INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 15, No. 3, p. 243-250, 2019

RESEARCH PAPER OPEN ACCESS

Exploring the vicissitudes in composition of various mango varieties of Pakistan subjected to different drying techniques

Shahbazul Hassan Jafary[1], Rabia Shabir Ahmad[2*], Muhammad Kamran Khan[2], Abdullah Ijaz Hussain[3]

[1]*Department of Food Science, Nutrition and Home economics, Government College University, Faisalabad, Pakistan*

[2]*Institute of Home and Food Sciences, Faculty of Life Sciences, Government College University, Faisalabad, Pakistan*

[3]*Department of Chemistry, Government College University, Faisalabad, Pakistan*

Key words: Mango, Freeze Drying, Cabinet Drying, pH, Physico-chemical.

http://dx.doi.org/10.12692/ijb/15.3.243-250 Article published on September 28, 2019

Abstract

Mango is one of important fruit crops in the world and in Pakistan is considered as king of fruits. Pakistani mango has specialty as it is recognized as one of the best of its kind in the world market. In current project, local varieties of mango were subjected to two different drying conditions (freeze drying and cabinet drying). For the purpose, four local varieties of mango including Chaunsa, Sindhri, Fajri and Dosehri were purchased from local market. Mangoes were pre-treated with potassium meta-bisulphite (KMS) solution of different concentrations (1%, 2% and 3 %). After pre-treatment mangoes were subjected to drying conditions anddried mangoes were then analysed for changes in physio-chemical properties. Results indicated that for removal of moisture contents from mangoes, freeze drying was more effective than cabinet drying however among all the varieties,Sindhri showed better results for moisture contents.Minimal effect of freeze drying (FD) on fat and protein contents as compared to cabinet drying (CD) was recorded. Among four varieties, Fajri had the highest fat and protein contents followed by Sindhri, Chaunsa and Dosehri.Likewise, significant change in pH and acidity were observed in case of cabinet drying as compared to samples dried via freeze dryer.

* **Corresponding Author:** Rabia Shabir Ahmad ✉ rabiaahmad@gcuf.edu.pk

Introduction

Mango (*Mangiferaindica*L.) is one of the common fruits of most continents, , 2016).In Pakistan, the area planted with fruit trees is 853.4 thousand hectares, with a production of 7178.8 thousand tons, while the area cultivated in Mango is 175 000 hectares, with a production of 1 784 thousand tons. Mango is the second fruit crop in Pakistan, producing 8.5% of the world's mango, mainly exports to the Middle East, Iran, Germany, Japan, China and Hong Kong, makes a valuable contribution as an important fruit crop (Pakistan Economic Survey, 2015).

Pakistan Mango is recognized as one of the best of its kind in the world market. With a production of 1.8 million tons per year, Pakistan is one of the major producers of mangoes and is considered the natural and natural habitat of mango. Pakistan is now the world's fourth largest producer in the world behind India, China, Mexico and Thailand. The climate of Pakistan is favorable to mango with the advantage of the warmer zone of Sindh for the early varieties because Sindhri and the modest zone of Punjab are the best adapted to know well the variety SB Chaunsa. The country exported 65 311 tones of mangoes valued at US $ 46 million in 2014-15 to the United Arab Emirates, Gulf States, Central Asian States, the EU, Australia, United States and Canada. Climate change has also affected the European horticultural sector in recent years, but has taken steps to effectively combat the effects of climate change (Noor, 2018).

There are a number of varieties of this fruit, including Sindhri, Langra, Dosehri, Anwar Rataul, GulabKhas, Sunera, Chaunsa, Chaunsa Black, Chaunsa Blanco, Began Phali, Fajri, etc. All these varied varieties have distinctive colors, aromas and aromas. Nature has blessed Pakistan with agro-climatic conditions that allow the production of quality mango. Per hectare, Pakistan's average yield is 11.20 tons per hectare, which is in part lower compared to other major mango producing countries in the world, for example. China and Brazil. Most countries grow varieties such as Haden, Tommy Atkins, Kent and Keitt. The most important commercial cultivars in Pakistan are Dosehri, Anwar Ratol, Langra, Chaunsa, Sindhri, Maldha and Fajri(Prospectiva, 2015).Current project was designed to compare the effect of two drying techniques including Freeze and Cabinet drying on various compositional parameters of four mango varieties.

Materials and methods

Raw material collection and pre-treatment

Four varieties of mangoes including SB chaunsa, sindhri, fajri and dosehri were purchased from local market.All four verities of the Mango (*Mangiferaindica L.*) were pre-treated by dipping in potassium meta-bisulphite (KMS) solution of different concentrations (1%, 2% and 3 %) as per below given plan.

Dehydration of Mango slices

Two drying techniques were employed: 1) Freeze drying (FD) and Hot Air Cabinet Drying (CD).

Freeze Drying (FD)

Freeze drying was carried out using a laboratory freeze dryer (Fauji Fresh & Freeze Industries situated at Sahiwal Pakistan). Samples were frozen at -20^{o}C and dried in a pilot-scale lyophilizer (Vertis Company Inc., Gardiner, NY, US) with the condenser temperature and chamber vacuum at -55^{o}C and 4 Pa respectively (Natalia *et al.,* 2015).

Hot-air/Cabinet dying (CD)

Hot Air Cabinet Drying was carried out at SFA Industries Kabirwala, Pakistan. Samples were dried in a cabinet dryer (USAID funded project implemented by Chemonics International Inc, 2012) operated at 60^{o}C with constant air circulation. The mango cubes were dried in a custom-made Infra-red (IR) heating unit consisting of aluminium housing, with two 40-Watt IR bulbs. The drying was terminated based on the appearance of dehydrated mango cubes. The dried mango cubes were ground using a coffee grinder to pass through US40 Sieve (0.5 mm) packaged in polyethylene bags and stored at -20^{o}C until analysed. The mango powders were used for analysing antioxidant, physicochemical and functional properties (Sogi*et al.,* 2015).

Physio-chemical Analysis

Moisture content, pH, titratable acidity and solubility Dehydrated mango were analysed for selected physio-chemical properties that are important for handling and utilization of dried ingredients.

Moisture Contents

Moisture content, dietary fibre, crude fat and crude protein of Dried Mango samples were measured by following the procedures of AACC (2000). The moisture content was estimated according to the AACC Method No. 44-01 (AACC, 2000) by drying 3g of the sample in a hot air oven (Model: DO-1-30/02, PCSIR, Pakistan) at 105±5°C till the weight of the sample became constant.

Crude Protein

The percentage of the nitrogen in the sample was determined using Kjeltech Apparatus (Model; D-40599, Behr Labor Technik, Gmbh-Germany) as described in AACC (2000) Method No. 46-13.

Crude Fat

Crude fat content was determined by taking 3g sample. For this purpose was used n-hexane as a solvent in Soxtec system (Model: H-2 1045 Extraction Unit, Hoganas, Sweden) according to the (AACC Method No. 30-10).

Titerable acidity

Titratable acidity of dehydrated mango samples was determined by taking 0.5 g of sample in 20 mL distilled water, adding two drops of phenolphthalein and titrating against standardized 0.1 mol/L NaOH solution (Cano-Chauca *et al.*, 2005).

pH

The pH was measured by taking 0.5 g sample in 50 mL distilled water using Oakton pH meter (Eutech Instruments, Singapore) (Cano-Chauca *et al.*, 2005).

Results and discussion

Effect of drying on Moisture content of Dried Mango

After Freeze Drying (FD) Moisture of final product for Chaunsa SB variety were 9.1%±0.5, 10.0%±0.5, 9.0%±0.4, and 10.1%±0.5 for To, T1, T2 and T3 respectively. Similarly the Moisture for Sindhriwere 6.9% ± 0.3, 7.1 ± 0.4, 8.6% ±0.4 and 8.1% ±0.4 for To, T1, T2 and T3. While the Fajri variety moisture contents were 12.6%± 0.6, 13.3%±0.7, 14.1%±0.7 and 13.4%±0.7 for To, T1, T2 and T3 respectively.

Table 1. Pre-Treatment plan for four varieties with preservative.

Treatments	Mango Varieties			
	SB Chaunsa	Sindhri	Fajri	Dosehri
To	0 ppm	0 ppm	0 ppm	0 ppm
T1	100 ppm	100 ppm	100 ppm	100 ppm
T2	200 ppm	200 ppm	200 ppm	200 ppm
T3	300 ppm	300 ppm	300 ppm	300 ppm

The Moisture for Dosehri variety were 12.6 %± 0.6, 13.9%±0.7, 13.6%±0.7 and 13.7%±0.7 for To, T1, T2 and T3 respectively. After Cabinet Drying (CD) the Solubility of final product for Chaunsa SB variety were 9.7%± 0.5, 10.4%± 0.5, 9.6%± 0.5 and 10.4%±0.5 for To, T1, T2 and T3 respectively. Likewise, moisture contents of Sindhriwere 7.3%± 0.4, 7.5%± 0.4, 9.2%±0.5 and 8.5%±0.4 for To, T1, T2 and T3 respectively. Solubility for Fajri variety were 13.0%±0.6, 14.2%±0.7, 14.7 ± 0.7 and 13.8%±0.7 for To, T1, T2 and T3 respectively. Solubility for Dosehri variety were 13.6%±0.7, 14.1%±0.7, 14.0%±0.7 and 14.3%±0.7 for To, T1, T2 and T3 respectively(Table 2).These results showed that freeze drying was more effective than cabinet drying as same drying time was given to both methods. This better outcomes of the freeze drying method could be due to uniform air circulation in freeze drying than in cabinet drying. It was also noted that out of four varieties,Sindhri moisture contents

reduced to acceptable level quickly than others in both drying methods i.e. (CD and FD). Similarly Chaunsa SB was second followed by Fajri and Dosehri. This change in moisture may be due to physical structure of the verities and initial moisture contents.All results were in agreement with Dalbir *et al.*, (2014). The initial moisture content values reported in the literature were lower than those observed in the present study which might be due to the variation in fruit maturity. These results were also in agreement with Ueda *et al.*, (2000) and Elamin, (2014) who studied the effect of drying temperature on drying time and moisture content, they concluded that the time required to reduce the moisture content to any given level was dependent on the drying temperature.

Table 2. Means value for moisture content (%).

Method of Drying	Variety	Treatment			
		T 0	T 1	T 2	T 3
Freeze Drying (FD)	Chaunsa	9.1 ±0.5 ^{DEFG}	10.0 ± 0.5 ^{DE}	9.0 ±0.4 ^{DEFG}	10.1 ± 0.5 ^{DE}
	Sindhri	6.9 ± 0.3 ^{I}	7.1 ± 0.4 ^{HI}	8.6 ±0.4 ^{EFG}	8.1 ±0.4 ^{FGHI}
	Fajri	12.6 ± 0.6 ^{C}	13.3±0.7 ^{ABC}	14.1±0.7 ^{ABC}	13.4±0.7 ^{ABC}
	Dosehri	12.6 ± 0.6 ^{C}	13.9±0.7 ^{ABC}	13.6±0.7 ^{ABC}	13.7±0.7 ^{ABC}
Cabinet Drying (CD)	Chaunsa	9.7 ± 0.5 ^{DE}	10.4 ± 0.5^{DE}	9.6 ± 0.5 ^{DEF}	10.4 ± 0.5 ^{D}
	Sindhri	7.3 ± 0.4 ^{HI}	7.5 ± 0.4 ^{GHI}	9.2 ± 0.5 ^{DEF}	8.5±0.4 ^{EFGHI}
	Fajri	13.0 ± 0.6 ^{BC}	14.2±0.7 ^{ABC}	14.7 ± 0.7 ^{A}	13.8±0.7 ^{ABC}
	Dosehri	13.6±0.7 ^{ABC}	14.1±0.7 ^{ABC}	14.0±0.7 ^{ABC}	14.3 ± 0.7 ^{AB}

Effect processing on Fat contents of Dried Mango

After Freeze Drying (CD) Fat (%) values of final product for Chaunsa were 0.788±0.04%, 0.6952%, 0.6419% and 0.6086% for To, T1, T2 and T3. Similarly the fat values for Sindhri variety were 0.8152%, 0.7119%, 0.6319% and 0.7686%for To, T1, T2 and T3 respectively. Similarly the fat values for Fajri variety were 0.7452%, 0.7419%, 0.9019% and 0.7186% for To, T1, T2 and T3 respectively.

Table 3. Mean values for Fat (%).

Method of Drying	Variety	Treatment			
		T 0	T 1	T 2	T 3
Freeze Drying (FD)	Chaunsa	0.788±0.04^{ABCDE}	0.6952±0.04^{AB}	0.6419±0.04^{BC}	0.6086±0.04^{CD}
	Sindhri	0.8152±0.04^{ABCD}	0.7119±0.04^{ABC}	0.6319±0.04^{BC}	0.7686±0.04^{AB}
	Fajri	0.7452±0.04^{ABC}	0.7419±0.04^{ABC}	0.9019±0.04^{A}	0.7186±0.04^{A}
	Dosehri	0.8752±0.04^{AB}	0.791±0.04^{ABC}	0.5819±0.04^{D}	0.7852±0.04^{AB}
Cabinet Drying (CD)	Chaunsa	0.645±0.04^{BCD}	0.770±0.04^{ABC}	0.586±0.04^{DE}	0.553±0.04^{EF}
	Sindhri	0.76±0.04^{ABC}	0.656±0.04^{ABCD}	0.576±0.04^{D}	0.71±0.04^{ABC}
	Fajri	0.680±0.04^{ABC}	0.705±0.04^{ABC}	0.846±0.04^{ABC}	0.663±0.04^{ABC}
	Dosehri	0.782±0.04^{AB}	0.770±0.04^{ABC}	0.526±0.04^{F}	0.73±0.04^{ABC}

The fat values for Dosehri variety were 0.8752%, 0.791%, 0.5819% and 0.7852% for To, T1, T2 and T3 respectively (Table 3). After Cabinet Drying (CD) the Protein of final product for Chaunsa SB were 0.645%, 0.770%, 0.586% and 0.553%for To, T1, T2 and T3 respectively. Similarly fat values for Sindhri variety were 0.76%, 0.656%, 0.576%, and 0.71% for To, T1, T2 and T3 respectively. Fat values for Fajri variety were 0.680%, 0.705%, 0.846% and 0.663% for To, T1, T2 and T3 respectively. Fat contents for Dosehri variety were 0.782%, 0.770%, 0.526% and 0.73% for To, T1, T2 and T3 respectively (Table 3). The results

showed minimal effect of freeze drying (FD) on fat compared to cabinet drying (CD). Fajri had the highest fat contents followed by Sindhri, Chaunsa SB and Dosehri. These results were in comparison with Ara*et al.*, (2014) for initial fat contents and there was no significant impact on denaturing of fat contents observed during freeze drying and similarly the cabinet drying also not affected the fat contents.

Table 4. Mean values for Protein (%).

Method of Drying	Variety	Treatment			
		T 0	T 1	T 2	T 3
Freeze Drying (FD)	Chaunsa	5.0167 ± 0.3^{HIJ}	4.683 ± 0.3^{JK}	4.583 ± 0.3^{K}	4.39 ± 0.3^{MN}
	Sindhri	5.750 ± 0.3^{DE}	6.93 ± 0.3^{A}	6.78 ± 0.3^{AB}	6.0 ± 0.3^{CD}
	Fajri	6.21 ± 0.3^{ABC}	6.966 ± 0.3^{A}	6.65 ± 0.3^{ABC}	6.75 ± 0.3^{ABC}
	Dosehri	5.20 ± 0.3^{GHI}	5.35 ± 0.3^{FG}	4.89 ± 0.3^{IJ}	4.25 ± 0.3^{N}
Cabinet Drying (CD)	Chaunsa	4.50 ± 0.3^{LM}	4.0 ± 0.3^{OP}	4.06 ± 0.3^{P}	4.0 ± 0.3^{OP}
	Sindhri	5.23 ± 0.3^{GH}	6.43 ± 0.3^{ABCD}	6.266 ± 0.3^{AB}	5.5 ± 0.3^{EF}
	Fajri	5.900 ± 0.3^{D}	6.35 ± 0.3^{AB}	6.133 ± 0.3^{BC}	6.36 ± 0.3^{AB}
	Dosehri	4.625 ± 0.3^{KL}	4.950 ± 0.3^{HI}	4.43 ± 0.3^{MN}	3.80 ± 0.3^{P}

Effect of processing on Protein contents of Dried Mango

The results were highly significant for combined effect of Treatment and Variety as shown in Table 4.After Freeze Drying (CD) protein (%) values of final product for Chaunsa SB variety were 5.016%, 4.68%, 4.58% and 4.39%for To, T1, T2 and T3 respectively. Similarly the protein values for Sindhri were 5.75%, 6.93%, 6.78% and 6.0% for To, T1, T2 and T3. Similarly the protein values for Fajri variety were 6.21%, 6.97%, 6.65% and 6.75% for To, T1, T2 and T3 respectively.

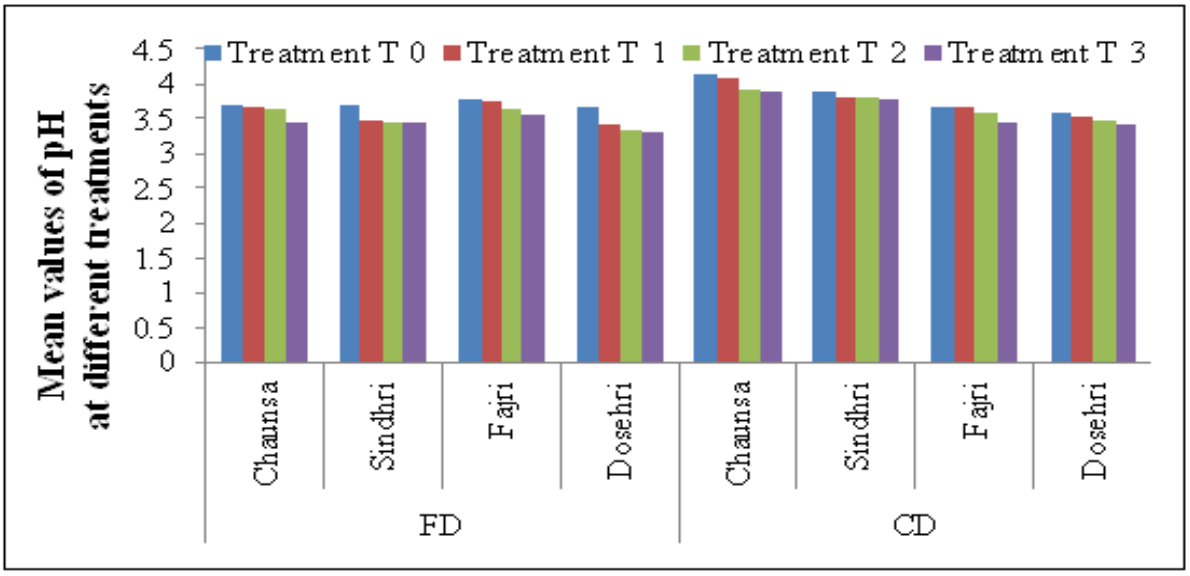

Fig. 1. Mean values for pH.

The protein values for Dosehri variety were 5.2%, 5.35%, 4.89% and 4.25% for To, T1, T2 and T3 respectively (Table 4). After Cabinet Drying (CD) the Protein of final product for Chaunsa SB variety were 4.50%, 4.0%, 4.07%, and 4.00% for To, T1, T2 and T3 respectively. Similarly protein values for Sindhri were 5.23%, 6.4%, 6.26% and 5.50%for To, T1, T2 and T3 respectively. Protein values for Fajri variety were 5.90%, 6.35%, 6.13% and 6.36% for To, T1, T2 and T3 respectively. Protein values for Dosehri variety were

4.62%, 4.95%, 4.43% and 3.80% for To, T1, T2 and T3 respectively (Table 4). The results clearly depicted that freeze drying had minimum loses of Protein contents for overall acceptability which may be due to difference in basic drying practice used by two drying techniques. Whereas Fajri was found more in protein contents followed by Sindhri which might be due to maturity stage and varietal character. The results obtained were comparable to findings of Ara*et al.*, 2014.

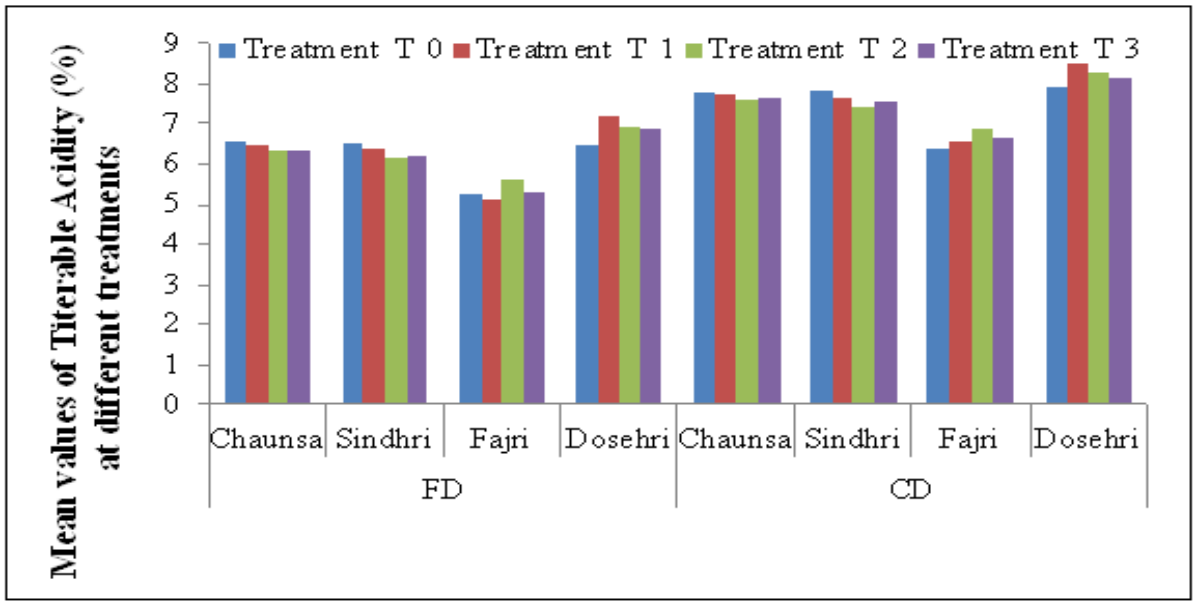

Fig. 2. Mean values for Titerable Acidity (%).

Effect of processing pH and Acidity of Dried Mango

After Freeze Drying (FD) the pH of final product for Chaunsa SB variety were 3.72±0.23, 3.68±0.3, 3.65±0.32 and 3.45±0.12 for To, T1, T2 and T3 respectively. Similarly pH values for Sindhri were 3.73±0.32, 3.5±0.22, 3.46±0.32 and 3.45±0.12 for To, T1, T2 and T3 respectively.

The pH values for Fajri variety were 3.79±0.2, 3.75±0.2, 3.65±0.2 and 3.57±0.2 for To, T1, T2 and T3 respectively.

The pH values for Dosehri variety were 3.7±0.2, 3.43±0.2, 3.35±0.2 and 3.3±0.2 for To, T1, T2 and T3 respectively (Figure 1). After cabinet drying (CD) pH of final product for Chaunsa SB variety were 4.16 ± 0.2, 4.1 ± 0.2, 3.94 ± 0.2, and 3.9 ± 0.2 for To, T1, T2 and T3 respectively. Similarly the pH for Sindhri were 3.9 ± 0.2, 3.84 ± 0.2, 3.82 ± 0.2 and 3.78 ± 0.2 for To, T1, T2 and T3. Whereas, the pH for Fajri variety were 3.7 ± 0.2, 3.67 ± 0.2, 3.59 ± 0.2 and 3.45 ± 0.2 for To, T1, T2 and T3 respectively. The pH for Dosehri variety were 3.6 ± 0.2, 3.54 ± 0.2, 3.49 ± 0.2 and 3.42 ± 0.2 for To, T1, T2 and T3 respectively (Fig. 1).

After freeze drying (FD) the Acidity values of final product for Chaunsa SB variety were 6.51%± 0.21, 6.43%± 0.21, 6.38%± 0.21 and 6.347%± 0.21 for To, T1, T2 and T3 respectively. Similarly Acidity values for Sindhri were 6.53%± 0.21, 6.37%± 0.21, 6.14%± 0.21 and 6.24%± 0.21 for To, T1, T2 and T3 respectively. The Acidity values for Fajri variety were 5.23%± 0.21, 5.13%± 0.21, 5.63%± 0.21 and 5.32%± 0.21 for To, T1, T2 and T3 respectively. The acidity values for Dosehri variety were 6.43%± 0.21, 7.19%± 0.21, 6.94%± 0.21 and 6.85%± 0.21 for To, T1, T2 and T3 respectively (Figure 2). After cabinet drying (CD) Acidity of final product for chaunsa SB variety were 7.80%± 0.21, 7.72%± 0.21, 7.68%± 0.21 and 7.64%± 0.21 for To, T1, T2 and T3 respectively. Similarly the Acidity values for Sindhri were 7.8233%± 0.21, 7.6467%± 0.21, 7.44%± 0.21 and 7.54%± 0.21 for To, T1, T2 and T3. Acidity values for Fajri variety were 6.42%± 0.21, 6.60%± 0.21, 6.93%± 0.21 and 6.62%± 0.21 for To, T1, T2 and T3 respectively. The Acidity values for Dosehri variety were 7.92%± 0.21, 8.49%±

0.21, 8.2%± 0.21 and 8.1%± 0.21 for T0, T1, T2 and T3 respectively (Figure 2). Significant change in pH and Acidity were observed in case of cabinet drying as compared to samples dried via freeze dryer, this may be due to heat depleting the acids present in mangoes. It was noted that out of four varieties Dosehri was most resistant in terms of increase in pH and acidity change, while chaunsa was second followed by Sindhri and Fajri. These variation in results among verities in pH might be due to different maturity index and repining condition, addition of preservative and above all heat given in cabinet dryer (CD).These results are in agreement with the findings of Jamil*et al.*, (2015), Ara*et al.*, (2014) and Mahendran, (2008). They studied immature/tender green fruits of four varieties includingSindhri, chaunsa SB, Langra and Desi,whichwere lower in pH values and high in acidity. This might be due to immature biological process stage of the fruit. These results are in contradiction with the findings of Gozlekci*et al.*, (2011). They harvested pomegranate fruits at 3 different development stages i.e. immature, unripe and mature. They claimed higher pH (4.56) from immature fruits as compared to unripe (2.95) and mature fruits (3.17). This contradiction is also possible because of totally different kind of fruits i.e. pomegranate and mango. In mango, usually pH increase and acidity reduced from immature to mature and mature to aged stages of fruit development. Likewise, Akhtar *et al.*, (2010)also mentioned minimum pH value below four and higher acidity above 0.60 in four mango varieties which wereDosehri, Chaunsa SB, Ratol and Langra fruits harvested even at maturity stage.

Conclusion

Freeze drying method was more effective for the moisture, protein and fat contents as compared to the cabinet drying. However, Sindhri moisture contents reduced to acceptable level quickly than other varieties. Significant change in pH and Acidity were observed in case of cabinet drying as compared to samples dried via freeze dryer, this may be due to heat depleting the acids present in mangoes. It was noted that out of four varieties Dosehri was most resistant in terms of increase in pH and acidity change, while Chaunsa was second followed by Sindhri and Fajri.

References

AACC. 2000. Approved Methods of the American Association of Cereal Chemists, 10th Ed. The American Association of Cereal Chemists, St. Paul, Minnesota, USA.

Akhtar S, Naz S, Mahmood S, Nasir M, Ahmad A. 2010. Physicochemical Attributes and heavy metal content of mangoes (Mangiferaindica L.) cultivated in different regions of Pakistan. Pak J Bot **42(4),** 2691-702.

Ara R, Motalab M, Uddin MN, Fakhruddin ANM, Saha BK. 2014. Nutritional evaluation of different mango varieties available in Bangladesh. International Food Research Journal **21(6),** 2169-2174.

Cano-Chauca, M, Stringheta PC, Ramos AM, Cal-Vidal C. 2005. Effect of the carriers on the microstructure of mango powder obtained by spray drying and its functional characterization. Innovative Food Science and Emerging Technologies **(6),** 420–428.

Elamin Akoy OM. 2014. Effect of Drying Temperature on Some Quality Attributes of Mango Slices. International Journal of Innovation and Scientific Research **4(2),** 91-99.

Gozlekci S, Ercisli S, Oktur ENF, Sonmez S. 2011. Physicochemical Characteristics at three development stages in Pomegranate cv. Hicaznar. Not Bot HortAgrobot Cluj **39(1),** 241-45.

Mahendran T. 2008. Effects of drying methods on the quality characteristics of mango powder. Journal of Science **5(1),** 54-64.

Mitra A. 2016. Fundamentals of quality control and improvement: John Wiley & Sons.

Natalia A, Salazar, Méndez EK, Catalina Álvarez Carlos E. 2015. Orrego. Mango (Mangiferaindica L.) Lyophilization Using Vacuum-Induced Freezing. International Journal of Biotechnology and Bioengineering **9(10).**

Noor. 2016. Pakistan to export 100,000 tonnes of Mangoes this season. http://www.foodjournal.pk/2015/May-June2015/PDF-May-June-2015/Exclusive-article-Mango

Noor, 2018. Pakistan aiming to fetch over US$ 70 million with Mangoes exports. http://www.foodjournal.pk/2018/May%20%20June%202018/PDF-March-April-2018/Dr_noor-Exclusive article%20Mango.

Pakistan economic survey. 2015. http://www.finance.gov.pk/survey/chapters16/highlights 2015_16

Prospectiva, 2020. World mango market supply, demand and forecast. 2015. https://www.prospectiva2020.com/sites/default/files/report/files/re_mango_march_2015.

Sogi DS, Siddiq M, Dolan KD. 2015. Total phenolics, carotenoids and antioxidant properties of Tommy Atkin mango cubes as affected by drying techniques. LWT-Food Science and Technology **62(1),** 564-568.

Ueda T, Matsuda N, Uchimiya H, Nakano A. 2000. Modes of interaction between the Arabidopsis Rab protein, Ara4, and its putative regulator molecules revealed by a yeast expression system. Plant J **21(4),** 341-9.

Wajeeha Jamil, Saeed Ahmad, Mudassar Ahmad, Sajid Ali, Malik Mohsin Abbas. 2015. Morpho-physiological and biochemical profiling of some mango cultivars in pakistan. J. Agric. Res **53(3),** 1-16.