Research Article

Effect of Drying Techniques and Storage on Mulberry (*Morus alba*) Quality

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Abstract | This research work was carried out to check the effect of selected dehydration techniques sun drier cabinet drier, tunnel dryer, solar drier and portable solar dryer, on the white mulberry fruit (*Morus alba*) variety grown in District Skardu, Gilgit Baltistan. After drying, mulberry fruit was stored for 150 days and evaluated for physiochemical and sensory parameters (water activity, ash content, percent acidity, pH, moisture content, reducing and non-reducing sugars, taste, texture, color and overall acceptability). Statistically minimum decrease was observed in water activity, pH, moisture content and organoleptic characters. While, stable increase was noted in percent acidity and ash content during storage. It was concluded and recommended on the basis of mentioned facts that mulberry fruit dehydrated by using solar drier and portable solar drier are best drying technique for mulberry fruits.

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Introduction

Mulberry (*Morus alba*) fruit is well known globally, that is consumed some time as fresh but most of the time after drying (Ercisli and Orhan, 2007; Sharma et al., 2011). This fruit is rich source of phenolics, flavonoids and anthocyanins in addition to sugars, organic acids and vitamins (Natic et al., 2015) that produce various biological activities. This fruit is widely being used as nutraceuticals, pharmacological preparations and herbal tonic, as it has potential applications as antioxidant, treatment for neurodegenerative disorders, treatments of bronchial disorders and also antimicrobial agent (Massod et al., 2008). In Pakistan the total area under mulberry cultivation was 510 thousand hectares with total production of 2325 thousand tons in 2012-2013 (Fruit, vegetable and Condiments Stat of Pak. 2012-2013). Mulberry fruit have high moisture level 62.20 to 74.62% therefore this fruit is regarded highly perishable (Muhammad et al., 2010). Due to high production and potential uses in food and pharmaceutical applications, this fruit is dried either for consumption as dried fruit or further use for industrial products. Various drying conditions has proven to differently effect the quality of this fruit (Doymaz, 2004). Furthermore, air drying temperature effects the physical and chemical properties of Mulberry that leads to nutritional and quality alterations, that is dependent on diffusivity values of heat for this fruit (Katsube et al., 2009).

Sun drying is one of the oldest forms of food preservation techniques used in Pakistan and has always been of great importance for the food industry. It is the process of moisture removal due to simultaneous heat and mass transfer (Chua et al., 2001), similarly

Table 1: *Effect of different drying techniques and storage on moisture content of dried mulberry fruit*

Treatments	Storage Interval (30 days)						%Decrease	Means
	Initial	30	60	90	120	150		
Sun drier	9.30	9.06	8.90	8.80	8.20	8.00	13.97	8.71a
Cabinet drier	8.50	8.40	8.30	8.20	8.15	8.10	4.70	8.29b
Tunnel drier	8.60	8.55	8.50	8.45	8.30	8.25	4.06	8.44b
Solar drier	7.90	7.83	7.73	7.63	7.50	7.40	6.33	7.66c
Portable solar drier	7.70	7.63	7.53	7.43	7.23	7.10	7.79	7.43d
Means	**8.40a**	**8.29ab**	**8.19ab**	**8.10bc**	**7.89cd**	**7.77d**		

Mean values followed by different small letters are significantly (P<0.05) different from each other

removing a large portion of the water content in a product in order to considerably reduced the reaction which leads to deterioration of the products (Doymaz, 2008). These problems direct the research to develop rapid, safe and controllable drying methods (Doymaz, 2004). For these reasons, different types of drying methodologies and instruments are being used for enhancing the storage life of fruits namely, solar dryer, tunnel dryer, tray dryer, cabinet dryer and microwave drying (Akbulut and Durmus, 2009; Doymaz, 2004; Hiregoudar et al., 2010; Taser et al., 2007 and Lohachoompol et al., 2004). These drying methods, especially thin layer drying (Kingsly and Singh, 2007) cabinet drying (Kingsly and Singh, 2007), tunnel drying (Goyal et al., 2007) and other solar drying (Raquel et al., 2011) methods are being used for various fruits and vegetables, but Mulberry fruit is generally dried by sun drying. By keeping in view the aforementioned facts this research work was conducted to reduce quantitative and quality losses of Mulberry fruit in Skardu (Gilgit-Baltistan) and to generate understanding about quality discrimination among different drying methods.

Materials and Methods

The experiment was carried out in the laboratory of PCSIR (Pakistan Council of Scientific and Industrial Research), Skardu Gilgit Baltistan during the month of July to September (2014). Mulberry fruit was collected from the local orchard and brought to laboratory for further study. The fresh mulberry fruits were dehydrated through different drying techniques (i.e. open sun drying/traditional method, cabinet drying, and solar house drying and for portable solar drier). The dried mulberry samples were evaluated for chemical properties (total soluble solids, titratable acidity, pH, moisture content, water activity, reducing sugar, non-reducing sugar) by the method as described by AOAC (2012) and sensory properties by the hedonic scale method as described by Larmond (1977). All the parameters were studied with one month interval for a total storage period of five months. Data was analysed by the using complete randomize design (CRD) and mean were separated by using LSD according to the method of Steel and Torrie (1998).

Results and Discussion

During storage moisture content decreased to various levels that depend on drying method used for the dehydration of various samples (Table 1). The minimum decrease was found in tunnel drier (8.60 to 8.25) 4.06% followed by cabinet drier (8.50 to 8.10) 4.70% and maximum decrease was detected in sun drier (9.30 to 8.00) 13.97% followed by portable solar drier (7.70 to 7.10) 7.79%. The highest mean value tunnel drier (8.44%) for treatment and lowest mean value was noticed in portable solar drier (7.44%), in term of storage maximum mean value for moisture (8.40%) and lowest mean value (7.77%) was noticed at five month storage period. Moisture content of the sample dried in different types of dryer showed significantly (P<0.05) difference to each other. From these results, it is evident that at storage interval moisture content decreased. Although previously it was revealed that moisture content decrease during storage might be influenced by the temperature and packaging material (Gonzalo et al., 2014; Abdelgader and Ismail, 2011). This variation in moisture content is due to drying method (Valdangnegro et al., 2013; Suna et al., 2014).

Due to variance in moisture the calculated value for ash content also varies (Table 2), where it seems that the ash content increased with the passage of time. Furthermore, the ash content may increase during storage may be due to the structural changes during storage (Wali et al., 2013). The maximum increased

Table 2: *Effect of different drying techniques and storage on ash content of dried mulberry fruit*

Treatments	Storage Interval (30 days)						%Increase	Means
	Initial	30	60	90	120	150		
Sun drier	2.40	2.63	2.70	2.75	2.80	2.85	15.79	2.69b
Cabinet drier	2.23	2.36	2.53	2.66	2.76	2.80	20.36	2.55d
Tunnel drier	2.20	2.36	2.63	2.75	2.80	2.90	24.14	2.60cd
Solar drier	2.40	2.56	2.60	2.74	2.81	2.87	16.38	2.66c
Portable solar drier	2.60	2.73	2.80	2.93	3.00	3.05	14.75	2.85a
Means	**2.36e**	**2.53d**	**2.65c**	**2.76b**	**2.83ab**	**2.89a**		

Mean values followed by different small letters are significantly (P<0.05) different from each other

Table 3: *Effect of different drying techniques and storage on TSS of dried mulberry fruit*

Treatments	Storage Interval (30 days)						%Increase	Means
	Initial	30	60	90	120	150		
Sun drier	24.50	24.56	24.66	24.70	24.90	25.00	2.00	21.47c
Cabinet drier	26.00	26.10	26.15	26.20	26.30	26.40	1.51	22.66a
Tunnel drier	25.00	25.15	25.25	25.35	25.40	25.50	1.96	21.90b
Solar drier	25.10	25.20	25.26	25.36	25.44	25.48	1.49	21.90b
Portable solar drier	24.10	24.20	24.30	24.40	24.50	24.60	2.03	21.16d
Means	**24.94f**	**25.04e**	**25.12d**	**25.20c**	**25.30b**	**25.39a**		

Mean values followed by different small letters are significantly (P<0.05) different from each other

occurs in tunnel drier (2.20 to 2.90) 24.14% followed by cabinet drier (2.23 to 2.80) 2.36% and minimum increase was noticed in portable solar drier (2.60 to 3.05) 14.75% followed by sun drier (2.40 to 2.85) 15.79%. For treatment maximum mean value noted in portable solar drier (2.85%) while minimum was recorded in was noticed in cabinet drier (2.55%), in term of storage maximum mean value for ash content (2.89%) and lowest mean value (2.36%) was noticed at three-month interval. The ash content value of samples found significantly (P<0.05) in all treatment during storage. Similarly (Gani and Kumar, 2013) reported that ash content is an inorganic content residue which remain after removal of water and organic matter and mostly could not be decreased during storage. The results of ash content fall within the limits (2.5-3.0%) in dried mulberry fruit according to the findings of Karkaur et al. (2002).

The results obtained from different dying techniques and storage interval effect on TSS content of dehydrated mulberry fruit are shown in Table 3. Results indicated TSS increased during storage period. The maximum increase was occurs in portable solar drier (24.10 to 24.60) 2.02 % followed by sun drier (24.50 to 25.00) 2.00% and minimum increase was observed in solar drier (25.10 to 25.48) 1.49% followed by cabinet drier (24.10 to 24.60) 1.51%. Cabinet drier (22.66%) showed maximum mean value and portable solar drier (21.16%) was found minimum mean value for treatment, in term of storage maximum mean value for TSS content (25.39%) and lowest mean value (24.94%) was noticed at three month interval. Total soluble solids of the treatments showed significantly difference (P<0.05) to each other. The TSS increased during storage and showed significant difference during time interval while temperature is one of the main factor which affect total soluble solids during storage. On the other hand, total soluble solids is also related to moisture content i.e. increase in moisture content cause dilution effect of solids (Irwandi et al., 1998).

The tritratable acidity results data of dried mulberry is presented in Table 4. Results pointed that during storage tritratable acidity increased, highest increased occurs in sun drier (1.15 to 1.40) 17.86% followed by tunnel drier (1.12 to 1.30) 13.85% and lowest increase was observed in portable solar drier (1.13 to 1.29) 12.40% followed by solar drier (1.14 to 1.31) 12.28%. The maximum mean value found in sun drier (1.27%) while minimum value noticed in cabinet drier (1.18%) for treatment, in term of storage maximum mean value for tritratable acidity (1.31%) and lowest mean value (1.13%) was noticed at three month interval. The results indicate that tritratable acidity of dried mulberry dried in different dryer showed significantly

(P<0.05) different to each other and it was increased with the storage interval. The increase in tritratable acidity may be affected by the temperature and presence of sugar content in fruits and also influenced by breakdown of sugar into acids (Clydesdale et al., 1972; Che-Man and Sanny, 1996; Lum, 2011).

The results obtained from different dying techniques and storage interval effect on pH of dehydrated mulberry fruit are shown in Table 5. Results indicated that pH of the dried mulberry sample decreased during storage. The minimum decrease was found in solar drier (6.43 to 6.28) 2.30% followed by portable solar drier (6.40 to 6.25) 2.34% and maximum decrease was observed in cabinet drier (6.60 to 6.31) 4.39% followed by sun drier (6.50 to 6.27) 3.53%. The maximum mean value for treatment was found in cabinet drier (6.43%) while minimum in portable solar drier (6.32%), in term of storage maximum mean value for pH content (6.47%) and lowest mean value (6.28%) was noticed at three month interval. The results of pH similar to the results of Karkaur et al. (2002) they reported that pH of dried mulberry was in the range of 6.6- 6.8%. The pH value of all sample were significantly (P<0.05) different to among the treatments and storage period. The differences of pH of the treatments were due to the types of drying methods used (Valdangnegro et al., 2013; Irwandi et al., 1998), furthermore, pH of dried product is due to increase in acidity which caused decrease in pH (Imran et. al., 2000; Che-Man and Sanny, 1996).

The results indicated that reducing sugar vale was increased during storage period (Table 6). Highest increased occurs in portable solar drier (64.94 to 65.15) 0.32% followed by sun drier (62.31 to 62.51) 0.31% and lowest increase was observed in cabinet drier (63.60 to 63.75) 0.23% followed by tunnel drier (64.78 to 64.94) 0.23%. The highest mean for treatment founded in solar drier (65.46%) while lowest in sun drier (62.41%), in term of storage maximum mean value for reducing sugar (62.20%) and lowest mean value (64.38%) was noticed at three month interval. The reducing sugar the samples showed significant (P<0.05) effect of treatment and storage period. The results reducing sugar content closely agreement to the findings 35.07-61.48% reported by Karkaur et al. (2002). Minimum increased in reducing sugar may be due to breakdown of sucrose in to fructose and glucose (Ruiz et al., 1997). Reducing sugar might be influenced by the acidity which lowered the reducing sugar in dried fruits during storage (Che-Man and Sanny, 1996).

Results indicated that non-reducing value decreased with storage period (Table 7). The highest decreased

Table 4: *Effect of different drying techniques and storage on acidity of dried mulberry fruit*

Treatments	Storage Interval (30 days)						%Increase	Means
	Initial	30	60	90	120	150		
Sun drier	1.15	1.19	1.24	1.30	1.35	1.40	17.86	1.27a
Cabinet drier	1.10	1.14	1.18	1.20	1.23	1.27	13.36	1.18c
Tunnel drier	1.12	1.18	1.20	1.22	1.26	1.30	13.85	1.21b
Solar drier	1.14	1.17	1.21	1.25	1.28	1.31	12.98	1.22b
Portable solar drier	1.13	1.16	1.19	1.23	1.27	1.29	12.40	1.21b
Means	**1.13f**	**1.17e**	**1.20d**	**1.24c**	**1.27b**	**1.31a**		

Mean values followed by different small letters are significantly (P<0.05) different from each other

Table 5: *Effect of different drying techniques and storage on pH of dried mulberry fruit*

Treatments	Storage Interval (30 days)						%Decrease	Means
	Initial	30	60	90	120	150		
Sun drier	6.50	6.42	6.37	6.35	6.30	6.27	3.53	6.37b
Cabinet drier	6.60	6.53	6.46	6.38	6.34	6.31	4.39	6.43a
Tunnel drier	6.45	6.41	6.37	6.35	6.31	6.29	2.48	6.36b
Solar drier	6.43	6.39	6.36	6.33	6.30	6.28	2.30	6.34bc
Portable solar drier	6.40	6.37	6.35	6.31	6.27	6.25	2.34	6.32c
Means	**6.47a**	**6.42b**	**6.38c**	**6.34d**	**6.30e**	**6.28e**		

Mean values followed by different small letters are significantly (P<0.05) different from each other

Table 6: *Effect of different drying techniques and storage on reducing sugar of dried mulberry fruit*

Treatments	Storage Interval (30 days)						%Increase	Means
	Initial	**30**	**60**	**90**	**120**	**150**		
Sun drier	62.31	62.36	62.4	62.43	62.48	62.51	0.31	62.41e
Cabinet drier	63.60	63.64	63.66	63.69	63.71	63.75	0.23	63.67d
Tunnel drier	64.78	64.81	64.85	64.88	64.91	64.94	0.24	64.86c
Solar drier	65.37	65.41	65.45	65.48	65.51	65.56	0.28	65.46a
Portable solar drier	64.94	64.98	65.01	65.05	65.10	65.15	0.32	65.03b
Means	**64.20f**	**64.24e**	**64.27d**	**64.30c**	**64.34b**	**64.38a**		

Mean values followed by different small letters are significantly (P<0.05) different from each other

Table 7: *Effect of different drying techniques and storage on non-reducing sugar of dried mulberry fruit*

Treatments	Storage Interval (30 days)						%Decrease	Means
	Initial	30	60	90	120	150		
Sun drier	6.14	6.09	6.05	6.02	5.97	5.94	3.25	6.03a
Cabinet drier	6.04	6.00	5.98	5.95	5.93	5.89	2.48	5.96b
Tunnel drier	5.66	5.63	5.59	5.56	5.53	5.50	2.82	5.57c
Solar drier	5.59	5.55	5.51	5.48	5.45	5.40	3.39	5.49d
Portable solar drier	5.29	5.25	5.22	5.17	5.13	5.08	3.96	5.19e
Means	**5.74a**	**5.70b**	**5.60c**	**5.63d**	**5.60e**	**5.56f**		

Mean values followed by different small letters are significantly (P<0.05) different from each other

Table 8: *Effect of different drying techniques and storage on water activity of dried mulberry fruit*

Treatments	Storage Interval (30 days)						%Decrease	Means
	Initial	**30**	**60**	**90**	**120**	**150**		
Sun drier	0.45	0.36	0.35	0.34	0.33	0.31	31.11	0.35bc
Cabinet drier	0.46	0.35	0.34	0.33	0.32	0.30	34.78	0.35c
Tunnel drier	0.47	0.36	0.35	0.34	0.33	0.32	31.91	0.36bc
Solar drier	0.43	0.38	0.37	0.36	0.35	0.34	20.93	0.37ab
Portable solar drier	0.42	0.39	0.39	0.38	0.37	0.36	14.28	0.38a
Means	**0.44a**	**0.36b**	**0.36bc**	**0.35bc**	**0.34cd**	**0.326d**		

Mean values followed by different small letters are significantly (P<0.05) different from each other

occurs in portable solar drier (5.29 to 508) 3.96% followed by solar drier (5.59 to 5.40) 3.39% and lowest increase was found in cabinet drier (6.14 to 5.94) 2.48% followed by tunnel drier (5.66 to 5.5) 2.82%. The maximum mean value for treatment was noticed sun drier (6.03%) while minimum in portable solar drier (5.19%), in term of storage maximum mean value for non-reducing sugar content (5.74%) and lowest mean value (5.56%) was noticed at three month interval. The non-reducing sugar the samples showed significant effect (P<0.05). Less decrease in non-reducing may be due to increased in acidity (Ruiz et al., 1997).

Results indicated that water activity decreased with storage period (Table 8). The highest decreased found in cabinet drier (0.46 to 0.30) 34.78% followed by tunnel drier (0.47 to 0.32) 31.91% while lowest increase was observed in portable solar drier (0.42 to 0.36) 14.28% followed by solar drier (0.43 to 0.34) 20.93%. Maximum mean value was found in portable solar drier (0.38%) and minimum value noticed in sun drier (0.35%) for treatment, in term of storage maximum mean value for water activity (0.44%) and lowest mean value was (0.32%) noticed at three month interval. Statistically, it was observed from the results that the water activity of the samples showed significantly (P<0.05) difference in respect to treatment and storage period. The mentioned water activity value related to the results of Singh et al. (2012), they reported in their study that dried aonla have a water activity ranged from (0.47-0.68). Decrease in water activity is due to the decrease in moisture content of all the samples. So water activity decreased may be due to fluctuation in storage temperature within 24h (Irwandi et al., 1998; Abdelgader and Ismail, 2011; Che-Man and Sanny, 1996).

Sensory evaluation

The dehydrated mulberry samples were evaluated for sensory analysis such as color, texture, taste and overall acceptability (Table 9). Color value of the dried sample decreased during storage the highest score decreased found in tunnel drier (8.03 to 5.20) 35.24% followed by cabinet drier (8.03 to 5.30) 33.99% and lowest decrease was observed in portable solar drier (8.46 to 7.70) 8.98% followed by solar drier (8.36 to 7.10) 15.07%. The highest mean score value for treatment was found in portable solar drier (7.85) while lowest mean score value was noticed in cabinet drier (6.21), in term of storage maximum mean value for color (8.21) and lowest mean score value (6.35) was noticed at three month intervals. Food color is the main factor of any product quality which affect consumer acceptance (Valdenegro et al., 2013). Statistically, the results indicated that the color of dried mulberry changed with the passage of time and showed significantly ($P<0.05$) differences. Basically, color is an indicator of any product to predict the quality changes and chemical changes of product which treated with different methods (Valdenegro et al., 2013). The results indicate that different types of drying methods significant affected the color of all samples and judges highly preferred the color of mulberry dried by MP4 during storage. Color may be affected by the packaging material (Irwandi et al., 1998) additionally by the presence of oxygen and non- enzymatic reaction during storage (Che-Man and Sanny, 1996).

Results elated to the texture of dehydrated mulberry fruit are shown in Table 10. Texture quality of dried mulberry samples decreased during 150 days storage period. The maximum decreased occurs in tunnel drier (8.13 to 5.25) 35.42% followed by cabinet drier (8.06 to 5.75) 28.66% and lowest decrease was observed in portable solar drier (8.53 to 6.30) 26.14% followed by solar drier (8.20 to 6.00) 26.82%. The highest mean score for treatment was found in portable solar drier (7.02) and lowest mean score value was noticed in tunnel drier (6.20), in term of storage maximum mean score value for texture (8.26) and lowest mean score value (5.86) was noticed at three month intervals. The dried samples showed the treatments affected significantly ($P<0.05$) on texture within the storage time.

The results showed that the texture hardened with the passage of time may be due to decrease in moisture

Table 9: *Effect of different drying techniques and storage on color of dried mulberry fruit*

Treatments	Storage Interval (30 days)						%Decrease	Means
	Initial	30	60	90	120	150		
Sun drier	8.20	7.40	7.10	6.56	6.50	6.45	21.34	7.03b
Cabinet drier	8.03	7.10	6.10	5.40	5.35	5.30	33.99	6.21c
Tunnel drier	8.03	7.03	6.40	6.30	5.25	5.20	35.24	6.36c
Solar drier	8.36	7.80	7.50	7.20	7.15	7.10	15.07	7.51a
Portable solar drier	8.46	8.30	7.70	7.50	7.45	7.70	8.98	7.85a
Means	**8.21a**	**7.52b**	**6.96c**	**6.59cd**	**6.34d**	**6.35d**		

Mean values followed by different small letters are significantly ($P<0.05$) different from each other

Table 10: *Effect of different drying techniques and storage on texture of dried mulberry fruit*

Treatments	Storage Interval (30 days)						%Decrease	Means
	Initial	30	60	90	120	150		
Sun drier	8.36	7.46	6.36	6.10	6.05	6.00	28.22	6.72b
Cabinet drier	8.06	7.2	6.03	5.76	5.70	5.75	28.66	6.41c
Tunnel drier	8.13	7.03	6.13	5.36	5.30	5.25	35.42	6.20d
Solar drier	8.20	7.30	6.26	6.10	6.05	6.00	26.82	6.65b
Portable solar drier	8.53	7.76	6.80	6.40	6.35	6.30	26.14	7.02a
Means	**8.26a**	**7.35b**	**6.32c**	**5.94d**	**5.89d**	**5.86d**		

Mean values followed by different small letters are significantly ($P<0.05$) different from each other

Table 11: *Effect of different drying techniques and storage on taste of dried mulberry fruit*

Treatments	Storage interval (30 days)						%Decrease	Means
	Initial	30	60	90	120	150		
Sun drier	8.03	8.00	7.46	7.26	7.20	7.15	10.95	7.51bc
Cabinet drier	8.46	8.10	7.23	7.06	7.00	6.95	17.84	7.46bc
Tunnel drier	8.36	8.06	7.13	7.03	7.00	6.98	16.50	7.42c
Solar drier	8.70	8.46	7.20	7.16	7.11	7.09	18.50	7.62b
Portable solar drier	8.80	8.56	7.90	7.86	7.84	7.80	11.36	8.12a
Means	**8.47a**	**8.23b**	**7.38c**	**7.27c**	**7.23c**	**7.19c**		

Mean values followed by different small letters are significantly (P<0.05) different from each other

Table 12: *Effect of different drying techniques and storage on overall acceptability of dried mulberry fruit*

Treatments	Storage Interval (30 days)						%Decrease	Means
	Initial	30	60	90	120	150		
Sun drier	8.16	8.03	7.20	6.96	6.85	6.80	16.66	7.33c
Cabinet drier	8.00	7.76	7.30	6.70	6.65	6.60	17.50	7.16d
Tunnel drier	7.96	7.86	7.16	6.80	6.75	6.70	15.82	7.20d
Solar drier	8.40	8.36	7.56	7.10	7.09	6.90	17.85	7.56b
Portable solar drier	8.86	8.56	7.76	7.40	7.35	7.30	17.60	7.87a
Means	**8.27a**	**8.11b**	**7.39c**	**6.99d**	**6.93de**	**6.86e**		

Mean values followed by different small letters are significantly (P<0.05) different from each other

content of product (Che-Man and Sanny, 1996). Sing et al. (2012) reported that the texture score ranged 6 – 8 in dried berry.

The results regarding to sensory evaluation of taste through 9 point hedonic scale are shown in Table 11. Results indicated that taste of dried mulberry samples were decreased within 150 days of storage. The highest decrease in score rate was found solar drier (8.70 to 7.09) 18.50% followed by cabinet drier (8.46 to 6.95) 17.84% while lowest decrease was observed in sun drier (8.03 to 7.15) 10.95% followed by portable solar drier (8.80 to 7.80) 11.36%. The highest mean score value for treatment was found in portable solar drier (8.12) and lowest mean score value was noticed in tunnel drier (7.42), in term of storage maximum mean value for taste (8.47) and lowest mean score value (7.19) was noticed at three month intervals. The treatments showed significantly affected (P<0.05) on taste during storage period. The previous research work revealed that taste of the product may be affected due to the breakdown of sugar content and the minimum increase in acidity % are also affected the taste of the stored product (Sing et al., 2012; Che-Man and Sanny, 1996).

The results considering to overall acceptability of dried mulberry at five months storage are shown in Table 12. The results of overall acceptability were shoed decreasing with storage period. The heights score rate decrease was occurred in solar drier (8.40 to 6.90) 17.85% followed by portable solar drier (8.86 to 7.30) 17.60% while lowest decrease score value was observed in tunnel drier (7.96 to 6.70) 15.82% followed by cabinet drier (8.00 6.600 17.50%. The highest mean score for treatment was found in portable solar drier (7.87) while lowest mean score value was observed in cabinet drier (7.16), in term of storage maximum mean score for overall acceptability (8.27) and lowest mean score (6.86) was noticed at 90 days interval. The overall acceptability of dried mulberry with respect to color, texture, flavor and taste was acceptable during 150 days interval. There were not highly significant (P<0.05) differences found during storage period. Sing et al. (2012) reported that overall acceptability during 90 days storage time was scored in the range of 8.51-7.81. The product was acceptable scores higher than 4 (Che-Man and Sanny, 1996).

Conclusion

The results of the present research work proves that dehydration of mulberry fruit in solar drier (solar house) and portable solar dryer followed by tunnel dryer and cabinet dryer were found better than open sun drying on the basis of physicochemical and sensory evaluation.

Authors' Contribution

Murtaza Ali carried out the research and prepared the draft of the manuscript. While Yasser Durrani and Muhammad Ayub designed the research work and checked the manuscript preparation and editing and replied to comments of referees. All the authors read and approved the final manuscript.

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