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# Comprehensive Assessment of Nutritional Composition, Phytoconstituents and Bioactive Properties of *Diospyros kaki* for Novel Functional Food Formulations

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### ABSTRACT

Persimmon (*Diospyros kaki*), belonging to the family Ebenaceae and commonly known as Japanese Phal or "Food of the Gods," is a fleshy, fibrous, deciduous tropical fruit classified as a berry. Due to its rich content of bioactive compounds, *D. kaki* was selected for the present study. The study aimed to evaluate its phytochemical composition, nutritional profile, antioxidant potential, antibacterial activity, and applicability in product formulation. Phytochemical analysis revealed the presence of flavonoids, saponins, tannins, and carotenoids, while nutrient analysis indicated significant levels of carbohydrates, proteins, fats and crude fiber. The fruit exhibited strong antioxidant activity and demonstrated antibacterial efficacy against *Bacillus cereus*, *Enterococcus sp.*, *Escherichia coli* and *Klebsiella sp.* Based on its bioactive potential, *D. kaki* was incorporated into various functional food products, including Kesari, Jaggery Shell, Milkshake, Button Badusha, and Pudding, which were evaluated for sensory attributes by 25 panel members. The results indicated that *D. kaki* is a rich source of bioactive compounds, and its incorporation into food products is feasible, highly acceptable, and potentially beneficial for human health. These findings suggest that *D. kaki* based products can be recommended across all age groups to support nutritional well-being and mitigate health issues.

**Keywords:** *Diospyros kaki*, Phytochemicals, Nutrients, Antioxidant, Antibacterial Activity

### Introduction

Fruits and vegetables are important component of human diet and play important role in maintain the human health. The health promoting potentials associated with their consumption are mainly due to presence of bioactive components and these phytochemicals are distinct bioactive molecules widely acknowledged for their beneficial roles in human physiology (Manachet *et al.*, 2004) number of plants gained popularity as wholesome food entities but still many horizons demand researchers attention. The consumption of fruits and vegetables globally supports to meet the requirements of vitamins and secondary metabolites for better health. Amongst, Persimmon (*Diospyros kaki* L.) is one of these nutritious fruits bestowed with strong antioxidant activity (Jung *et al.*, 2005; Igualet *et al.*, 2008).

Persimmon (*Diospyros kaki*, 1782) is an ancient fruit tree, of the family Ebenaceae, among the first to be cultivated by man. Originally from China, it then spread to the far east, from Korea to Japan, where it is also known as the loto of Japan. In the land of the rising sun this beautiful plant is also called the tree of peace, as some specimens managed to survive the atomic bomb dropped on Nagasaki in 1945. The most common varieties are lotodiromagna, vanilla of campania, fuyu, kawabata, suruga; one of the best known is the sicilian variety of misilmeri exported all over the world (Bellini *et al.*, 2008). China is ranked first in persimmon production in the world, with an annual production of 1.65 million metric tons (Karaman *et al.*, 2014).

Persimmon fruits are climacteric and ethylene regulates their process of ripening. Therefore, the shelf life of persimmon fruits can be increased by slowing the ripening process by inhibiting ethylene biosynthesis or its action, hence enhancing their storage life (Luo, 2007) persimmon is eaten as fresh or dried fruits. During drying, persimmon peel is removed; otherwise, it produces bitter taste because of its astringency. Usually, whole fruit and slices are dried to make dried persimmon products. Juices, sherbet, or puree is prepared from peeled persimmon pulp. However, unpeeled whole persimmon fruit can be used for persimmon vinegar and wine production (Akter *et al.*, 2010).



Persimmon is prominent for its nutrition (Achiwa *et al.*, 1997) comprising 80.3% water, 0.58% protein, 0.19% total lipids, 18.6% total carbohydrates and some minerals (magnesium, iron, zinc, copper, manganese, etc.) and up to 1.48 g and 7.5 mg total dietary fiber, and ascorbic acid respectively (Ozen *et al.*, 2004; Ercisli *et al.*, 2007). Persimmon leaves and extracts are being used as a green tea, oriental medicines, deodorants, antiallergic substrates, and cosmetics (especially for dermatitis) as they prevent skin problems and have an antiwrinkle effect and skin whitening effect (Sun *et al.*, 2011). Carotenoids are the major pigment present in persimmon. They contribute to both color and nutritional value (Zhao *et al.*, 2011). Carotenoids identified in persimmon fruits are cis-mutatoxanthin, antheraxanthin, zeaxanthin, neo lutein, cryptoxanthins,  $\alpha$ -carotene, and  $\beta$ -carotene and also fatty acid esters of  $\beta$ -cryptoxanthin and zeaxanthin (Jang *et al.*, 2010).

The vitamin C content of the persimmon helps enable the anti-inflammatory effect. Vitamin C has links to reducing the effect of many diseases including heart disease trusted source, diabetes trusted source, and prostate cancer trusted source persimmons are high in fiber, particularly if they are dried trusted source. Consuming fiber can help to lower levels of “bad cholesterol” in the body. Soluble fiber, such as that found in persimmons, can bind with cholesterol in the digestive system and remove it trusted source from the body. Persimmon leaves have beneficial effects against oxidative stress, hypertension, diabetes mellitus and its complications, and atherosclerosis (Kotani *et al.*, 2000; Wang *et al.*, ). The bioactive components present in it especially carotenoids and tannin are helpful in quenching free radicals, decreasing cardiovascular risk factors (blood pressure & cholesterol), and reducing the risks of diabetes mellitus along with effectiveness against cancer insurgence (Park *et al.*, 2002; Lee *et al.*, 2006).

The tannins present in persimmon are eventually responsible for curing physiological threats. They possess antibacterial (Kawase *et al.*, 2013), anti-allergic (Kotani *et al.*, 2000), free radicals scavenging (Sakanaka *et al.*, 2005), lowering blood pressure (Jo *et al.*, 2003), anticancer and antioxidant activities (Gali *et al.*, 1992). The antioxidant activities of tannin are due to presence of nucleophiles moieties (Laranjinha *et al.*, 1994) along with some antimutagenic properties (Achiwa *et al.*, 1997) through inhibition of nitrogen reactive compounds. They are also effective in reducing the incidence of stroke (Wu and Hwang, 2002; Jung *et al.*, 2005) and hypertensive disorders (Sakanaka *et al.*, 2005).

Persimmon is a fruit potent for obesity and diabetes. Proanthocyanidin is the major component isolated from persimmon peel and has been demonstrated to play a role in obesity and diabetes (Lui Chinfanget *et al.*, 2012). *Diospyros kaki* is used as a medicinal plant in Chinese traditional medicine especially in cosmetics and dermatological applications. Traditionally this plant is used to treat different skin conditions including pimples, skin eruptions and eczema. Extracts from *Diospyros kaki* folium decreases number of skin pores' size, removes solidified sebum from the skin and can facilitate removal of Demodex mites (causative microbe for rosacea and seborrheic dermatitis) from the skin. The crude extracts, its purified fractions and various phytonutrients obtained from persimmon have a great potential for both dermatological and cosmetic application (Kashif Muhammad *et al.*, 2017).

## Methodology

### Collection of Sample

*Diospyros kaki* (Persimmon fruit) have many nutrients but it is not commonly used as other fruits varieties. So, to bring awareness about its nutrients, health benefits and its sensory character it was selected to use in the study. It was collected from the local shop, Nagercoil, Kanyakumari district. The ingredients were purchased from the nearby supermarket. The persimmon fruits (*Diospyros kaki*) were collected, cleaned and peeled the outer layer. After peeling the fruits, it was ground to make a smooth paste. The pulp was stored in an airtight container for further studies.

### Qualitative Phytochemical Analysis

Persimmon fruit pulp was analysed to reveal its phytoconstituents by the standard protocol (Sofowora, 1993).

### Nutrient Analysis

The sample was subjected to analyse the nutrients such as carbohydrate, protein, fat and crude fibre with the standard procedure.

### Antioxidant Activity

Antioxidant activity of the sample was tested with DPPH assay. Radical scavenging activity was calculated by the following formula,

$$\text{Percentage inhibition} = \frac{\text{absorbance of control} - \text{absorbance of test}}{\text{absorbance of control}} \times 100$$

### Antibacterial Activity

Antibacterial activity of the sample was analysed with kirby Bauer Disc method.

### Formulation of the Products

*Diospyros kaki* was selected for the preparation of the formulated products. The products incorporated with *Diospyros kaki* were *Diospyros kaki* Button Badhusa, *Diospyros kaki* Kesari, *Diospyros kaki* Pudding, *Diospyros kaki* Milk shake, and *Diospyros kaki* Jaggery shells.

### Sensory Evaluation of the Formulated Products

Sensory assessment was done based on the quality description i.e., appearance, colour, flavour, taste, texture, and overall acceptability using a score card. The sensory evaluation was carried out for the products such as Button badhusa, *Diospyros kaki* incorporated Button Badhusa, Kesari, *Diospyros kaki* incorporated Kesari, Pudding, *Diospyros kaki* incorporated Pudding, Milk shake, *Diospyros kaki* incorporated Milk shake, Jaggery shells, *Diospyros kaki* incorporated Jaggery shells, Products were evaluated by a panel of 25 panel members from the PG ana Research Department of Nutrition and Dietetics, Muslim Arts College, Thiruvithancode, Kanyakumari district.



Plate -2 Sensory Evaluation of the products

## Results

### Sample collection

*Diospyros kaki* was collected and processed then subjected to Qualitative phytochemical analysis, nutrient analysis, antioxidant activity, and antibacterial activity. The products were formulated, sensory evaluated and done a self-life study. All data were collected and tabulated as below:

### Qualitative phytochemical Analysis

Qualitative analysis of the phytoconstituents present in *Diospyros kaki* showed the presence of tannin, flavonoid, saponin, carotenoid and the absent of alkaloid (Table-1).

Table-1 Qualitative phytochemical analysis

| S.no | Phytochemical screening | Result |
|------|-------------------------|--------|
| 1    | Tannin                  | +      |
| 2    | Flavonoid               | ++     |
| 3    | Saponin                 | ++     |
| 4    | Alkaloid                | —      |
| 5    | Carotenoid              | ++     |

NB: + = Positive, — = Negative

### Nutrient Analysis

Carbohydrate was estimated in the *Diospyros kaki* sample by anthrone method. Glucose was taken as a standard and the concentrations were estimated in the OD at 630nm. Amount of carbohydrate present in the 100 g *Diospyros kaki* was 38.5 g of carbohydrate.

Protein estimation was carried out by Bradford's method. Bovine Serum Albumin (BSA) was taken as a standard in varying concentration such as 10,20,40,80,100 and 200 µg/ml. Absorbance was estimated at 595nm. Absorbance was of increased with increasing concentration. Amount of protein present in the 100 g *Diospyros kaki* sample was 0.8 g at 595nm.

Fat content present in the *Diospyros kaki* was estimated by using modified batch solvent extraction. The amount of fat estimated was 0.55g. Crude fiber content of *Diospyros kaki* was determined and tabulated (Table-1). It was showed that the weight of crude fiber was 0.7g (Figure-1).

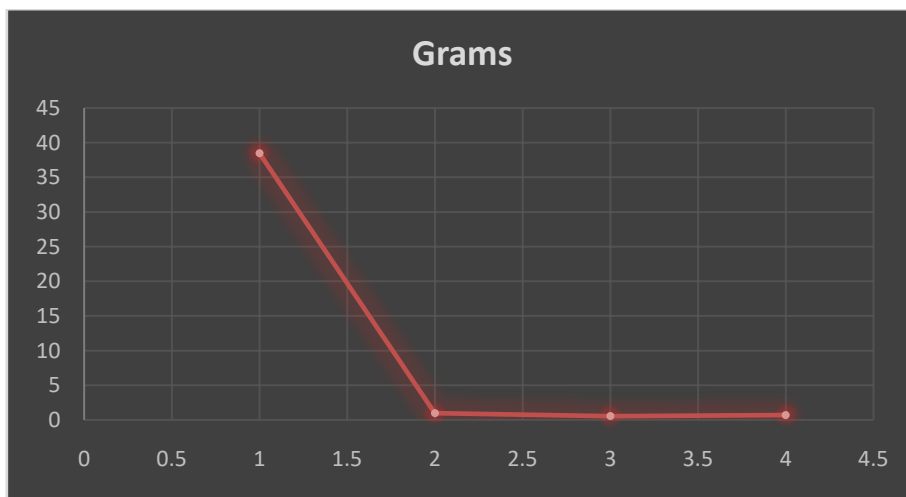


Figure-1 Nutrient Analysis

#### Antioxidant Activity

Antioxidant activity of *Diospyros kaki* against DPPH assay was determined, it was noticed that the antioxidant activity of *Diospyros kaki* was 55mg TE/100g, 47.5 mg TE/100g, 41.34 mg TE/100g, 38.6 mg TE/100g and 35.0mg TE/100g at different sample points. The peak antioxidant value of *Diospyros kaki* was observed at 41.34 mg TE/100g (Figure-2).

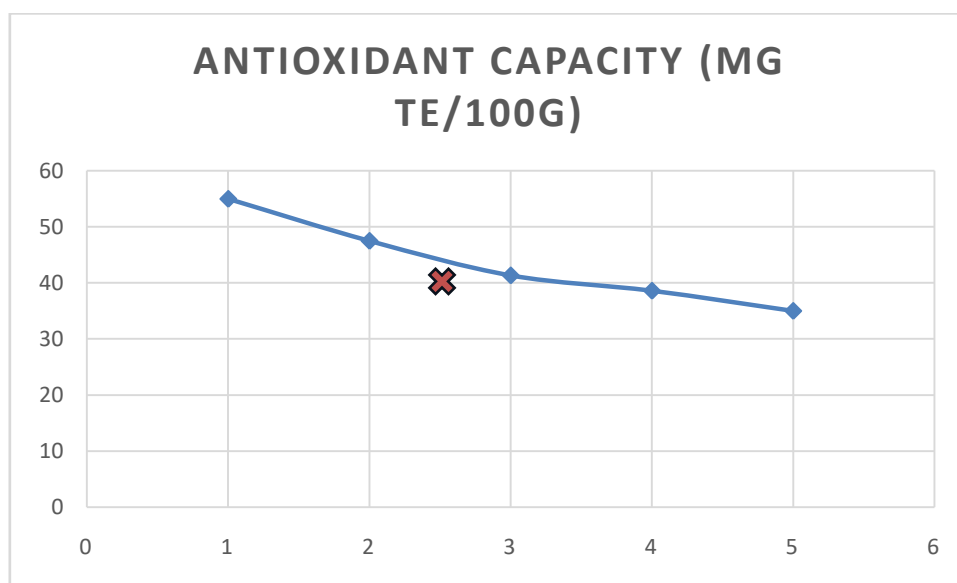


Figure-2 Antioxidant Capacity

#### Antibacterial activity

After incubation, the plates are examined and the diameter of the zones were measured. The *Diospyros kaki* sample showed zone of inhibition against the bacteria *Enterococcus* and *Klebsiella* as 9 mm and 8 mm respectively. Thus, the sample *Diospyros kaki* showed inhibitory action against the pathogens, it revealed the antibacterial activity like antibiotic (Plate-3).

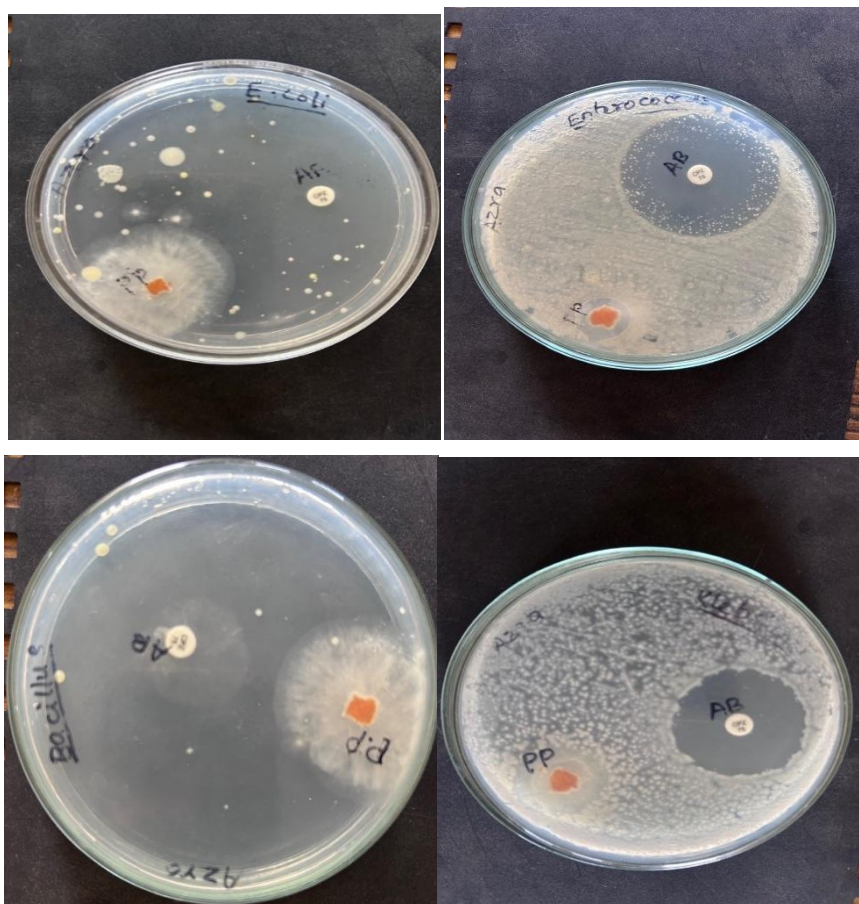


Plate-3 Antibacterial Activity

### Sensory Evaluation of the Formulated Products

Due to rich source of bioactive components, different products were prepared with *Diospyros kakipulp*. The sensory parameters were analysed and tabulated. The mean score values of sensory evaluation show different acceptability values for different products. Among these *Diospyros kaki* Kesari showed  $4.92 \pm 0.271$  mean value, *Diospyros kaki* Jaggery shell showed  $4.92 \pm 0.27$  mean value, *Diospyros kaki* Milkshake showed  $4.76 \pm 0.42$  mean value, *Diospyros kaki* Button badhusha showed  $4.76 \pm 0.4$  mean value and *Diospyros kaki* Pudding showed  $4.8 \pm 0.4$  mean value. Overall acceptability of the formulated products were excellent when compared to the standard products. The sensory analysis of the formulated products given in the following tables and figures,

Table-2 Sensory Parameters of Kesari

| Sl.no | Sensory parameters    | Standard (KS)    |        | Product (DKKP)   |       |
|-------|-----------------------|------------------|--------|------------------|-------|
|       |                       | Mean $\pm$ SD    | SME    | Mean $\pm$ SD    | SME   |
| 1     | Appearance            | $3.8 \pm 0.692$  | 0.138  | $4.72 \pm 0.448$ | 0.089 |
| 2     | Texture               | $3.64 \pm 0.794$ | 0.158  | $4.72 \pm 0.448$ | 0.089 |
| 3     | Taste                 | $3.76 \pm 0.818$ | 0.163  | $4.76 \pm 0.427$ | 0.085 |
| 4     | Flavour               | $3.68 \pm 0.733$ | 0.1466 | $4.88 \pm 0.325$ | 0.065 |
| 5     | Colour                | $3.68 \pm 0.733$ | 0.146  | $4.64 \pm 0.58$  | 0.116 |
| 6     | Overall acceptability | $3.88 \pm 0.707$ | 0.141  | $4.92 \pm 0.271$ | 0.054 |

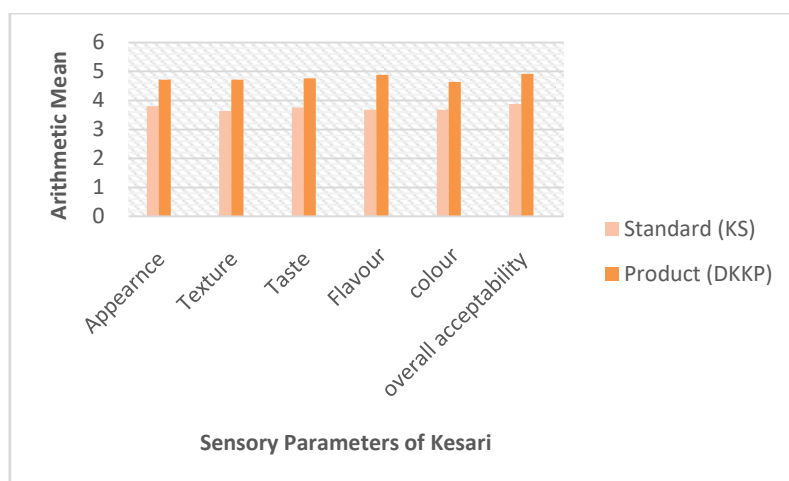


Table-3 Sensory Parameters of Jaggery Shell

| Sl.no | Sensory parameters    | Standard (JSS) |        | Product (DKJSP) |      |
|-------|-----------------------|----------------|--------|-----------------|------|
|       |                       | Mean±SD        | SME    | Mean±SD         | SME  |
| 1     | Appearance            | 3.72±0.67      | 0.134  | 4.88±0.32       | 0.06 |
| 2     | Texture               | 3.42±0.889     | 0.17   | 4.8±0.14        | 0.02 |
| 3     | Taste                 | 3.68±0.93      | 0.18   | 4.8±0.4         | 0.08 |
| 4     | Flavour               | 3.8±0.154      | 0.0309 | 4.76±0.59       | 0.11 |
| 5     | Colour                | 3.76±0.252     | 0.050  | 4.92±0.27       | 0.05 |
| 6     | Overall acceptability | 3.76±0.7493    | 0.149  | 4.92±0.27       | 0.05 |

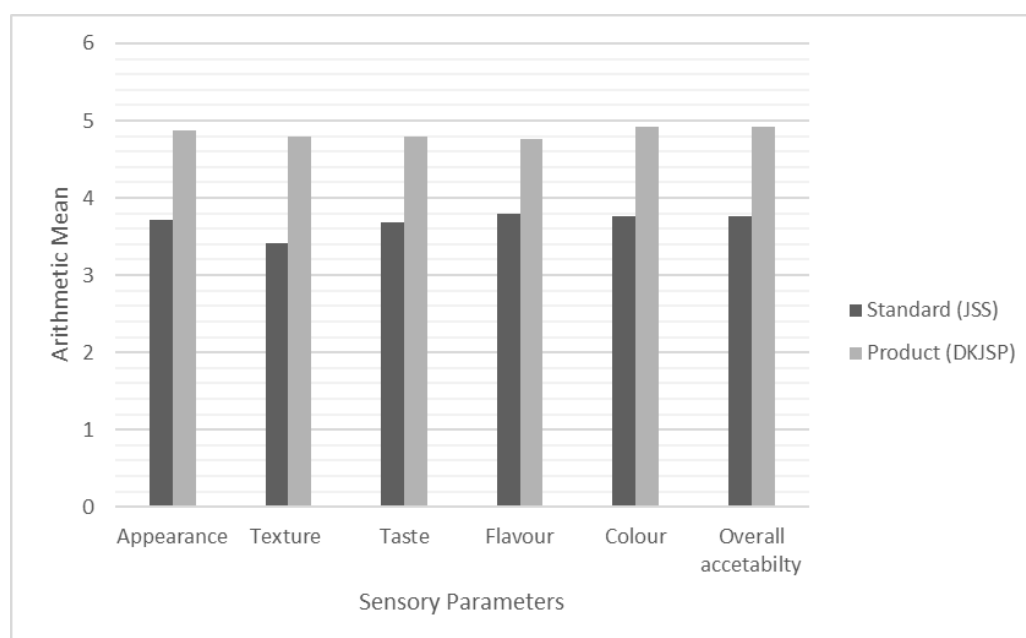


Table-4 Sensory Parameters of Milkshake

| Sl.no | Sensory parameters    | Standard (MSS) |      | Product (DKMSP) |      |
|-------|-----------------------|----------------|------|-----------------|------|
|       |                       | Mean±SD        | SME  | Mean±SD         | SME  |
| 1     | Appearance            | 3.8±0.74       | 0.14 | 4.88±0.32       | 0.06 |
| 2     | Texture               | 3.64±0.93      | 0.18 | 4.8±0.4         | 0.08 |
| 3     | Taste                 | 3.6±1.01       | 0.20 | 4.84±0.36       | 0.07 |
| 4     | Flavour               | 3.56±0.89      | 0.17 | 4.72±0.44       | 0.08 |
| 5     | Colour                | 3.68±0.85      | 0.17 | 4.72±0.51       | 0.10 |
| 6     | Overall acceptability | 3.6±0.77       | 0.15 | 4.76±0.42       | 0.08 |

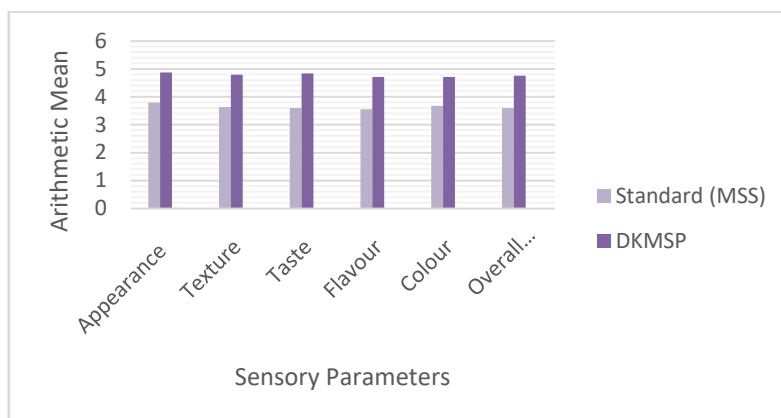


Table-5. Sensory Parameters of Button Badhusa

| Sl.no | Sensory parameters    | Standard (BBS) |      | Product (DKBBP) |      |
|-------|-----------------------|----------------|------|-----------------|------|
|       |                       | Mean±SD        | SME  | Mean±SD         | SME  |
| 1     | Appearance            | 3.8±0.56       | 0.11 | 4.76±0.42       | 0.08 |
| 2     | Texture               | 3.56±0.75      | 0.15 | 4.84±0.366      | 0.07 |
| 3     | Taste                 | 3.56±0.69      | 0.13 | 4.68±0.46       | 0.09 |
| 4     | Flavour               | 4.13±0.68      | 0.13 | 4.64±0.54       | 0.10 |
| 5     | Colour                | 3.64±0.62      | 0.12 | 4.8±0.36        | 0.07 |
| 6     | Overall acceptability | 3.68±0.61      | 0.12 | 4.76±0.4        | 0.08 |

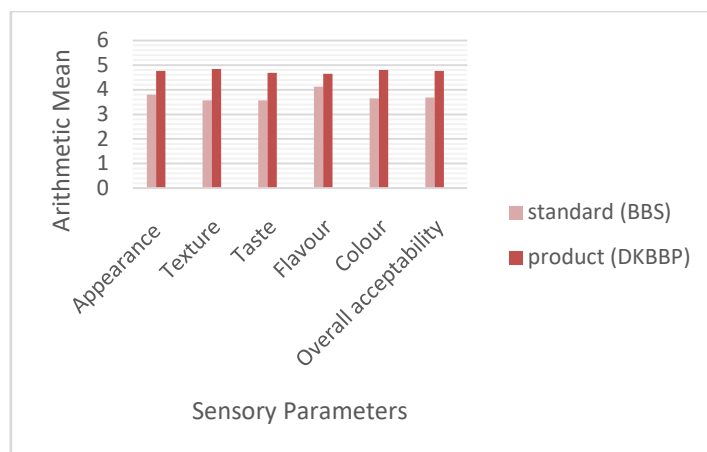
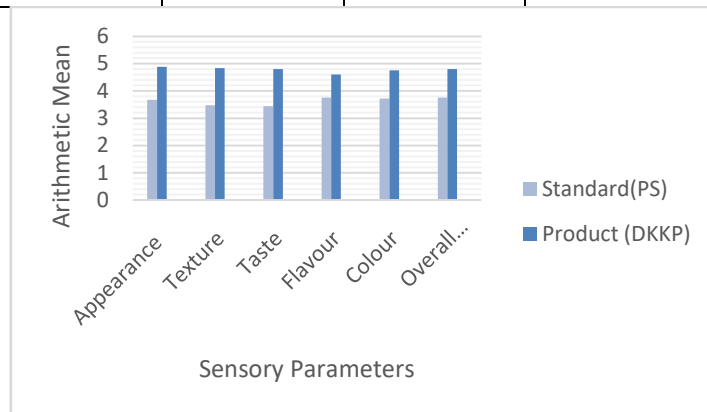


Table-6 Sensory Parameters of Pudding

| Sl.No | Sensory parameters    | Standard (PS) |      | Product (DKKP) |      |
|-------|-----------------------|---------------|------|----------------|------|
|       |                       | Mean±SD       | SME  | Mean±SD        | SME  |
| 1     | Appearance            | 3.68±0.73     | 0.14 | 4.88±0.32      | 0.06 |
| 2     | Texture               | 3.48±0.74     | 0.14 | 4.84±0.32      | 0.06 |
| 3     | Taste                 | 3.44±0.94     | 0.18 | 4.8±0.36       | 0.07 |
| 4     | Flavour               | 3.76±0.82     | 0.16 | 4.6±0.48       | 0.09 |
| 5     | Colour                | 3.72±0.82     | 0.16 | 4.76±0.42      | 0.08 |
| 6     | Overall acceptability | 3.76±0.81     | 0.16 | 4.8±0.4        | 0.08 |



## DISCUSSION

Chen *et al.*, (2016) and Butt *et al.*, (2015) reported that carotene in *Diospyros kaki* was recorded 28.76 ug/100 g, total flavonoid showed 9.74 mg/100 g and tannin was 3.9 mg/100 g respectively. In the present study, phytoconstituents were qualitatively analyzed in *Diospyros kaki*. It showed the presence of flavonoid, tannin, saponin and carotenoid and it was absence with alkaloids

Kondo *et al.*, (2004), Yaqub *et al.*, (2016), reported that antioxidant concept in food could be defined as the capacity of any substance that delays or inhibits the oxidation of substrates *Diospyros kaki* is a fruit with higher antioxidant capacity because of its high content of phenolic compounds (especially tannins), carotenoids, and water-soluble vitamins, such as vitamin C. Several studies have shown that the antioxidant potential and of Persimmon is much higher (=406 µmol Trolox/g) when compared to other fruits such as apples (=110 µmol Trolox/g) blueberries (=187 µmol Trolox/g), or strawberries (≈163 µmol Trolox/g). In the present study antioxidant activity of *Diospyros kaki* against DPPH assay was determined. It showed that the antioxidant activity of *Diospyros kaki* as 55.0, 47.5, 41.34, 38.6, and 35.0 mg TE/100g respectively. It has the highest antioxidant capacity as 41.34 mg/TE 100g



Achiwa *et al.*, (1997) and Ozen *et al.*, (2004) reported that *Diospyros kaki* is prominent for its nutrition comprising 0.58 % protein, 0.19% total lipids, 18.6% total carbohydrates and 7.5 mg total dietary fiber respectively. In the present study, *Diospyros kaki* was analysed for its nutritional composition. It showed protein 1g, carbohydrate 38.5g, fat 0.55g, and dietary fiber 0.7g.

Antibacterial activity of *Diospyros kaki* was tested in the study, against the pathogenic bacteria *Bacillus cereus*, *Enterococcus*, *E. coli*, and *Klebsiella*. After incubation, the plates are examined and the diameter of the zones of inhibition was measured. The clear zone of inhibition represented the resistance of the sample for selected bacterial species. The *Diospyros kaki* sample showed zone of inhibition against the bacteria *Enterococcus* and *klebsiella* as 9 mm and 8 mm respectively. In the present study *Diospyros kaki* also induced to formulate products such as Kesari, Jaggery shell, Milkshake, Button badhusha and Pudding, these were highly acceptable by the panel members when compared with the standard products. So, the product formulation with *Diospyros kaki* is possible and acceptable.

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## Conclusion

The present study concluded that the *Diospyros kaki* is rich in nutrients, phytochemicals and antioxidant potential that are helpful in quenching free radicals, decreasing cardiovascular risk factors and reducing the risk of diabetes mellitus along with effectiveness against cancer. The product formulation with this sample is also possible and highly acceptable. So, it can be recommended for all age groups to eradicate human illness.

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