manilkara achras* (Mill) Fosb., syn *Achras sapota* L.) In: EM Yahia, editor. *Post-harvest biology and technology of tropical and subtropical fruits*. Sawston, Cambridge: Woodhead Publishing Limited.
- Zainol, M.K., Wong, K.Y., Mohd Zin, Z., Kamarudin, K.S., Danish-Daniel, M.A.A. and Hasmadi, M. (2018). Effect of ethanol concentration in ultrasonic assisted extraction technique on antioxidative properties of passion fruit (*Passiflora edulis*) leaves. *Malaysian Applied Biology*, 47(6): 19-27.