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Influence of Processing on Physicochemical, Nutritional and Phytochemical Composition of *Ficus carica* (Fig) Fruit.

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ABSTRACT

In this study, the effects of three different processing methods, sun drying (SD), freezing (FRS), microwave drying(MDS) and fresh fruits for Ficus carica in terms of proximate, physical, nutritional and phytochemical composition have been studied. These local variety of fruits were selected from Himachal, (India). These fruits were obtained fresh, cleaned and washed prior to selected techniques. Analysis of data showed that drying techniques improved the protein, carbohydrates, ash content, dietary fiber (neutral detergent fiber, acid detergent fiber, cellulose, hemicelluloses and lignin), total phenol, antioxidant activities and mineral content. Drying destroyed total flavonoids, tannin, alkaloid and anthocyanin content. The result obtained in this research is clearly indicated that some processing methods are proved good for more nutrient retension as compared to others. This study aim to make consumers aware of the effects of processing methods on nutritional value of fruits and that they should become accustomed to eating seasonal fresh fruits

Keywords: Sun drying, freezing, microwave drying and Ficus carica.

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INTRODUCTION

Many studies have demonstrated that daily intake of fruits is associated with the diminution of chronic degenerative diseases (Dragsted et al.1993). But, in another investigations, it has been also, observed that fruits has medicinal properties that may reduce the risk of many diseases (Lodhil et al.1969; Vinson, 1999). Many types of fruits might be grown in India particularly, underutilized fruits (Gajana and Godwa, 2010). Ficus carica is commonly referred as “Fig" (Jander and Machado, 2008). Ficus carica L., a deciduous tree belonging to the Moraceae family,is one of the earliest cultivated fruit trees. Ficus carica is cultivated in Southwest Asia and also in India commercially few centers near Pune (Maharashtra) and Anantpur district (South India) but, mostly grown in Uttar Pradesh, Mysore, Punjab and Himachal Pradesh (The Wealth of India, 2001). It is rich in vitamins, mineral elements, water, and fats and highest plant sources of calcium and fiber (Vinson, 1999). In the presenting study, the processing of Ficus carica need to be done to increase their shelf life. The purpose of the research was to investigate the effect of processing methods (sun drying, freezing and microwave drying) on physical, nutritional and phytochemical composition of fresh selected whole Ficus carica fruits.

MATERIAL AND METHODS

Sample selection: Ripened fresh fruits (15gm individual packages for different selected processing methods) were collected from orchard of a local cultivar of Ficus carica in Bilaspur (Himachal Pradesh), from January 2014- June 2015.

Sample Preparation

Sorting – Fresh, black and non insected fruits were collected and discolored, decayed fruits were discarded before washing.

Washing-The whole selected fruits were washed three times with distilled water to remove unwanted dirt particles and air dried to remove extra water and after drying fruits were then weighed and divided equally in four batches like fresh, sun drying, freezing and microwave drying.

Drying techniques-The selected fresh whole fruits were subjected to three different methods:

Sun drying – Ficus carica (15gm) fruits were distributed on the stainless steel trays and dried under direct sunlight at temperature between 25 and 30°C, for 5 days with about 36 hours of daylight, between 15 July to 20 July,2015.

Freezing- In freezing, the selected whole fresh (15gm) Ficus carica fruits were put in the lyophilized condition at -20°C freezer till weight become constant.

Microwave drying

Fresh Ficus carica (15 gm) fruits were placed in a single layer in a Pyrex petri dish and heated in an microwave oven (Sharp R-248e; 800W) for 3 minutes and 15 seconds till weight become constant. After heating, the fruit was allowed to cool at room temperature. After cooling a second time, the weight was measured to check the percent-age of weight loss.

Sample extraction- Solvent extraction was done with methanol. 1gm dried powder (for three selected treatments) and 1gm fresh fruits of Ficus carica were weighed, separately mixed with 80 per cent methanol (v/v) at a ratio 1:4 in a conical flask (wrapped with aluminum foil) and agitated at 200rpm, at 50°C with the aid of an orbital shaker (Heidolph Unimax 1010,Schwabach, Germany) for 2 hours. Mixture was filtered through a whatman filter paper No.4 and a clear solution obtained for further analysis (Emmy et al. 2009).

Physical properties- Length and width was measured by vernier calliper method (Mohsenin, 1970). And, density was measured by toluene displacement method (Mohsenin, 1986; Gezer et al. 2002).

Proximate analysis - The selected whole fruits fresh and dried under the influence of selected methods were analyzed for proximate composition (moisture, ash, fat, protein, carbohydrates, dietary fiber). Proximate analysis were analyzed in triplicates. Moisture, ash and fat content were determined by AOAC, 2000. Carbohydrates was determined by anthrone method (Hedge and Hofreiter, 1962). Protein was determined by micro-kjedahl method (AOAC,2000). Dietary fiber (cellulose, hemicelluloses and lignin) were determined by Van Soest, (1977). Mineral content were estimated by GC-MC (2008, AYUSH).

Phytochemical composition- The phenolic content in the fruit extract were determined in triplicate in gallic acid equivalent by using Folin -Ciocalteu method (Thimmaiah, 1999). Total antioxidant activity measured by Kekuda et al. (2010). Flavonoid content was determined by spectrophotometer and expressed as quercetin per 100 gm of fruit (Luximon-Ramma et al. 2002). Anthocyanin was determined by pH-differential method. And absorbance was measured at 520nm and 700nm and expressed as cynidine-3-glycoside equivalents per 100 gm of fruits (Giusti and Wrolstad, 2001). Alkaloid was estimated by Herborne,(1973). Tannins was determined by using Spectrophotometric methods (Iwuoha and Kalu 1995).

Statistical analysis-Statistical analysis were conducted by using SPSS (Statistical Program for Social Sciences,SPSS Corporation ,Chicago,IL) version 16.0 for windows. Data are represented as mean and standard deviation. All determinations were done at least in triplicate and average were calculated. Where appropriate data were subjected to statistical analysis of variance (ANOVA) to determine the significance of treatment relationship. The confidence limit used in thisstudywerebasedon 95% probability ($p<0.05$).

RESULTS AND DISCUSSION

The data contained physical properties, proximate and phytochemical composition depicted in Tables and Figures given below:

Table 1.1. Physical properties of Ficus carica

Drying method	FS	SD	FRS	MDS
Length(mm)	15.46± 0.05^{a}	14 .26±0.05^{b}	14.46±0.05^{c}	14.16±0.05^{bd}
Width(mm)	18.14±0.00^{a}	17.46±0.05^{b}	17.86±0.05^{cd}	17.16±0.05^{de}
Density(gm/cc)	0.93±0.02^{a}	0.94±0.01^{a}	0.91±0.00^{a}	0.95± 0.00^{ab}

Table 1 depicted the length of Ficus carica was ranged from ranged from 15.46 mm, 14.26 mm, 14.46 mm and 14.16 mm for fresh, sun drying, freezing and microwave drying. The width ranged from 18.14 mm, 17.46 mm, 17.86 mm and 17.16 mm for fresh, sun drying, freezing and microwave drying. Similar findings have been reported by Behzad, (2011).The result of the length and width showed that there was a significant difference ($p<0.05$) between the sample. Drying process decreased the length with decreasing the sphericity of the fruits (Milovan et al. 2011). Sample dried in microwave contained lesser length as compared to sun dried sample because of decreased more moisture content by high heating intensity in the microwave. Isik and Izli (2007) reported similar results with our study i.e. length decreased as the moisture content decreased. Freezing also showed reduction in the length due to storage period (Aleid et al. 2014). The density of Ficus carica was ranged from 0.93gm/cc, 0.94gm/cc, 0.91 gm/cc and 0.95 gm/cc for fresh, sun drying, freezing and microwave drying. Similar results were reported by Sayed et al.(2010). Result showed that density of fresh fruit was less as compared to dried because of increased density during drying process due to the variation in the mass, volume and structure of the cell wall and removal of water content (Pacco et al. 2007; Baryeh, 2002; Ratti, 1994). Density increased in microwave dried sample as compared to sun dried sample due to the constant increasing drying rate with increasing microwave output power. In microwave drying, the density of fruit increased with increased 35 per cent drying rate (Elhana, 2008). Ramaswamy and Tung (1981) reported that in frozen state of fruits, the density decreased approximately 5.2 - 6.8 per cent as compared to unfrozen state.

Table 1.2. Nutritional Composition Of Ficus Carica

Drying method	FS	SD	FRS	MDS
Moisture(%)	80 .2±0.00[a]	25.86±2.48[b]	81.0±1.97[ac]	25.43±3.23[cb]
Ash (%)	4.00±0.34[a]	4.42±0.19[a]	4.20±4.15[a]	4.30± 4.26[a]
Carbohydrates (g/100g)	16.3±0.18[a]	65.15±0.20[b]	16.0±0.03[ac]	65.18±0.08[cd]
Fat (%)	0.53± 0.08[a]	0.56±0.00[a]	0.51 ± 0.07 [a]	0.59± 0.03[a]
Protein (%)	0.53± 0.08[a]	3.01±0.09[a]	2.71 ±0.32[a]	3.18± 0.07[a]

The moisture content was determined and depicted in (Table 1.2) and it ranged from 80 per cent, 25.95 per cent, 81 per cent and 25.40 per cent for fresh, sun drying, freezing and microwave drying and there was a significant difference ($p<0.05$) between the sample. These results were consistent with the findings of (Mehmeet et al. 2009; Maha et al.2013). The low moisture content is important during storage as they can be kept for a longer time without spoilage. (Mcloughlin et al. 2003) reported that microwave energy is rapidly absorbed by water molecules and resulted, rapid evaporation of water that caused higher drying rates. Higher moisture content in freezed sample may be due to syneresis (Sae-KangandSuphantharika, 2006). The ash content of Ficus carica was ranged from 4.00 per cent, 4.42 per cent, 4.20 per cent and 4.30 per cent for fresh, sun drying, freezing and microwave drying. (Soni et al. 2014) reported similar results. Ash is the amount of mineral present in a sample or a substance. Ash content is one of the methods which are used for finding out how much minerals are present in a particular sample. The ash content was higher in sun dried sample and lower in fresh sample (Maha et al.2013). It implies that there was no much difference in the ash content after processing of the samples. High content of ash may be due to the removal of moisture content (Morris et al. 2004). The Carbohydrates content of the samples reported from 16.3 gm / 100gm, 65.15 gm / 100 gm, 16.0 gm / 100 gm and 65.18 gm/100gm for fresh, sun drying, freezing and microwave drying. Similar results have been obtained by Mehmeet et al. (2009). Microwave dried sample showed better preservation of the nutrients as compared to sun dried sample because sun drying caused reduction in the nutritional contents due to prolonged heating (Kyzlink, 1990; Clary et al.2007). The fat content ranged from 0.53 per cent, 0.56 per cent, 0.51 per cent and 0.59 per cent for fresh, sun drying, freezing and microwave drying. Similar results have been obtained by Maha et al. (2013) . In this study it was observed that the fat content increased in dried samples due to removal of moisture content, which is directly related to increase the concentration of nutrients (Morris et al.2004). (Clary et al.2007) reported consistent results that drying process increased 4.5 times fat content in fruits. The protein content was ranged from 2.98 per cent, 3.01 per cent, 2.71 per cent- and 3.18 per cent for fresh, sun drying, freezing and microwave drying. Similar results have been obtained by (Mehmeet et al.2009). According to Sikora et al. (2013) ash content decreased after freezing due to the loss of some nutrients by the presence of some enzymes in fresh fruits (Fennema et al.1975; Desrosier et al.1977; Brennan et al.1990; Morgons, 1984).

Table 1.3. Dietary Composition Of Ficus Carica

Drying method	FS	SD	FRS	MDS
NDF(%)	12.73±0.05[a]	12.83±0.05[a]	12.53±0.11[bc]	12.86± 0.05[ad]
ADF(%)	0.40±0.10[a]	0.56±0.11[a]	0.38±0.07[a]	0.60± 0.05[a]
Hemicellulose(%)	12.33±0.11[a]	12.26±0.05[a]	12.16±0.05[a]	12.30±2.17[a]
Cellulose(%)	15.91±0.05[a]	16.11±0.07[a]	15.90±0.40[a]	16.68± 0.05[bc]
Lignin (%)	1.72±0.01[a]	1.73±0.01[a]	1.70±0.01[a]	1.74±0.01[ab]

The neutral detergent fiber (NDF) of Ficus carica is depicted in (Table 1.3) and it ranged from 12.73 per cent, 12.83 per cent, 12.53 per cent and 12.86 per cent for fresh, sun drying, freezing and microwave drying. Similar results were reported by Lisa and Laura (2002). The result showed that there was a significant difference ($p<0.05$) between the sample. Drying increased the dietary fiber either may be due to reduction of the moisture content or by enzymatic break down of substances into soluble compounds (Fennema, 1976). After freezing, it reduced due to the degradation of cell wall components i.e. cellulose, hemicellulose, pectin and lignin. And, degradation of the polysaccharides tissues also caused apparent reduction in the fiber (Khan and Vincent, 1996). The acid detergent fiber (ADF) ranged from 0.40 per cent, 0.56 per cent, 0.38 per cent and 0.60 per cent for fresh, sun drying, freezing and microwave drying. The results of the ADF that there was no significant difference ($p< 0.05$) between the samples. Hemicellulose content was ranged from 12.33 per cent,

12.26 per cent, 12.16 per cent and 12.30 per cent for fresh, sun drying, freezing and microwave drying. Cellulose content ranged from 15.91 per cent, 16.11 per cent, 15.91 per cent and 15.90 per cent for fresh, sun drying, freezing and microwave drying. Similar results have been obtained by Njidaa, (2010). Lignin content was ranged from 1.72 per cent, 1.73 per cent, 1.70 per cent and 1.74 per cent for fresh, sun drying, freezing and microwave drying. Similar results were reported for ADF and lignin content by Lisa and Laura, (2002). The results of the lignin content that there was a significant difference ($p< 0.05$) between the samples. The lignin content was maximum in the microwave dried sample and minimum in freezed sample.

Table 1.4. Phytochemicals Composition- Total Phenolic Content (Tp), Total Flavonoids Content (Tf) And Antioxidant Activity (DPPH And Frap)

Drying method	FS	SD	FRS	MDS
(TP)(mg TAE/g)	4.58±0.00^{a}	4.92±0.00^{a}	4.52±0.00^{cd}	4.94± 0.01^{db}
(TF)(mg E/100g)	0.21±0.00^{a}	0.19±3.39^{b}	0.23±0.00^{cd}	0.20± 0.00^{ae}
(DPPH) (%)	73.42±0.83^{a}	75.36±1.45^{a}	71.66±1.52^{ab}	75.84± 1.67^{ac}
(FRAP) (%)	76.22±4.90^{a}	76.55±0.09^{a}	75.76±5.77^{a}	78.54±0.56^{a}

Total phenolic content is expressed as mg of tannic acid equivalents in 100 g of dried sample (mg TAE per100 g dried sample)

Total flavonoid content is expressed as mg of quercetin equivalents in 100 g of dried sample (mg QE per 100 g dried sample

The total phenol content was ranged from 4.58 mg TAE/100gm, 4.92 mg TAE/100gm, 4.52 mg TAE/100 gm and 4.94 mg TAE/100gm for fresh, sun drying , freezing and microwave drying. (Ana et al. 2011) reported similar results. Table 1.4 showed the results of the total phenol content that there was a significant difference ($p< 0.05$) between the samples. Phenolic compounds are known to act as antioxidants not only because of their ability to donate hydrogen or electrons but mainly due to their stable radical intermediates, which prevent the oxidation (Cuveliev and Berset, 1992; Maillard et al. 1996). Total phenolic content either may be increased or decreased after drying, depending not only on the cultivar, but also on the production system used, conventional or organic (Sablani et al. 2011). According to this study, it was observed that the phenolic content increased after drying due to loss of moisture (Sarsavadia, 2007) and (Slatnar et al.2011) have been obtained similar findings. Drying responsible to release the bond phenolic compounds from matrix during the breakdown of cellular constitutents (Arslan and Ozcan, 2010). Drying at low temperature resulted, reduction in the phenol content (Gupta et al. 2011) and long drying time might have destroy some phenolic compounds (Li et al. 2006). Microwave drying increased the phenolic content as compared to sun drying due to less heating duration in the microwave might have required to increased the phenolic content (Garau et al. 2007). But, in case of sun drying required large drying period for which fruit sample is exposed to the atmospheric oxygen that caused the reduction in ascorbic acid and phenolic compounds etc. (Sarsavadia, 2007). Freezing decreased the phenolic content due to either oxidation or leaching of water soluble phenolic compounds (Pupponen et al. 2003). The total flavonoid content ranged from 0.21 (mg Q E/100g db), 0.19 (mg Q E/100g db), 0.23 (mg Q E/100g db) and 0.20 (mg Q E/100g db) for fresh, sun drying, freezing and microwave drying. Similar findings were reported by Ana et al. (2011). Fresh sample contained more flavonoid as compared to dried sample because of thermal degradation of flavonoids during processing (Crozier et al.1995; Price and Rhodes, 1997). Heating may be breakdown some phytochemicals which affect cell wall integrity and caused a migration of some flavonoid component (Davey et al. 2000). Thermal degradation occurred during processing in the presence of oxygen by direct oxidation mechanism or through the action of oxidizing enzymes i.e. (PPO) polyphenoleoxidase. Degradation of flavonoid is occurred not only due to temperature and heating, it may also depend on other parameters such as pH, the presence of oxygen, and the presence of other phytochemicals in the medium (Ioannou et al. 2012). Less degradation of flavonoid occurred in microwave drying as compared to sun drying due to increased microwave output power (Mechlouch et al. 2015).The flavonoid content of fruits decreased at lower temperature during heating (Chen, 2011). Flavonoid content (flavonols) increased after freezing due to the presence of 35 per cent more quercetin derivatives in frozen fruits as compared to fresh, which led to increase the extractability and hydrolysis of quercetin (Hakkinen et al. 2000). Antioxidant activity, 2,2-diphenyl-1-picrylhydrazyl (DPPH) ranged from 73.42 per cent,75.36 per cent,71.66 per cent and 75.84 per cent for fresh, sun drying, freezing and microwave drying . Emine and Hisil, (2013) reported similar result. The result showed that there was a significant difference

(p<0.05) between the sample. Microwave dried sample contained higher antioxidant activity due to the release of a free phenolic fraction. Turkmen and Velioglu, (2005) also reported that microwave processing increased the antioxidant activity because of enhancement of antioxidant properties of naturally occurring compounds such as Millard reaction product that have antioxidant activity (Yin and Chang, 1998). (Yamaguchi et al. 2001) reported that the release of phenolic compounds after microwave drying resulted to enhance the antioxidant activity in fruit extracts. Microwave dried sample contained more antioxidant activity as compared to sun dried sample because of increased microwave output power (Mechlouch et al.2015). In result, freezing fruits have lesser antioxidant activity due to cell wall disruption, which released the oxidative and hydrolytic enzymes that can destroy antioxidants in fruits (Chism, 1996) and Kalt et al. (2000) mentioned that frozen fruits have lower level of antioxidant activity (60%–80%) as compared to the fresh. Ferric reducing scavenging activity (FRAP) ranged from 76.22 per cent, 76.55 per cent, 75.76 per cent and 78.54 per cent for fresh, sun drying, freezing and microwave drying . (Emine and Yasar, 2013) were reported similar results. FRAP used to determine the capacity of the plant extract to donate electron to Fe3+ and reduce it to Fe2+ ion. Higher FRAP value, means higher the antioxidant activity (Yan et al. 2006). Radical scavenging activity enhanced after thermal treatment due to the inhibition of oxidative enzymes and destruction of the cell wall which release the antioxidant compounds (Yamaguchi et al. 2001).

Table 1. 5. Antinutritional Content And Anthocyanin Content

Drying method	FS	SD	FRS	MDS
(Tannin-g/100g)	0.67 ± 0.00^{a}	0.61 ± 0.00^{b}	0.60 ± 0.00^{cb}	0.62 ± 0.00^{db}
(Alkaloid-/100g)	7.80 ± 0.04^{a}	7.76 ± 0.02^{a}	7.60 ± 0.1^{bc}	7.79 ± 0.04^{ad}
(Anthocyanin- g/100g)	4.78 ± 0.19^{a}	4.67 ± 0.00^{a}	4.89 ± 0.19^{a}	4.56 ± 0.50^{a}

The total tannin content was ranged from 0.67 gm/ 100 gm, 0.61 gm /100 gm, 0.60 gm /100gm and 0.62 gm /100gm for fresh, sun drying, freezing and microwave drying. Bandekar et al. (2013) mentioned similar findings. Drying process decreased the tannin content due to thermal degradation and extraction which led to release the tannin content from the cell matrix by the breakdown of bonds with proteins (Rehman and Shah, 2001). Heating caused the loss of tannin content due to the oxidation of bioactive compounds (Yoshioka et al. 1990). In microwave drying less degradation of the tannin content as compared to sun drying due to the absence of sunlight and low oxygen (Rwubatse et al.2014). Soluble tannin is responsible for the astringency sensation, during freezing soluble tannin coagulates and become insoluble (Brackmann et al.1997; Matsu and Itoo, 1978). Freezing also decreased the tannin content due to the change of chemical properties of tannin and dehydration of colloidal substances (Nakamura, 1961). The alkaloid content was ranged from 7.80 gm/ 100 gm, 7.76 gm /100 gm, 7.60 gm/100gm and 7.79 gm/100 gm for fresh, sun drying, freezing and microwave drying. Similar reports have been obtained by Soni et al. (2014). In this study it depicts that drying process decreased the alkaloid content as compared to fresh because of thermal breakdown, it affect the integrity of cell structure and resulted migration of components, leading losses by various chemical reactions (involving enzymes, light and heat). In microwave drying less degradation of alkaloid content as compared to sun drying due to the absence of sunlight and low oxygen (Rwubatse et al.2014). Freezing decreased the alkaloid content as compared to the thermal treatment and similar results were reported by Atlabachew et al.(2013). Anthocyanin content of ranged from 4.78 mg/100gm, 4.67 mg/100gm, 4.89 mg/100gm, 4.56 mg/100gm for fresh, sun drying, freezing and microwave drying. Similar results were mentioned by Anat et al. (2006). Drying process decreased the anthocyanin content (Juan et al.2013) due to various factors such as temperature, presence of oxygen, metal ion, co-pigmentation, pH and light (Mishra and Yang, 2008). Due to fast heating process in the microwave led to thermal degradation of the anthocyanin by the production of heat from within cells as well as from the outside by radiation, conduction and convection as compared to sun drying because UV irradiation is the non thermal factor for the color stability of anthocyanins content (Golmakani and Rezaei, 2008; Pala and Toklucu, 2011). Freezing increased the anthocyanin extraction due to the cellular disruption in fruits (Skrede, 1996). And enhanced the release of membrane bound anthocyanin as compared to heating, freezing slightly increased the anthocyanin content and induced the formation of ice crystals that favours localized concentration of solutes (phytochemicals) reallocation of water molecules in the cell structure. During freezing large amount of ice crystals formed and caused lesser degree of cell disruption (Szczesniak, 1998; Leong and Oey, 2012).

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Table 1.6. Mineral composition

Drying method	FS	SD	FRS	MDS
Calcium-(mg/100g)	80.6± 0.577 [a]	285.230± .005 [b]	80.76± 0.05 [cd]	302.86± 0.05 [dc]
Iron-(mg/100g)	12.01±0.005 [a]	12.66± 0.005 [b]	11.51 ±0.005 [cd]	13.20 ±0.005 [dc]
(Phosphorus);(mg/100g)	17.66± 0.05 [a]	123.13± 0.005 [a]	17.41± 0.005 [ac]	106.16± 0.05 [cd]

The calcium content was ranged from 80.6 mg /100gm, 285.23 mg/100gm, 80.76 mg/100gm and 302.86 gm/100gm for fresh, sun drying, freezing and microwave drying. Consistent findings have been obtained by Fateh et al. (2014). After drying treatment minerals (calcium, phosphorus and iron) increased because of increasing dry matter content. The changes in the concentration of minerals is also depend on the method and the drying temperature (Ozcan et al. 2004).Microwave dried sample contained higher mineral content as compared to sun dried. This might be due to the conversion of energy into heat in the microwave drying process which resulted in higher temperature (Derya and Ozcan, 2012). In case of freezing, mineral content decreased 10 per cent and 45 per cent due to leaching of the mineral content. It might be due to during freezing, residual soil particles (mineral rich soil) washed off which are left on the surface of fruits (Puuponen et. al.2003). Iron content ranged from12.01 mg /100gm, 12.66 mg/100gm, 11.51 mg/100gm and 13.20 mg/100gm for fresh, sun drying, freezing and microwave drying. Similar findings were reported by Khan et al. (2010). Phosphorus content ranged from 17.66 mg /100gm, 123.13 mg /100gm, 17.41 mg /100gm and 106.167 mg /100 gm for fresh, sun drying, freezing and microwave drying. Khan et al.(2011) gave similar results.

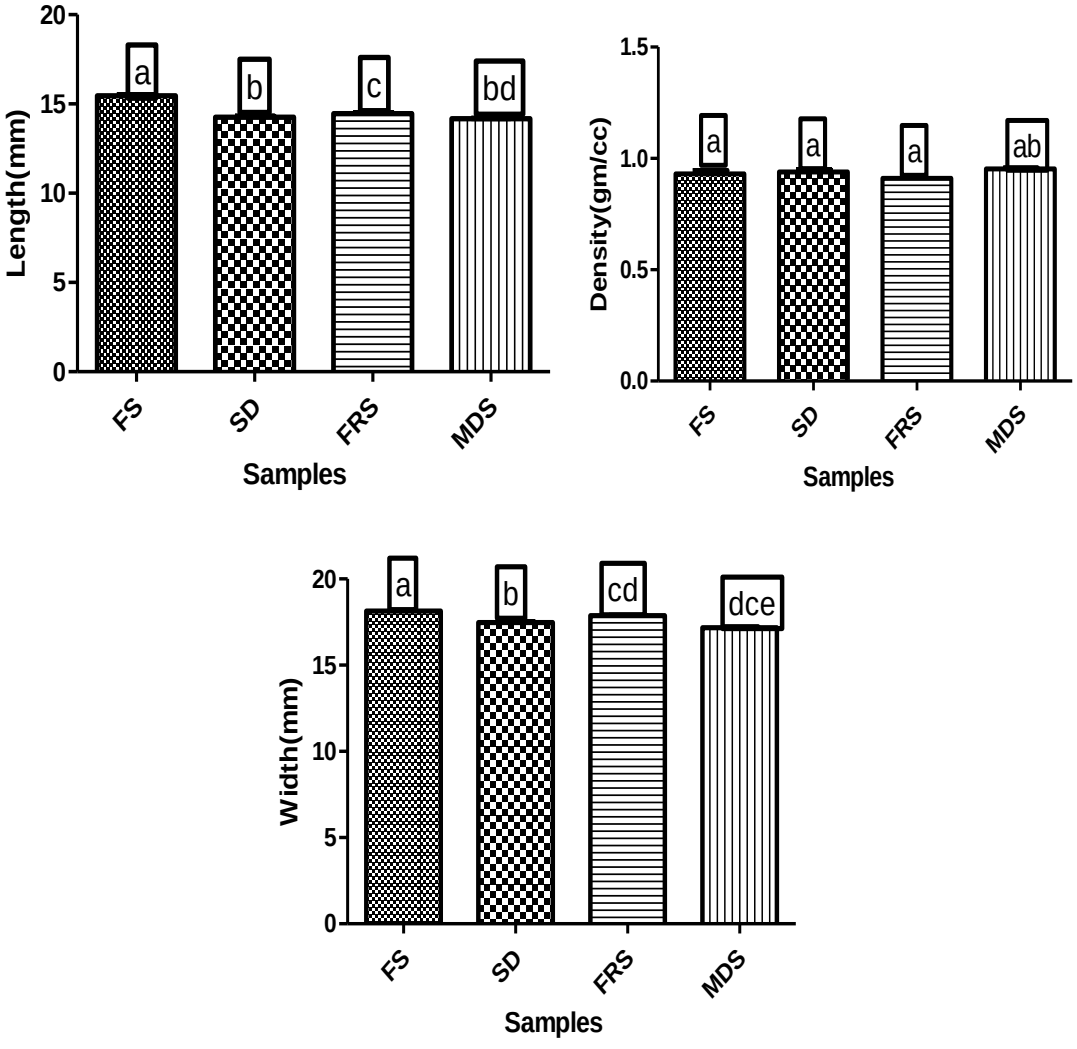

Fig.1. Physical Properties (Length, Width and Density)

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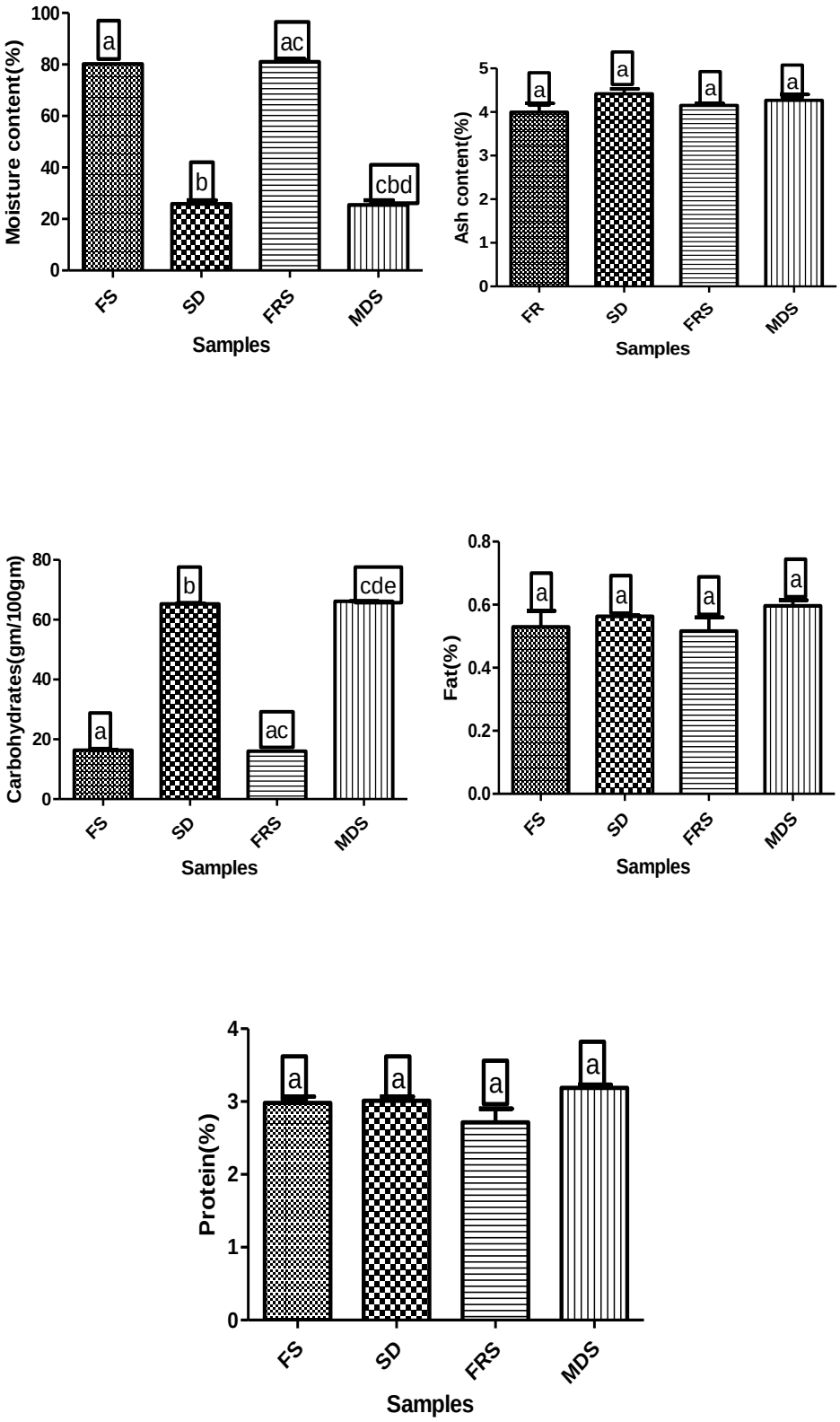

Fig.2. Nutritional parameters (Moisture, ash, carbohydrates, fat and protein)

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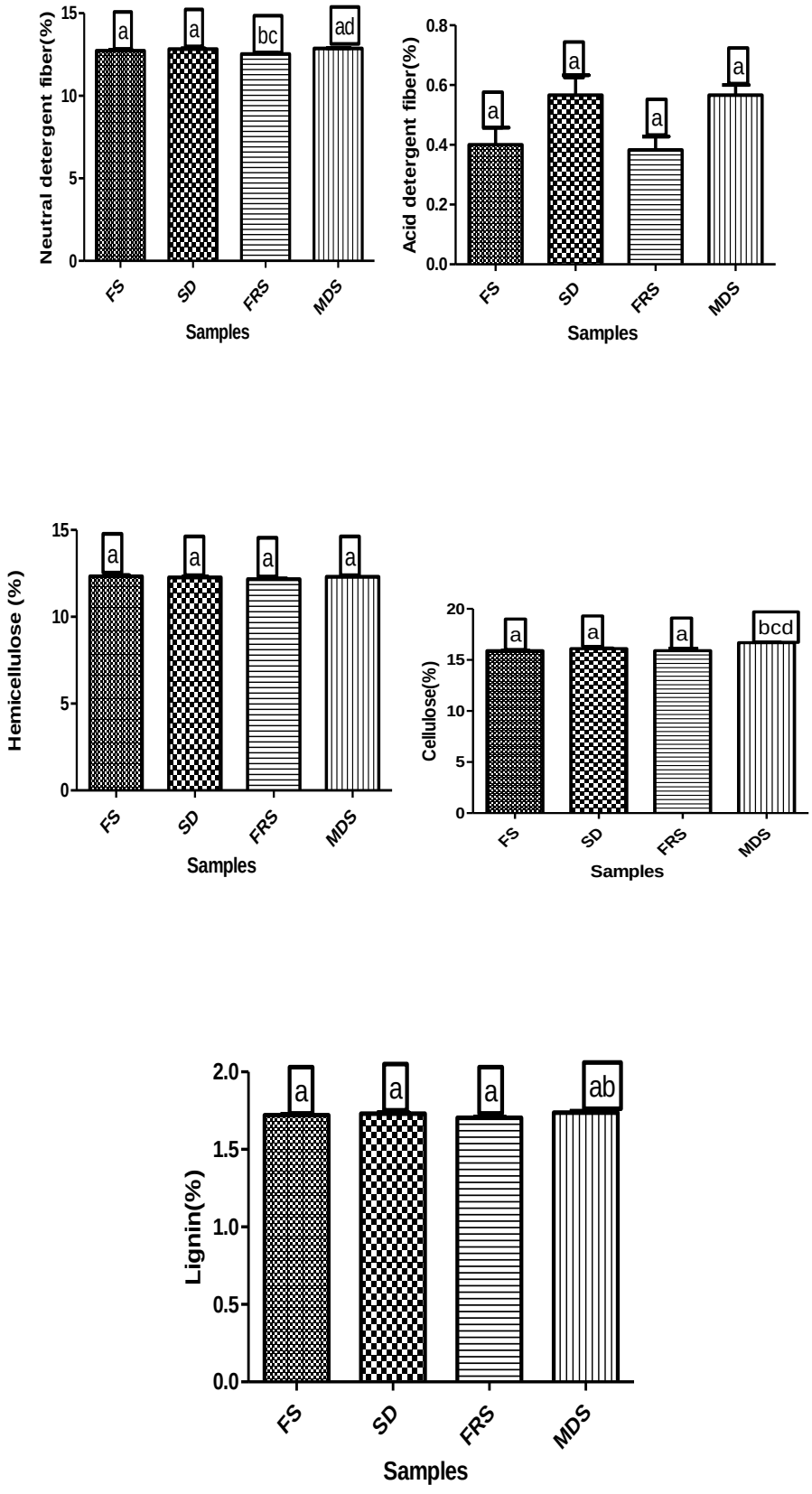

Fig.3. Dietary fiber NDF, ADF, Hemicellulose, Cellulose, Lignin) content

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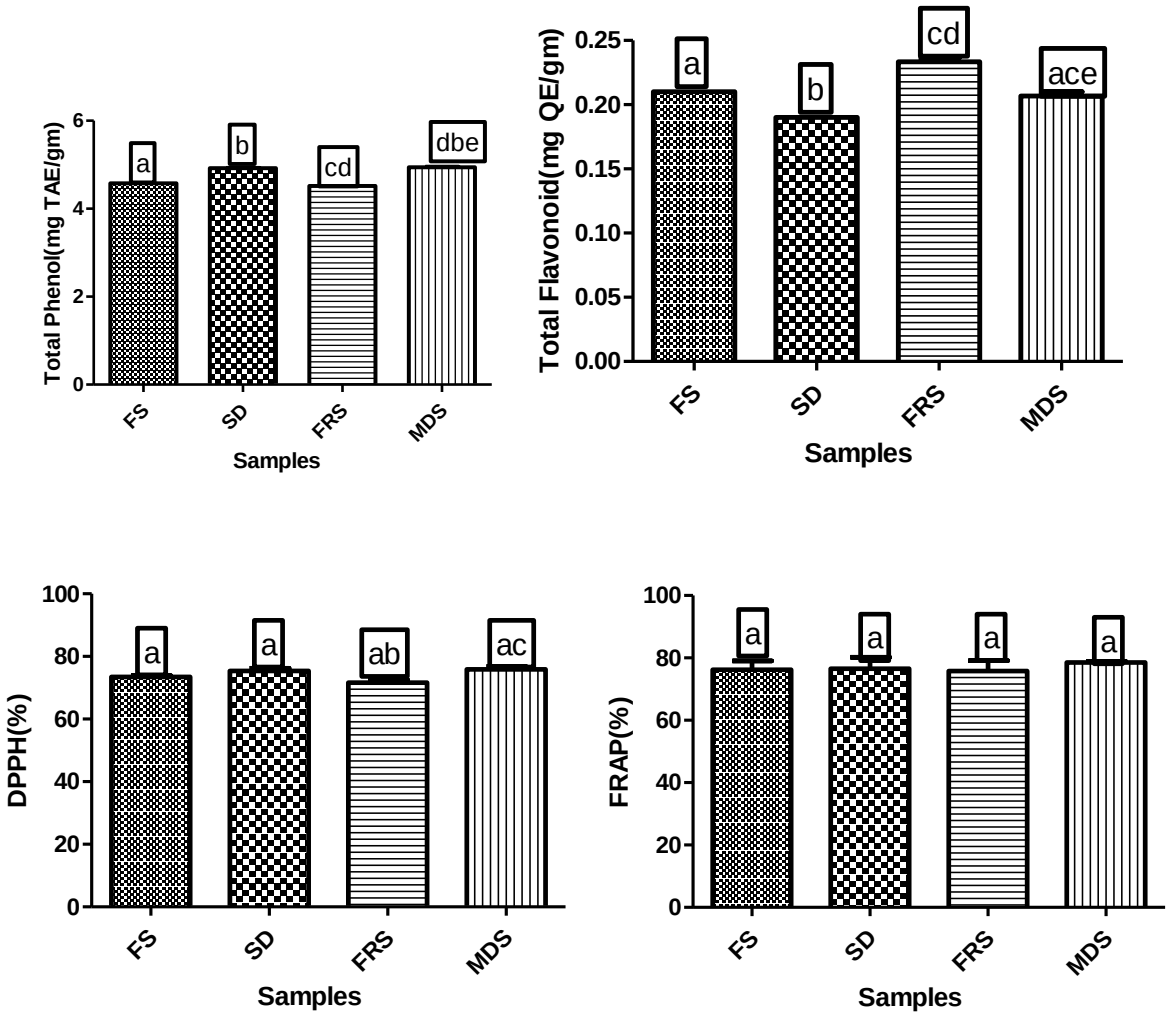
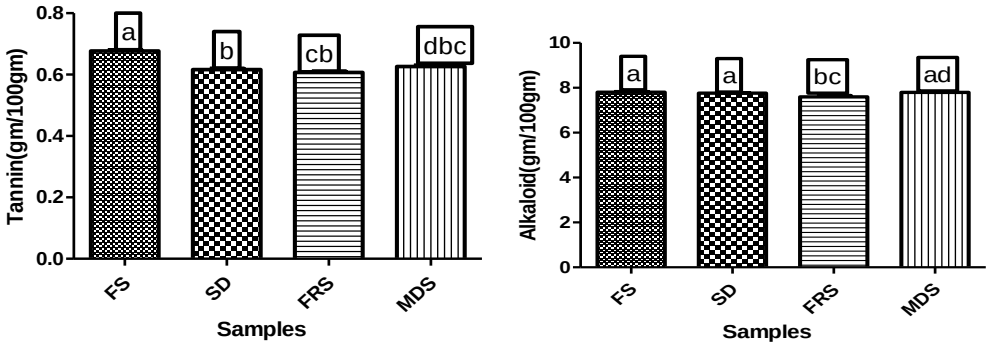


Fig.4. Phytochemical composition (TP, TF, DPPH and FRAP)



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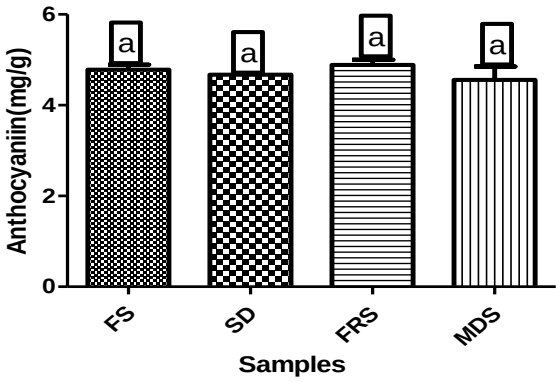
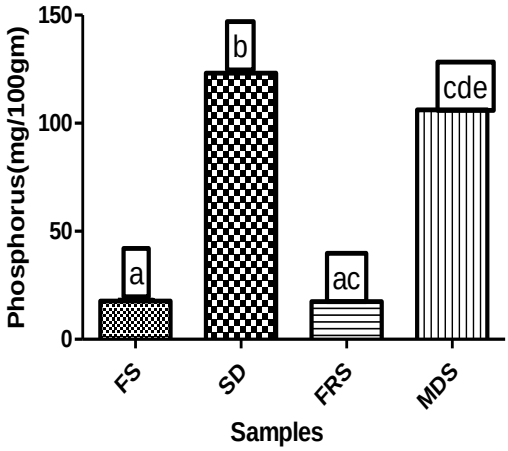
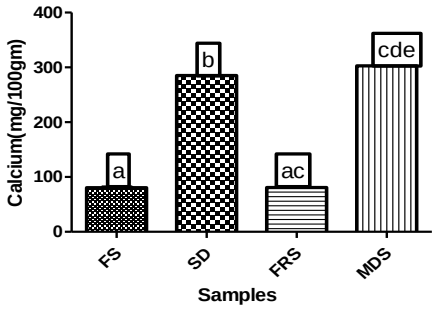


Fig.5. Anti-nutritional and anthocyanin content





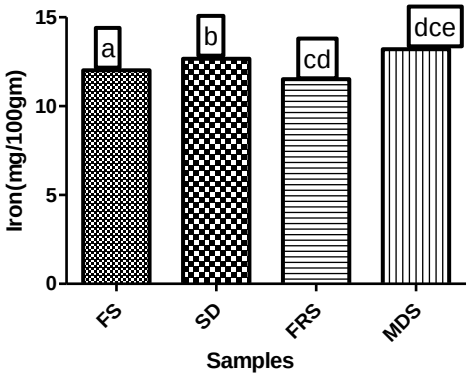


Fig.6. Mineral composition

CONCLUSION

This study conclude that these selected methods: Sun drying, microwave drying and freezing have a significant impact on the physico-chemical, nutritional and phytochemical properties. Compare to fresh and freezing, drying method would be used to produce good quality dried fruit in terms of protein, carbohydrates, ash content, dietary fiber (ADF, NDF, cellulose, hemicelluloses, pectin), anti- nutritional content (tannin, alkaloid) and minerals. Purpose of the study is to generate awareness among people about the influence of processing methods on fruits and to increase the intake of underutilized fruits in their daily diet. The future studies should focus on a nutrients retension by using different drying methods (shade dried, vacuum air dried, freeze drying) and pretreatments.

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