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Investigating Fresh and Dried Okra (Hibiscus Esculentus) for their Physico-Chemical and Antioxidant Properties: A Comparative Study

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Abstract: ***This study aimed to determine and compare the proximate composition and antioxidant assays of fresh and dried okra pods and seeds. The okra mucilage extracted from the okra fruit was evaluated for the antioxidant properties. The results of this investigation indicate that both fresh and dried okra seeds contain higher protein (19.20%) and lipid (12.72%) content in comparison to that of protein (5.43%) and lipid (8.19%) contents in okra pods. All the antioxidant assays in methanol indicated that both fresh and dried okra seeds showed higher DPPH reducing power, total phenolic content and FRAP activity compared to that of pods. The results of the functional properties indicate that okra mucilage exhibited good WAC (g water/g dry sample weight), OAC (1.58 g oil/g dry sample weight) and EC (46.87%), thus it can be acceptable alternative for fat and good water absorbing additive in different food formulations.***
KeyWords: Okra, mucilage, Okra pod, antioxidant activity, Okra seed.

I. INTRODUCTION

Plant species used as food must be diversified to meet challenging demands of nutritionally balanced food for the world's increasing population and relieve the intense pressure on land use and natural resources (Hughes, 2009). Okra (Abelmoschus esculentus moench) a native plant from Africa (commonly known as Lady finger/Bhindi) belongs to Malvaceae family and is one of the most important vegetables widely grown in India for its tender fruits and young leaves due to their organoleptic qualities. Moreover it is easy to cultivate and grows well in both tropical and temperate zones and is thus widely distributed. Okra is a hot weather, tropical, low land crop, susceptible to drought and low night temperatures. Okra, originally an Indian plant, is now grown in many other areas of the world including the Middle East, Africa and the Southern states of the USA. Okra is cultivated for its fibrous fruits or pods containing round, white seeds. Okra is said to be very useful against genito-urinary disorders, spermatorrhoea and chronic dysentery (Nadkarni, 1927). Its medicinal value has also been reported in curing ulcers and relief from hemorrhoids (Adams, 1975). In West Africa, the plant is widely cultivated because the leaves can also be consumed and the stem is used for fiber and rope. The fruits are used in both fresh and dried forms, the latter being common in the Sahel (Siemonsma ; 1982). In the African context, okra has been called as "a perfect villager's vegetable" because of its robust nature, dietary fibers and distinct seed protein balanced in both lysine and tryptophan amino acids (unlike the proteins of cereals and pulses) However, okra has been considered a minor crop and until recently no attention was paid to its improvement. Although extensive information is available on okra proximate, the antioxidant properties have been rarely investigated. Recently, polyphenolic content of okra seeds was reported (Shui and Peng, 2004; Arapitsas, 2008). According to (Manach et al., 2005), oil concentration of okra seeds from Greece was found to be 15.9 to 20.7%, depending on the extraction method. The oil was found to contain a high level of linoleic acid (up to 47.4%) and tocopherols isomers. (Savello et al., 1980) also reported that okra seed oil is a rich source of linoleic acid, a polyunsaturated fatty acid essential for human nutrition. Nevertheless, in spite of considerable investigation of the oil and its qualities during the period from 1930 to the present, the potential of okra seed has never been realized.

There are four known domesticated species of Abelmoschus. Among these, A. esculentus (common okra) is most widely cultivated in South and East Asia, Africa , and the southern USA. Like soybean oil, okra seed oil is rich (60 to 70%) in unsaturated fatty acids (Crossly and Hilditech; 1951). A. moschatus, is cultivated for its seed, which is used for ambretee in India and several animism practices in south Togo and Benin. The utilization of mucilage gums depends on their unique functional properties, such as viscosity, emulsifying and foaming properties, gelation and water binding as well as on their bio-active role in the prevention or treatment of certain diseases. Mucilage and gums are known as rich sources of polysaccharides since ancient times.

They are widely used in the pharmaceutical & food industries as thickeners, water retention agents, emulsion stabilizers, suspending agents, binders etc. Apart from their role in finished medicinal products, newer uses have been found in the preparation of cosmetics, textiles and paper industry. The main components of this mucilage are galactose (25%), rhamnose (22%), galacturonic acid (27%) and amino acids (11%) (Sengkhamparn et al., 2009).

Okra pods specially when heated produce more sticky mucus. This mucilage has a good potential for pharmaceutical applications such as diluents binder, pharmaceutical excipients over synthetic excipients, disintegrant in tablets, thickeners in oral liquids, protective colloids in suspensions, film forming agents in transdermal and periodontal films and gelling agents in gel base for topical application due to ease of application for better percutaneous absorption. The okra fruit rhamnogalacturonans polysaccharide component show increased cell proliferation. (Savello et al; 1980), showed potential application of okra mucilage as a plasma replacement or blood volume expander. Natural gums or mucilage are sometime preferred due to their low cost, availability and low toxicity (Baveja et al; 1988). Abelmoschus esculentus (L) Moench commonly known as okra is rich in water extractable polysaccharides that can give high viscosity at very low concentrations (Onunkwo & Mba;1996). Characterization of okra polysaccharide reveal that hot water or buffer extracted fractions were rich in galactose, rhamnose and galacturonic acid (Sengkhamparn et al.,2010); (Whistler & Conrad; 1954). Due to their thickening properties, okra gum polysaccharides are being used as fat substitute in chocolate bar cookies (Romanchik; et al 2002), egg white substitute (Costantino & Romanchick-Cerpoviez, 2004), and in frozen dairy products (Romanchik et al; 2006). Previous investigations into the composition and properties of okra mucilage have been reviewed by (Be Miller et al; 1993). Various workers have given different compositions of the mucilages. Whistler and Conrad found okra mucilage to be an acidic polysaccharide consisting of galactose rhamnose and galactouronic acid. The utilisation of mucilage gums depends on their unique functional properties, such as viscosity, emulsifying and foaming properties, gelation and water binding as well as on their bio-active role in the prevention or treatment of certain diseases. Mucilage and gums are known as rich sources of polysaccharides since ancient times. They are widely used in the pharmaceutical & food industries as thickeners, water retention agent, and emulsion stabilizers, suspending agents, binders etc. Apart from their role in finished medicinal products, newer uses have been found in the preparation of cosmetics, textiles and paper industry.

The present study was therefore carried out to a) study physicochemical and antioxidant properties of fresh okra pods and seeds b) study the effect of drying on physicochemical and antioxidant properties of okra pods and seeds and c) study the functional properties of okra mucilage. In addition the study proposes more investigation improve the taste of fat-free okra gum cookies. In order to maintain the flavor and aftertaste of the original chocolate cookies, lower fat replacement of 25% to 50% may be more convenient than replacing the whole fat contents in chocolate cookies. Fat replacement of 50% and higher seems to constitute a taste altering problem and therefore more thorough research is needed to fix this problem.

II. EXPERIMENTAL SECTION

A. Materials

The soft and mature okra, *Hibiscus esculentus* Moench, (5-10 cm in length) were purchased from a local market Hazratbal Srinagar, J & K India. Okra pods were cut, seeds were removed before extraction. Methanol (99%), HCl (37%), ammoni, DPPH were all Sigma Aldrich products and were used as received. Tripply distilled water was used in all the experiments. All the experiments were repeated thrice to check reproducibility.

B. Methods

1) *Proximate Analysis:* The percentage moisture, ash, protein, fat and crude fiber content of okra pods and seeds were evaluated as per standard procedure of AOAC (2005).

C. Moisture Content

One of the standard reference methods for moisture determination is the oven drying method (AOAC 2005, method 950.46). The petridish and lid were dried in the oven at 105ºC for 3 hours and transferred to a desiccator to cool. About 8-10 g of pods or seeds was weighed accurately to the dish. The petridish with the sample was placed in the hot air oven (Model: Narang Scientific Works, Pvt. Ltd., New Delhi-144) at 100-105ºC for 16-18 hours. After drying, the petridish were transferred to the desiccator to cool. The dish and its dried sample were reweighed until the weight was constant. The results were calculated according to the equation

$$\text{Moisture}(\%) = \frac{W_1 - W_2}{W_1} \times 100 \qquad (1)$$

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here: W1= Weight (g) of sample before drying

W2= Weight (g) of sample after drying

D. Fat Content

A prerequisite for the extraction of fat is the drying of the product as described under moisture determination. In a classical soxhlet extraction, the sample is extracted many times by reflux with a solvent such as petroleum ether; the solvent is evaporated and the extracted fat is weighed (AOAC, 960.39). Flask and lid were placed in the oven for 3 hours to ensure that the weight of the flask became stable. About 3-5 g of moisture free sample was weighed to paper filter and wrapped. Sample was then taken in to extraction thimble and transferred to Soxhlet apparatus (Model). About 50 ml of petroleum ether was filled into the flask (Canister) and taken to the heating mantle. Soxhlet apparatus was connected, water turned on and heating mantle was switched on. The sample was heated for 16 hours at heat rate of 2-3 drops/sec. Solvent was evaporated by using condenser. The flask was kept in air oven maintained at 90ºC for 30 minutes until the residual solvent completely evaporated. After drying, the bottle was transferred to desiccator to allow it to cool. The bottle and its dried content were reweighed. Results were evaluated through the following equation

$$\text{Fat (\%)} = \frac{\text{Weight of oven dried residue}}{\text{Weight of sample}} \times 100 \quad (2)$$

E. Ash Content

For the ash determination the samples were ground to homogeneity and dried at 100-105ºC the same method used for moisture determination. The crucibles were placed in the furnace at 550ºC to ensure the impurities on the surface of crucible were burned off. The crucible were then cooled in a desicator and weighed. 5 g of moisture free sample was accurately weighed in the crucible and heated over low Bunsen flame with lid half covered. When the fumes were no longer produced, the crucible was placed in the muffle furnace (Model: Narang Scientific Works, Pvt. Ltd., New Delhi-101) and heated to about 550 ºC for 5-6 hours. After cooling down in a desicator, the sample weight and the ash content were calculated. Results were evaluated according to equation 3

$$\text{Ash(\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100 \quad (3)$$

F. Crude Fiber Content

For the determination of crude fiber about 2 g of fat free sample was accurately weighed and transferred into beaker containing 200 ml of 1.25 % H_2SO_4 and placed on a heater fitted with a regulator. After boiling for 30 minutes the solution was filtered. Residues were washed with hot water and transferred to same beaker. Then the residue was treated with 200 ml of 1.25% NaOH and boiled. After 30 minutes the solution was filtered, washed and then transferred to crucible with the help of 10-15 ml distilled water. Crucible containing residue was dried at 100ºC to a constant weight and burned in muffle furnace at 550ºC for 5-6 hours. The sample was cooled and weighed. Results were expressed as shown in equation 4

G. Calculation

$$\text{Crude fiber(\%)} = \frac{\text{(wt. of crucible + dried residue before ashing) - (wt. of crucible + dried residue after ashing)}}{\text{Wt. of sample taken}} \times 100 \quad (4)$$

H. Protein Content

The method used for the determination of protein id the Kjeldahl method, in which all the nitrogen in the sample is reduced to NH_3 (Ammonia) by heating in acid with a catalyst (AOAC 981.10). About 2 g of sample was digested with 20 ml of concentrated Sulphuric acid (H_2SO_4). A Kjeldahl catalyst containing 5 parts of potassium sulphate mixed with 1 part of copper sulphate was added to hasten digestion. A flask was prepared with the chemicals except the sample as blank. After digestion, sample was transferred to 250 ml volumetric flask and volume made up to mark. From 250 ml, 10 ml was taken into protein distillation unit (Plate-21) for distillation. Liberated ammonia after the addition of 40% Sodium Hydroxide (NaOH) was absorbed by boric acid solution containing Tashiro's indicator (4% boric acid, methyl red, bromocresol green) and titrated against N/50 HCL. Results were expressed as shown in Eq. 5

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$$\text{Protein (\%)} = \frac{(A-B) \times N \times 14.007 \times 6.25}{\text{Weight of sample}} \times 100 \qquad (5)$$

Where

A = Volume of HCl used in sample titration
B = Volume of HCl used in blank titration
N= Normality of HCl
W= Weight (g) of sample
14.007= Atomic wt. of nitrogen
6.25= Protein-nitrogen conversion factor

I. Extraction of Mucilage from Okra Pods

Okra gum was extracted from the pods of Okra fruits. The fruits were cleaned, washed, sliced, crushed and then macerated in distilled water for 10 hours with intermittent stirring. The mucilage was filtered through a white muslin cloth to extract the gum and acetone was added to precipitate the extracted gum. The gum was then filtered under vacuum to remove acetone and dried in a desiccator (5, 7).

Okra fruit
↓
Cleaning of fruit
↓
Removal of seeds
↓
Slicing of pods
↓
Dipping in dist. Water (10hr.)
↓
Filtration
↓
Centrifugation of extract
↓
Drying(45◦C)
↓
Mucilage

Flow diagram of okra mucilage extraction

J. Antioxidant Activity Assay of Okra Seeds and Pods

1) *DPPH Scavenging Activity:* The scavenging activity of 1, 1-dihpenyl-2-picrylhydrazyl (DPPH) radical was measured according to the method of Joyeux, Lobstein, & Mortier;(1995) with minor modification. Briefly, different concentrations of the extract of okra pods and seeds (100 µl) were added to 1.0 ml of a 0.01% methanolic solution of DPPH. Absorbance at 517 nm was measured after 30 min. The % inhibition was calculated against a control and compared to BHT as standard.
The relative inhibition of the antioxidants against DPPH was calculated according to the following equation:

$$\% \text{ inhibition} = A_{\text{control } 517} - A_{\text{sample } 517} / A_{\text{control } 517} \times 100$$

Where $A_{\text{control } 517}$ is the absorbance of the control and $A_{\text{sample } 517}$is the absorbance of the extract or α- tocopherol.

2) *Reducing Power:* The reducing power was determined based on method described by Yen and chen; (1995) with certain modifications. Different concentrations of the okra pods and seeds separately (100 µl) were mixed with 0.2 M sodium phosphate buffer pH 6.6 (2.5 ml) and 1% (w/v) aqueous potassium ferricyanide (2.5 mL). The mixture was incubated at 50ºC

for 20 min. 10% (w/v) of trichloroacetic acid (2.5 mL) was added to the mixture, which was then centrifuged at 3000 x g for 10 min. The supernatant (2.5 mL) was diluted with deionized water (2.5 mL) and 0.1% (w/v) ferric chloride (0.5 mL) was added. The absorbance was measured at 700 nm against a blank and compared to BHT as standard.

3) *Total Phenolic Content:* Total phenolic content were determined with Folin–Ciocalteau reagent. The varying concentration of the supernatant (200 µl) was added to 2.5 ml of freshly prepared Folins reagent (1:10 v/v with water). The mixture was allowed to equilibrate for 5min. and then mixed with 2 ml of 75 g/l sodium carbonate solution. After incubation at room temperature for 90 min., the absorbance of the mixture was read at 760nm using the respective solvent as blank. The results were expressed as milligrams of gallic acid equivalents per gram (mg GAE/g) of lotus stem. Determination of the ferric reducing antioxidant power (FRAP):

The antioxidant capacity of methanolic extracts of okra pod and seed samples were estimated according to the procedure described by Benzie and Strain; (1996) as modified by Pulido et al;(2000). The FRAP method reagent was prepared as a mixture of 10 ml of 300 mM acetate buffer (PH 3.6), 1ml of 10 mM TPTZ , 40 mM hydrochloric acid solution and 1ml of 20 mM $FeCl_3$ solution. The FRAP reagent once prepared was immediately incubated for 10 minutes at 37 ^{0}C , then 3 ml of the reagent was added to 0.1 ml of the extracts of different fractions of okra pod and seed. The reaction mixture was incubated for 4 minutes at room temperature and the absorbance at 593 nm was measured using a spectrophotometer (Hitachi U-2900).

K. Functional Properties of Okra Mucilage

1) *Water Absorption Capacity:* Water absorption capacity (WAC) of the okra mucilge was determined as described by Mishra and Rai; (2006) in triplicate using 2.5% okra mucilge suspensions at a temperature of 25 °C. Dried okra mucilge samples (0.125 g) were weighed into pre-weighed centrifuge tubes and 5 mL of distilled water was added. The samples were heated at the above temperature for 1 h with constant shaking and thereafter centrifuged for 15 min at 1500 g. The free water was decanted and the tubes allowed to drain for 10 min at a 45° angle. Subsequently the sample tubes were weighed, and the gain in weight was used to calculate the water absorption capacity.
   WAC = $(W_3 – W_{2)}/W_1$
   W_1= Weight of sample
   W_2= Weight of empty centrifuge tube
   W_3= Weight of tube after centrifugation and decanting
2) *Oil Absorption Capacity:* Okra mucilge (2.5 g dry weight basis (dwb) was mixed with 20 ml oil (Dalda-Andheri (E), Mumbai) in a pre-weighted centrifuge tube and then stirred for 2 min on vortex mixer and allowed it to stand for 30 min at 25°C, centrifuged at 3000 × g for 10 min at 10 °C (Eppendorf 5810 R, Germany) and the supernatant was decanted. Gain in weight was expressed as oil absorption capacity (Anderson *et al.*, 1969).
   WAC = $(W_3 – W_{2)}/W_1$
   W_1= Weight of sample
   W_2= Weight of empty centrifuge tube
   W_3= Weight of tube after centrifugation and decanting

III. RESULTS AND DISCUSSIONS

A. Proximate Composition

The proximate composition of fresh and dried okra (H. esculentus L.) pod and seed used in the experiment are shown in Table 1 and 2. The data of fresh okra pod and seed reveals that okra pod had higher moisture (84.01%) and ash content (1.27%) while okra seed recorded higher protein (5.43%) and fat content (8.19%). The percentage of moisture content revealed that the fruit with (84.01%) as the highest moisture content than seeds (81.27%).The high moisture content in okra fruits is in agreement with high moisture content in okra pods at 89 g/100 g as reported by Goplana et al; (2007).

The highest protein and fat content in okra seed proved that protein and fat is more available in the seeds than the fruits. The proximate composition of oven dried okra pod and seed (Table4) showed that okra seed had recorded higher moisture (7.89%), protein (19.20%) and fat (12.72%) contents while, pod showed higher ash content (9.61).

Table 1: Proximate composition of Fresh Okra fruits and seeds

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Component	Okra Fruits	Okra Seeds
Moisture	84.01 ± 0.94	81.27 ± 0.39
Protein	2.29 ± 0.34	5.43 ± 0.08
Fat	0.26 ± 0.06	8.19 ± 0.96
Ash	1.27 ± 0.10	1.05 ± 0.54

All values are mean ± standard deviation of three replicates (n=10).

Table 2: Proximate composition of Oven dried (60 ^{o}C) Okra fruit and seeds

Component	Okra Fruits	Okra Seeds
Moisture	7.34 ± 0.47	7.89 ± 0.64
Protein	14.49 ± 0.57	19.20 ± 0.35
Fat	2.02 ± 0.25	12.72 ± 0.22
Ash	9.61 ± 0.36	4.98 ± 0.18

All values are mean ± standard deviation of three replicates (n=10).

B. Assay for Antioxidant Activity

1) DPPH: The antioxidative potential of the extracts was measured due to their radical scavenging effects by measuring changes in absorbance of DPPH radical at 517nm. When DPPH is paired with protonating substance such as an antioxidant, the radical is scavenged and the absorbance is reduced that results in discolouration i.e., purple colour changes to yellow. In order to evaluate the antioxidant activity of the extracts of fresh and dried pod in methanol, the radical scavenging activity based on DPPH assay was determined and the results were observed and are shown in table below for the fractions. The percentage increase in concentrations of the extract was from 80 to 120 µl. The % inhibition of fresh and dried pod at different concentrations in aqueous methanol was 35.30, 44.53, 51.21 for fresh pod and 41.08, 73.11, 75.27 for dried pods. The results reveals that fresh pod showed less and dried pod showed more in comparison to that of α-tocopherol (56.28 %), the known antioxidant at the same concentration. The % inhibition of fresh and dried seed at different concentrations (80 to 120 µl) in methanol was 91.66, 95.74, 98.00 for fresh seed and 92.00, 93.65, 95.40 for dried seed. The results reveal that both fresh and dried seed showed more in comparison to that of α-tocopherol (56.28 %), the known antioxidant at the same concentration.

Table 3:- DPPH radical scavenging activity

Treatment	% inhibition		
	80 µl	100 µl	120 µl
Fresh Pod	35.30 ± 3.75	44.53 ± 2.24	51.21 ± 2.60
Dried Pod	41.08 ± 0.98	73.11 ± 0.57	75.27 ± 0.93
Fresh seed	91.66 ± 2.11	95.74 ± 0.98	98.00 ± 3.13
Dried Seed	92.00 ± 1.63	93.65 ± 1.5	95.40 1.46

All values are mean ± standard deviation of three replicates (n=10).

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C. Reducing Power

The reductive ability of okra pod and seed extracts in different methanol was investigated by causing reduction of Fe^{3+} to Fe^{2+} through donation of an electron, causing the test solution to change color from yellow to green or blue based on the reducing ability of substances. The reducing capacity might be due to their hydrogen donating ability (Shimada; *et al* 1992). The data reveals that the reducing power of extract increased in a dose dependent manner. Higher reducing power of the methanolic extract might be due to the greater hydrogen donating capability.

The percentage increase in concentrations of the extract was from 100 to 300 µl. The % inhibition of fresh and dried pod extracts at different concentrations in aqueous methanol was 56.2, 65.4, 76.6 for fresh pod and 13.13, 16.37, 20.3 for dried pods. The results indicated that drying decreased the reducing power of okra pods and the % inhibition of both fresh and dried okra pod extracts was less in comparison to that of BHT (98.05%), the known antioxidant at the same concentration.

The % inhibition of fresh and dried seed at different concentrations (100 to 300 µl) in methanol was 91.4, 93.7, 95.8 for fresh seed and 17.25, 19.90, 23.00 for dried seed. The results indicated that drying decreased the reducing power of okra seeds and the % inhibition of both fresh okra seed extracts were close to that in comparison to BHT (98.05%), and dried okra seed extracts much less in comparison to that of BHT (98.05%) the known antioxidant at the same concentration.

Table 4:- Reducing power (%inhibition)

Treatment	% inhibition		
	100 µl	200 µl	300 µl
Fresh pod	56.2 ± 0.93	65.4± 0.45	76.6 ± 0.87
Dried Pod	13.13 ± 0.09	16.37 ± 0.74	20.3 ±0.93
Fresh seed	91.4 ± 0.44	93.7 ± 0.04	95.8 ± 0.76
Dried Seed	17.25 ± 0.08	19.90 ± 0.05	23.00 ± 0.53

All values are mean ± standard deviation of three replicates (n=10)

D. Total Phenolics

Phenolic compounds were considered as a major group of compounds that contributed to the antioxidant activity of quince. Phenolic compounds are secondary metabolites widely distributed in the plant kingdom. More than 4000 phenolic compounds (such as phenolic acids, flavonoids or tannins) have been found in vascular plants, where they prevent free radical damage to proteins, carbohydrates, lipids and DNA caused by UV radiation from the sun (Vinson *et al* ; 2001**).** The results of the total phenolic content of the present investigation are shown in table 8 . Total phenolics in different extracts of fresh and dried okra pod at different concentrations (100µl, 200 µl and 300 µl) were 15.23, 18.54, 24.56 GAE/100g for fresh pod and 20.00, 26.33, 27.11 GAE/100g for dried extracts in methanol. Total phenolics in different extracts of fresh and dried okra seed at different concentrations (100µl, 200 µl and 300 µl) were 45.45, 51.03, 57.29 GAE/100g for fresh seed extracts and 63.89, 65.09, 69.52 GAE/100g for dried extracts in methanol. The results of the present investigation shows that both fresh and dried seed extracts exhibited higher phenolic contents than fresh and dried pod extracts. Phenolic acids and flavonoids have been reported to be the main phytochemicals responsible for the antioxidant capacity of fruits and vegetables.

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Table 5. Total phenolic content (GAE/100g)

Treatment	GAE/100g		
	100 µl	200 µl	300 µl
Fresh Pod	15.23 ± 0.045	18.54 ± 0.011	24.56 ± 0.023
Dried Pod	20.00± 0.77	26.33 ± 0.54	27.11 ± 0.67
Fresh seed	45.45 ± 1.17	51.03 ± 1.04	57.29 ± 1.23
Dried seed	63.89±0.39	65.09±0.74	69.52±0.89

All values are mean ± standard deviation of three replicates (n=10)

E. Ferric Reducing Antioxidant Power (FRAP)

The Ferric reducing ability of okra pod and seed polyphenols was determined by the method described by Benzie and Strain; (1996), to measure reducing power in plasma, but the assay subsequently has also been adapted and used for the assay of antioxidants in botanicals. The reaction measures reduction of ferric 2, 4, 6-tripyridyl-s-triazine (TPTZ) to a colored product. The FRAP values obtained from different fractions are shown in table 9. The FRAP values of the fresh and dried okra pod extracts were 4.8, 5.1, 6.8 µmol/l for fresh and 4.13, 4.79, 5.64 µmol/l for dried okra pod extracts in methanol. The FRAP values of the fresh and dried okra seed extracts were 36.7, 47.4, 53.20 µmol/l for fresh and 29.89, 43.67, 48.85 µmol/l for dried okra seed extracts in methanol. It is clear from the data that both fresh and dried seed extracts at different concentrations (100µl, 200µl and 300µl) had highest value for in comparison to the both fresh and dried okra pod extracts in methanol.

Table 6:- FRAP(µmol/L) activity

	µmol/L		
	100 µl	200 µl	300 µl
Fresh Pod	4.8 ± 0.9	5.1± 0.03	6.8 ± 0.07
Dried Pod	4.13 ± 0.04	4.79 ± 0.06	5.64 ± 0.01
Fresh seed	36.7 ± 1.0	47.4 ± 1.3	53.20 ± 1.06
Dried Seed	29.87 ± 0.87	43.67 ± 0.98	48.85 ± 1.11

All values are mean ± standard deviation of three replicates (n=10)

F. Water and Oil Absorption Capacity

The results of the water and oil absorption capacity of the okra mucilage are presented in table10. The okra mucilage showed water absorption capacity (WAC) value of 3.94 g water/g dry sample and oil absorption capacity of 1.586 94 g oil/g dry sample weight of mucilage. The results indicated that okra mucilage exhibited higher value of water absorption capacity compared to the oil absorption capacity

The emulsion capacity of the okra mucilage is presented in Table 7. The okra mucilage exhibited 46.875 % of emulsion capacity. The emulsion capacity is associated with the capacity of mucilage to act as a thickening agent due to its ability to increase the viscosity of the aqueous phase in an O/W emulsion, thus hindering movement of the oil droplets of the dispersed phase.

Table 7:- Functional properties of okra mucilage.

Sample	WAC (gwater/gdry samplewt.)	OAC (goil/gdry samplewt.)	EC (%)
Okra mucilage	3.94 ± 0.97	1.586 ± 0.86	46.875 ± 1.02

All values are mean ± standard deviation of three replicates (n=10)

G. Mucilage Yield

Regarding the yield of mucilage extracted from okra pods, it was observed that from 600g of fresh cleaned and sliced okra pods, 7.2g of mucilage was obtained which depicts that the mucilage yield percentage is 1.2% .The yield percentage depends on the extraction procedure followed. Maximum yield of mucilage was obtained only soaking for 6 hrs before filtration as suggested by (P.Nazni and P.Vigneshware; 2014).

Weight of clean okra pods=600 g

Mucilage extracted=7.2 g

Yield=1.20%

IV. CONCLUSIONS

Okra (*Hibiscus esculentus),* which is one of the most important vegetable widely grown in India for its tender fruits was evaluated for the proximate composition, antioxidant assay and functional properties in both fresh and dried forms. The results of this investigation indicate that both fresh and dried okra seeds contain higher protein (19.20%) and lipid (12.72%) content in comparison to that of protein (5.43%) and lipid (8.19%) contents in okra pods. The antioxidant assays indicate that okra fruit and seed is a good source of phytochemicals. Okra possesses high amounts of total flavonoids as well as moderate amounts of total phenolics, making it a good source of natural antioxidants. Thus based on the antioxidant activity, both okra pod and seed extracts should be considered as an additive to other products for the oxidative protection. All the antioxidant assays in methanol indicated that both fresh and dried okra seeds showed higher DPPH, reducing power, total phenolic content and FRAP activity compared to the pods. The results of the functional properties shows that okra gum is an acceptable replacement for fat and good water absorbing additive in different food products. Further investigation of individual compounds, there in vivo antioxidant activities and in different antioxidant mechanisms is needed.

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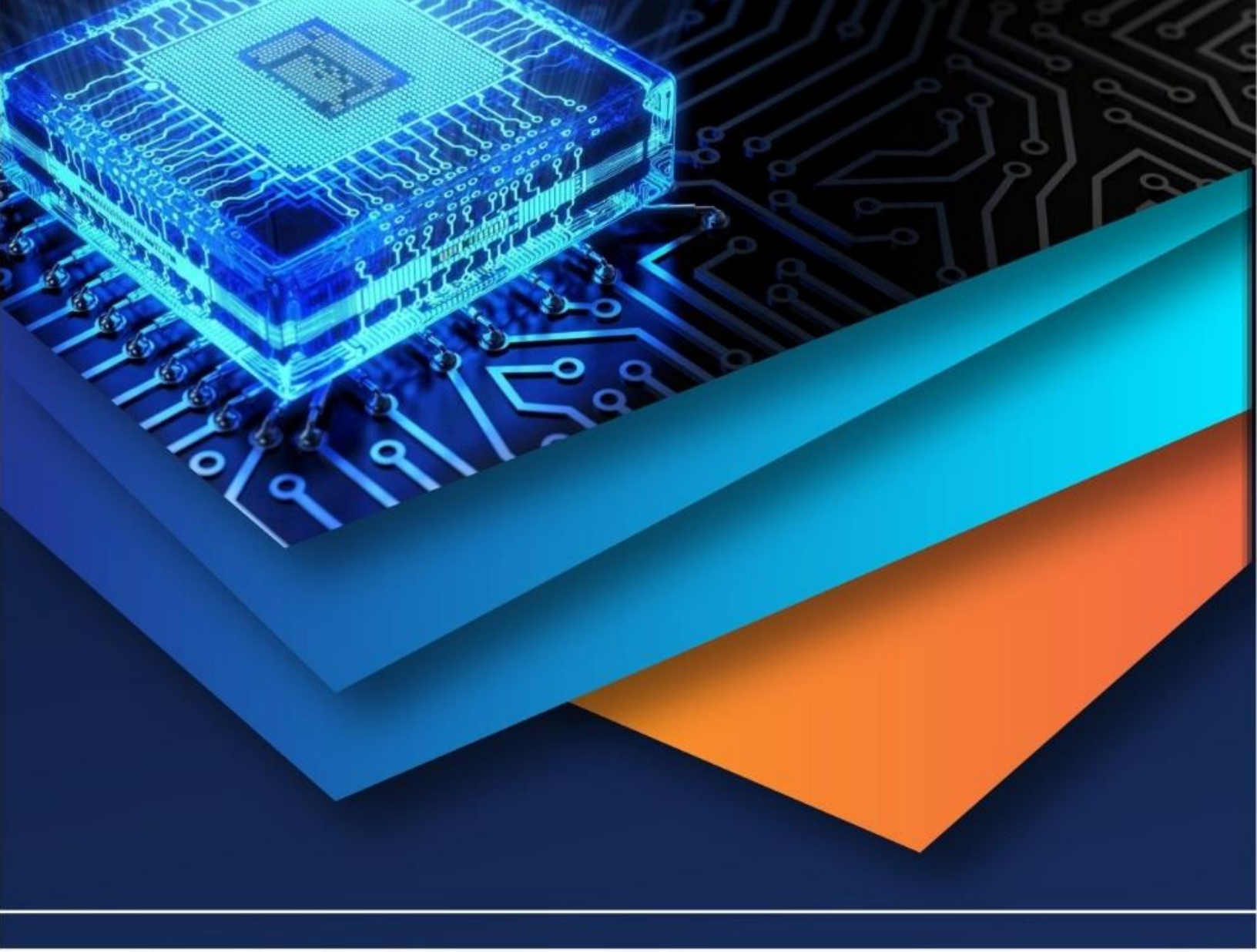

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