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A Physico-Chemical study of different Fig (*Ficus Carica* L.) varieties in Haramosh valley, Gilgit-Pakistan

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Abstract*—The present study was conducted to analysis the basic physico-chemical properties of four Figs (Ficus carica L.) varieties i.e. English Fig, wild fig, dark brown fig and dark black fig and its by-products was prepared in Haramosh valley.Fresh fig fruits were picked or harvested when they begin to soften and the color change indicates maturity. Then washed, cut in quarters, pulped and then the pulp was processed into fig jam and squash. The physico-chemical analysis i.e. pH, total soluble solids (TSS), titratable acidity, reducing sugar, moisture content and ash content of four fresh varieties of fig were determined while physico-chemical analysisof by-products (Jam and squash) prepared from three fig varieties including english, dark brown and dark black fig was also determined. The results showed that pH and moisture content were gradually decreased in all samples during storage interval whereas TSS, titratable acidity, reducing sugar and ash content increased. Regarding physico-chemical analysis of by-products TSS, acidity, reducing sugar, non-reducing sugar and total sugar increased while pH decreased during storage interval.The maximum mean value for pH, moisture content and ash content was found in English fig however for TSS and reducing sugar maximum value was observed in dark black fig. Data regarding titratable acidity highest value was recorded from wild fig. Furthermore pysico-chemical properties of by-products shows that maximum mean value of pH was detected in dark brown fig whereas maximum value of acidity, TSS, reducing sugar and total sugar was recorded from English fig, however maximum value of non-reducing sugar was observed in dark black fig. It may be concluded from the study that English fig is favorable for a long period of storage.Moreover it is concluded that processing of fig fruit pulp into jam and squash resulted in a significant increase in physico-chemical characteristics such as TSS, titratable acidiy and sugar content however decreases its pH. The processing of fig fruit pulp into jam and squash ensures the safety and quality of the by-products without losing its nutritional and antioxidant benefits.*

***Keywords*—Physico Chemical, Fig Fruit, Percentage, Nutrients and Sensory Evaluation.**

I. INTRODUCTION

Fruits are one of the oldest forms of food known to man. Fresh and dry fruits are the natural staple food of man. They contain substantial quantities of essential nutrients in a rational proportion. They are excellent sources of minerals, vitamins and enzymes. They are easily digested and exercise a cleansing effect on the blood and the digestive tract. Fig (*Ficuscarica*L.) is one of the important fruit (Sarfaraz *et al.,* 2009). Early studies carried out to identify cyanidin 3-glucoside (Cy. 3-gluc). Furthermore, four anthocyanin were reported in the Fig, with cyaniding 3-rhamnoglucoside (Cy. 3-rut) accounting for about75% of total pigments; other pigments were cyaniding 3, 5-diglucoside (11%), cyanidin 3-glucoside (11%) and pelargonidin 3-rhamnoglucoside (3%) (Puech *et al.,* 1975; Solomon *et al.,* 2006; Del Caro and Piga, 2007). The fruit skin contributed most of the polyphenols and antioxidant activity compared to the pulp especially in darker varieties (Solomon *et al.,* 2006; Goulart, 1980).

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The nutrient composition of dried Fig is total calories 283, total fat 0.52g, saturated fat 0.0g, cholesterol 0.0 mg, sodium 12.26 mg, potassium 609 mg, total carbohydrate 66.16g, total dietary fiber 12.21g, insolublefiber 8.74g, soluble fiber 3.47g, sugars 49.0g, protein 3.14g, vitamin A 9.76 IU, vitamin C 0.68 mg, calcium 133.0 mg. Figs are fat free, sodium free and like other plant foods its cholesterol free (Pasman *et al.*, 1997). The fiber found either in soluble or insoluble form.Pasman *et al.*, (1997) concluded that fiber may be useful in the treatment of obesity. Thus Figs and their soluble fiber may helpful to weight reduction. Further studiesreported that in obese women average energy intake reduction can be fulfill after fiber supplementation. In a second study of subjects with low-energy intakes, hunger scores were significantly decreased after fiber supplementation (Pasman, 1997). The presence of phytosterols (433 mg/100g dry basis) has also been reported in Fig fruit (Jeong and Lachance, 2001). The fresh and dried Figs also contain relatively high amounts of crude fiber (5.5%, w/w) and polyphenols (Vinson, 1999; Vinson *et al.*, 2005).

Some recent works have reported that Fig antioxidants can protect lipoproteins in plasma from oxidation and produce a significant increase in plasma antioxidant capacity for 4 h after consumption (Vinson *et al.*, 2005). Solomon *et al.*,(2006) also reported that the higher the polyphenols contents especially anthocyanins in Fig fruit, the higher was their antioxidant activity. Figs also comprise of sugars and organic acids that influence their quality and exhibit one of the highest concentrations of polyphenols among the commonly consumed fruits and beverages which contribute positively to human health (Veberic, Colaric, and Stampar, 2008; Vinson *et al.*, 2005; Oliveira *et al.*, 2009).

Fruit quality characteristics of some cultivars and types of Fig (*Ficus carica* L.) in Dortyol, Hatay, Turkey which has a Mediterranean climate. The main Fig cultivars grown in Turkey (‘Sarilop’, ‘Bursa Siyahi’, ‘Goklop’, ‘Yediveren’, ‘Yesilguz’, ‘Morguz’, ‘Sari Zeybek’, and ‘UfakYesil’) were evaluated along with 24 selections from a larger collection from the Mediterranean Region of Turkey.

Carlos *et al.*,(2010)determined the effect of two fruit maturity stages on the quality attributes of four fresh Fig cultivars including consumer acceptance and antioxidant capacity. Fig quality attributes such as weight, soluble solids concentration (SSC), titratable acidity (TA). They noted that SSC, TA, firmness, antioxidant capacity, and consumer acceptance varied by cultivar. Fig cultivars harvested at the advanced maturity stage (tree ripe) had lower TA and firmness but higher weight, and SSC than Figs harvested at ‘‘commercial maturity.’’ Fig maturity did not affect antioxidant capacity but “tree ripe’’Figs had higher consumer acceptance than commercial maturity Figs.The main aims & objectives of the study were to determined the basic physicochemical characteristics such as moisture, ash, TSS, reducing sugar & acidity of four fig (*Ficus carica* L.) varieties, i.e. English fig, dark brown fig, dark black & wild fig and to determined physic-chemical properties of Fig by-products such as jams, squash.

II. MATERIAL AND METHODS

2.1. Study Area

The present study was conducted to analysis the basic physico-chemical properties of four Figs (*Ficuscarica* L.) varieties i.e. EnglishFig, wild Fig, dark brown Fig and dark black Fig and its by-products found in Haramosh valley. Haramosh is the most beautiful valley of the district Gilgit that lie in the longitude covering an area of 2340 km^2. The area has several mountains, glaciers, peaks, forests, shrub lands, alpine meadows at different elevations. The three mountain ranges i.e., the Himalayas, the Karakoram and the Hindukush Ranges are meeting together in this area. The Rakaposhi Haramosh Mountains are a sub range of the Karakoram Range. The two peaks, Rakaposhi (7788m) and Haramosh (7409m) are among the highest in the world in terms of rise above local terrain due to their positions near very low valleys. Rakaposhi rises dramatically above a bend in the Hunza River forming the western anchor of the range while Haramosh stands on the north side of the Indus River in the south central position of the range. There is a rich diversity of habitats e.g., lakes, springs, streams, small rivers, cultivated fields, road sides, sub alpine and alpine meadows, steep mountain slopes and permanent glaciers etc., which support a rich and equally diverse floristic wealth. The local people largely depend upon their natural flora for various needs.

2.2. Sample Collection

Four different fig fruit varieties which included Englishfig, wild fig, dark brown and dark black figwere randomly collected or sampled from Haramosh valley in district Gilgit of north areas during summer season as (June, july & august) in 2010. Fresh fig fruits were picked or harvested when they begin to soften and the color change indicates maturity. During picking worn the gloves to prevent damaging the fresh fruit and to prevent the skin irritation caused by the white sap that contains ficin exuding from the broken stem. Since fresh figs ripen irregularly, picking was done weekly during the long harvest period. After picking

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these fruits were immediately transported in local wood basket and brought in Food Science and Technology Laboratory, in Karakorum International University Gilgit. After than these fruits were cleaned, washed and cut the fruit stem by using steel knife.

2.3. Preparation of Samples

As the study was carried out to analyze the physico-chemical properties of figs and prepared different products made from fig fruitso the pulp of differentfig varieties were extracted separately for processing. The pulp was extracted by grinding the fruits samples with the help of grinder. The fruits were washed and cut the undesirable portion like stems etc with the help of steel knife before grind. Weight the extracted pulp before processing and that pulp were used to determine different test as well as different products were prepared by using that pulps and analyzed physico-chemical properties of fig.

2.4. Physico-Chemical Analysis

Following methods were used to determine the physico-chemical analysis i.e. Ash, moisture, pH, total soluble solid, and acidity of four fresh varieties of fig and the same methods were also used to analyze the physico-chemical properties (TSS, reducing sugar, pH, acidity, non-reducing sugar and total sugar) of by-products prepared from three figs varieties i.e. English, dark brown and dark black fig.

III. RESULTS AND DISCUSSIONS

3.1. pH

The effect of storage temperature on pH of four fig varieties was recorded after 10 days interval up to 30 days. The mean values for pH recorded were 4.7 in english fig, 4.6 in dark brown,4.1 in dark black and 4.0 in wild fig. Highest meanvalue of pH recorded was 4.7 in english fig while lowest level was 4.0 in wild fig as presented in (Table 1). It was observed that storage interval had significant effect on pH of all samples. The pH gradually decreased in all samples during storage. The mean pH value of english fig decreased from 4.98 to 4.7, dark brown fig 4.96 to 4.6,dark black fig 4.48 to 4.1 and wild fig was 4.86 to 4.0.The results was agree with Sandhu *et al.*,(2001) and Sharma *et al.*,(2008) they observed the decrease pH in papaya and guava pulp during storage. Decrease in pH of the fruit pulp samples proportional to increase in acid.

Table.1: pH of Samples

Cultivars	**Storage days**				
	0	10	20	30	Mean
English Fig	4.98	4.82	4.75	4.46	4.7
Dark brown Fig	4.96	4.79	4.66	3.99	4.6
Dark black	4.48	4.36	3.91	3.84	4.1
Wild Fig	4.86	4.54	3.43	3.34	4.0

3.2. Total Soluble Solids (BRIX°)

Total soluble solids (TSS) of four fig varieties using refractometer was carried out. Results showed thatthe mean value 9.65 was recorded in english fig, 10.63in dark brown, 12.82 in dark black and 10.70 in wild fig. Highest level of TSS 12.82 was observed in dark black fig and lowest level 9.65 in english fig varieties. It was observed that the total soluble solids in all sample were increase during the storage of 30 days. The total soluble solids in english fig increased from 9.4to 10.2, dark brown fig 10.2to 11.10,dark black fig 12.2to 13.6 and wild fig 10.2 to 11.14. These results were correlated with Sandhu *et al.*,(2001). They also found the increased in TSS of guava and papaya pulp during storage interval. Increased TSS content during storage might be due to conversion of polysaccharide in to soluble sugar.

Table.2: Total Soluble Solids

Cultivars	**Days**				
	0	10	20	30	**Mean**
English Fig	9.4	9.12	9.88	10.2	9.65
Dark brown Fig	10.2	10.32	10.92	11.10	10.63
Dark black	12.2	12.5	13.0	13.6	12.82
Wild Fig	10.2	10.49	11.0	11.14	10.70

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3.3. Titratable Acidity

Data regarding titratable acidity of all samples at various storage intervals are given in (Table 3). The highest mean value of titratable acidity 0.095 was recorded in wild fig and the lowest acidity 0.054 was found in dark brown fig. It was observed that acid contents in all sample increased slightly during storage. The acidity increase was recorded 0.080 to 0.090 in english fig, 0.051 to 0.058 in dark brown fig, 0.084 to 0.093 in brown fig, 0.093 to 0.099 in wild fig. The resultsarein accordance with Sandhu *et al.*,(2001) they also found the increased in acidity of guava and papaya pulp during storage interval. Increased acidity content during storage might be due to formation of various organic acids in the fruits such as sulphurous acid. Trends of decreasing pH and increasing acidity found in these studies are well supported by previous researchers (Tandon,*et al.*, (2003); Sandhu *et al.*,2001).

Table.3: Titratable Acidity

Cultivars	**Storage days**				
	0	10	20	30	**Mean**
English Fig	0.080	0.082	0.087	0.090	0.084
Dark brown Fig	0.051	0.052	0.055	0.058	0.054
Dark black	0.084	0.085	0.087	0.093	0.087
Wild Fig	0.093	0.094	0.096	0.099	0.095

3.4. Reducing Sugar (%)

It is observed that the storage intervals greatly affectreducing sugars of all varieties (Table 4). The reducing sugar in four varieties at the first day in english fig was 6.88, dark brown fig 7.88, dark black fig 12.1 and wild fig 10.0 and after 30 days the values recorded in english fig was 7.29, dark brown fig 9.16, dark black fig 13.11 and wild fig 11.53. The maximum reducing sugar was found in dark black variety 12.64while minimum reducing sugar was noted in english fig 7.07. It is revealed that the reducing sugar widely increase in all sample during storage at room temperature as the reducing sugar increased in english fig 6.88 to 729, dark brown Fig 7.88 to 9.16, dark black Fig 12.1 to 13.11and in wild fig10.0 to 11.53. These result aresimilar with (Ayub *et al.*, 2010) the increase in reducing sugar is due to the conversion of sucrose to reducing sugars (fructose & glucose). Hashmi *et al.*,(2007) observed increasing in reducing sugar may be due to acids and higher temperature in mango pulp.

Table.4: Reducing Sugar (%)

Cultivars	**Days**				
	0	10	20	30	**Mean**
English Fig	6.88	6.91	7.21	7.29	7.07
Dark brown Fig	7.88	7.98	8.12	9.16	8.26
Dark black Fig	12.1	12.5	12.88	13.11	12.64
Wild Fig	10.0	10.41	11.4	11.53	10.83

3.5. Moisture Content (%)

The values of moisture are presented in (Table 6). The moisture content recorded at first day in English Fig, dark brown Fig, dark black Fig and wild Fig was 86.57, 82.46, 85.63 and 79.64.1t is observed that the moisture content in all varieties decreased during storage intervals of 30 days. The moisture decreased in English Fig was from 86.57 to 85.64, dark brown Fig 82.46 to 81.97, dark black Fig 85.63 to 83.99 and wild Fig 79.64 to 77.22.The maximum moisture content recorded in English Fig variety 85.94 and lowest moisture in wild Fig 78.21.The results were agreed with Sandhu *et al.*,(2001) and Sharma *et al.*,(2008) they observed the decrease moisture in papaya & guava pulp during storage.

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Table.5: Moisture Content (%)

Cultivars	***Days***				
	0	*10*	*20*	*30*	***Mean***
English Fig	*86.57*	*86.15*	*85.41*	*85.64*	*85.94*
Dark brown Fig	*82.46*	*82.41*	*81.77*	*81.97*	*82.15*
Dark black Fig	*85.63*	*84.56*	*84.19*	*83.99*	*84.59*
Wild Fig	*79.64*	*78.56*	*77.44*	*77.22*	*78.21*

3.6. Ash Contents

Data regarding ash content of all samples at various storage intervals are given in (Table 6). The mean values shows that highest ash value 0.82 was recorded in English Fig and the lowest 0.67was noted in wild Fig. It was observed that ash contents in all sample increased slightly during storage. The ash increase was recorded 0.76 to 0.84 in English Fig, 0.68 to 0.75 in dark brown Fig, 0.66 to 0.72 in black Fig and 0.64 to 0.70 in wild Fig. The resultsare in accordance with Sandhu *et al*.,(2001) they also found the increased in ash of guava and papaya pulp during storage interval.

Table.6: Ash Contents

Cultivars	**Days**				
	0	10	20	30	Mean
English Fig	0.76	0.89	0.81	0.84	0.82
Dark brown Fig	0.68	0.70	0.72	0.75	0.71
Dark black Fig	0.66	0.67	0.70	0.72	0.68
Wild Fig	0.64	0.66	0.68	0.70	0.67

3.7. Physico-chemical characteristics of by-products (Jams and squash)

Jam and squash are products of sugar and pectin contain fruits. It has characteristics of texture; colour and taste. It should be capable of storage for reasonable period after opening of bottle without risk of spoilage. The physico-chemical analysis of three fig varieties including English, dark brown and dark black fig was determined. All the prepared jams and squash were analyzed forphysico-chemical characteristics (TSS, Reducing sugar, pH, Total sugar, Acidity and Non reducing sugar) by keeping jams and squash for storage interval of 30 days at ambient temperature. Many indigenous fruits are grown in Haramosh valley,one of them is Figwhich is grown in this area but unfortunately due to low shelf life this variety is not properly utilized. This study was conducted for the proper utilization of Figs varieties by processing. Chemical and organoleptic characters of jams and squash were evaluate by using different parameters.

3.8. pH

Effect of storage temperature on pH of fig jams and squash were recorded after 10 days interval up to 30 days. Mean pH values in fig jams and squash recorded were 3.39 in english fig jam, 4.07 in dark brown fig,3.34 in dark black fig and 3.1 in squash. The maximum level of pH recorded was 4.07 in dark brown fig jam while minimum level was noted 3.34 in dark black fig. The value recorded for squash was 3.1 lower than jams pH (Table 7). It was observed that storage intervals had significant effect on pH of all jams and squash.The pH gradually decreased in all samples during storage. The pH value of english fig jam decreased from 3.87 to 2.99, dark brown fig jam 4.24 to 3.6, dark black fig jam 3.95 to 2.69 and squash 3.52 to 2.55. The pH of jam is an important factor to obtain optimum gel condition. During storage intervals pH decreased due to increase in acidity during storage this may be due to the formation of acidic compounds. These results are also in agreement with Ehsan *et al.*, (2002) reported decreasing trend in pH of all treatments of mixed jam prepared from water and lemon during storage.

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Table 7: *pH of by-product*

Cultivars	**Days**				
	0	10	20	30	Mean
English Fig jam	3.87	3.81	2.90	2.99	3.39
Dark brown Fig jam	4.24	4.17	4.3	3.6	4.07
Dark black Fig jam	3.95	3.88	2.84	2.69	3.34
Squash	3.52	3.31	3.22	2.55	3.1

3.9. Acidity

The formulated jam samples were also analyzed for acidity and maximum mean value was calculated for english fig jam 0.098 and minimum value for dark brown fig jam 0.059. The maximum value recorded for acidity during storage period at initial day for english fig jam 0.097 which increased at 30 days 0.099.Increased in acidity of fruit jams was reported earlier to be results of ascorbic acid degradation or hydrolysis of pectin result(Sogi and Singh,2001). Studies on bitternessdevelopment during storage in kinnow juice ready to serve beverage squash jam and candy.Similar results were reported by Riaz, *et al.*, (1999) who observed decrease in ascorbic acid content of strawberry jam from 18 mg/100g to 13 mg/100g during 90 days of storage. Torezan, (2002) reported that jam presented twice the vitamin C content (14.5 mg/100g) thanvitamin B (7.6 mg/100g) because of its faster processing, reducing, thermal and oxidative degradation.

Table 8: *Acidity of by-product*

Cultivars	**Days**				
	0	10	20	30	Mean
English Fig jam	0.097	0.098	0.098	0.099	0.098
Dark brown Fig jam	0.055	0.057	0.061	0.064	0.059
Dark black Fig jam	0.064	0.066	0.069	0.071	0.067
Squash	0.093	0.096	0.098	0.099	0.096

3.10. Total Soluble Solid

The analysis of total soluble solids (TSS) of jams made up of three varieties of Fig and squash made from Fig fruits by using refractometer. The mean value 64.27was observed in English Fig, 62.25 in dark brown,60.84 in dark black and 53.7 in squash. Highestmean value of TSS 64.27 was observed in English Fig jam and lowestvalue 53.7 was noted in squash. It is observed that the total soluble solids in jams as well as in squash were increase during the storage of 30 days. The total soluble solids in English Fig jam increased from 63.7 to 67.9, dark brown Fig jam 59.7 to 65.6, dark black Fig jam 57.4 to 63.87 and squash 50.2 to 57.9. These results are in accordance with Tremazi, (1967) who reported that total soluble solids increased in canned Pakistani peaches on storage. Riaz *et al.*, (1999) observed increased in total soluble solids of strawberry jam during storage. Ehsan *et al.*, (2002) and Ehsan *et al.*, (2003) reported the increase in TSS of watermelon lemon Jamand grape fruit apple marmalade.

Table.9: Total Soluble Solids of by-product

Cultivars	***Days***				
	0	*10*	*20*	*30*	***Mean***
English Fig jam	*63.7*	*63.21*	*65.3*	*67.9*	*64.27*
Dark brown Fig jam	*59.7*	*60.12*	*63.6*	*65.6*	*62.25*
Dark black Fig jam	*57.4*	*59.8*	*62.32*	*63.87*	*60.84*
Squash	*50.2*	*53.1*	*53.6*	*57.9*	*53.7*

3.11. Reducing Sugar

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The sugars present in jams comprise natural and added sugars. In the present study maximum mean value for reducing sugar was observed in English Fig jam 36.31 while the minimum mean value for reducing sugar recorded for dark black Fig jam 17.62. The maximum value for reducing sugars during storage period at initial days English Fig jam was 33.06 which increased upto39.55 after 30 days whereas minimum value recorded for reducing sugar at initial day 16.94 in dark black jam,increased during storage from 16.94 to 18.4. The value recorded for reducing sugar in squash at initial day was 15.80 which increased upto 16.32. The value recorded for reducing sugar in squash was very low than jams since squash has low reducing sugar. Increase in reducing sugar may be due to prolong storage and hydrolysis of sugars with increase in acidity and decrease in pH. Similar results were reported by Pandit, (1991) who observed the increase reducing sugar in apple and water melon jam during storage. The similar results were reported by Riaz, *et al.,* (1999) who noticed increasing trend in reducing sugars of strawberry Jam during 3 months storage. Anjam, *et al.,* (2000) while working on apricot diet jam observed increase in reducing sugars. Ehsan *et al.,* (2003) reported increasing trend in reducing sugars of grape fruit apple marmalade reducing sugars.

Table.10: Reducing Sugar of by-product

Cultivars	**Days**				
	0	10	20	30	Mean
English Fig jam	33.06	35.21	37.42	39.55	36.31
Dark brown Fig jam	25.2	25.15	26.4	26.17	25.73
Dark black Fig jam	16.94	17.6	17.54	18.4	17.62
Squash	15 .80	15.85	16.12	16.32	15.93

3.12. Non Reducing Sugar

Results for non-reducing sugar showed that maximum mean value for non-reducing sugars was recorded for dark black jam 40.15and minimum for English Fig jam 28.94. The value recorded for squash was slightly high than jams products 40.66. Storage effect showed that maximum non reducing sugars was recorded at initial day which was 42.88 in dark black jam which decreased at 30 days to 37.99 and minimum non reducing sugar recorded 29.17 in English Fig jam decreased during storage 27.99.At the initial days non-reducing sugar in squash was 42.07 which decreased to 39.97 during storage. The results are in accordance with Riaz *et al.,* (1999) they also observed decrease in non-reducing sugarsin strawberryjam. Ehsan *et al.,* (2003) observed decrease in non-reducing sugars of grape fruit apple marmalade.

Table.11: Non Reducing Sugar of by-product

Cultivars	**Days**				
	0	10	20	30	Mean
English Fig jam	29.17	29.9	28.70	27.99	28.94
Dark brown Fig jam	34.95	33.45	32.51	30.70	32.90
Dark black Fig jam	42.88	40.21	39.55	37.99	40.15
Squash	42.07	40.32	40.28	39.97	40.66

3.13. Total Sugar

Results for total sugar showed that maximum mean value of total sugars was recorded 64.60 in English Fig jam while minimum total sugar was recorded 61.40 in dark black jam.The value recorded for squash was 59.34 slightly low than jams products. Storage effect showed that total sugar increased during storage.The results are in accordance with. Riaz *et al.,* (1999) they also observed increase in total sugars in strawberry jam.

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Table.12: Total Sugar of by-product

Cultivars	**Days**				
	0	10	20	30	Mean
English Fig jam	62.23	63.6	65.2	67.4	64.60
Dark brown Fig jam	60.1	62.3	63.1	63.8	62.32
Dark black Fig jam	59.82	60.2	61.7	63.9	61.40
Squash	57.87	57.90	59.3	61.9	59.24

IV. CONCLUSION

It may be concluded from the study that English fig is favorable for a long period of storage. Moreover it is concluded that processing of fig fruit pulp into jam and squash resulted in asignificant increase in physic-chemical characteristics such as TSS, titratable acidiy and sugar content however decreases its pH. The processing of fig fruit pulp into jam and squash ensures the safety and quality of the by-products without losing its nutritional and antioxidant benefits.

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