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STANDARDIZATION OF PROTOCOL FOR PREPARATION OF DEHYDRATED WHOLE LIME FRUITS

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ABSTRACT

There is a lot of demand for dried black lime or dehydrated whole lime in the Middle East countries because of the non-availability of fresh lime. The flavour quality of dehydrated lime fruits is affected by the presence of bitterness. The pre-treatments imposed for removal of bitterness consist of blanching of fruits at 85°C and 95°C in different salt solutions (4, 8 and 12%) prior to drying followed by drying them in an electric tray drier at 60°C. The minimum moisture content (11.75%) and water activity (0.34) of dehydrated whole lime fruits after drying were recorded in fruits blanched @ 95°C for 8 minutes in a 12% salt solution. However, the maximum moisture content (12.56%) and water activity (0.46) were registered in untreated (without pre-treatments) at the initial period. The maximum acidity (6.67%) and ascorbic acid (35.71 mg/100 mg of fruit) content were also recorded maximum in this treatment. *L** value for fruits blanched @ 95°C for 8 minutes in 12% salt solution was minimum (33.18) which shows the darkness of dehydrated fruits. The highest score for taste, flavour and overall acceptability was recorded (7.00, 9.00 and 8.00, respectively) in fruits blanched @ 95°C for 8 minutes in 12% salt solution. Whereas, the untreated fruits and fruits blanched with normal water were recorded the lowest score for organoleptic evaluation. The best quality of dehydrated whole lime fruits were obtained by blanching the fresh yellow coloured fruits in water containing 12% NaCl for 8 minutes followed by drying them in an electric tray drier at 60°C.

Keywords **:** Dehydrated whole lime, Kagzi lime, blanching, black lemon.

Introduction

Kagzi lime (Pati lime, Spur lime, Acid lime, Mexican lime) in Hindi is known as 'Neebu or Nimbu', belongs to the family Rutaceae with botanical name *Citrus aurantifolia* Swingle. It is one of the most important citrus fruits for vitamin C and acetic acid sources. Acid lime is mainly grown in semi-arid climate of Andhra Pradesh, Maharashtra, Tamil Nadu, Gujarat, and Karnataka. Currently, India leads global acid lime production with an area of 3.09 lakh hectares yielding 37.71 lakh metric tonnes (Anon., 2024). Lime is globally recognized for its tart, tangy, flavored juice and for its unique characteristic flowery aroma. It is used for flavoring alcoholic drinks and as a garnish for fish and meat and for preparing beverages. The important commercial products of lime are lime juice, lime cordial, lime oil and calcium citrate, dried or dehydrated lime peel, lime powder and pickles. Dried lime peel powder and lime sediment obtained when lime juice is clarified are utilized for cleaning metal ware. Lime peel is also used as cattle feed. Lime is an appetizer, stomachic, antiscorbutic and anthelimintic. It is also known to check biliousness. Salted lime peel is recommended for indigestion.

During harvesting season there is a glut in the market leading to unfavorable (throw away prices) prices for the producer; so also in the lean season higher prices prevail for the consumers. Moreover, it

becomes impracticable to handle all the available fruits which may lead to a huge amount of loss. There is a lot of demand for dried black lime or dehydrated whole lime in the Middle East countries because of the non-availability of fresh lime. The dried lemons are called black lemon - loomi or lumi in the Gulf countries (Basunia *et al.* 2013). The dehydrated limes are used as a whole, sliced or ground as a spice in cooking foods particularly for their distinct citrus flavour and sour tang. It is also used as flavour ingredient in bakery products, salad dressing and dry products. The flavour quality of dehydrated lime fruits is affected by the presence of bitterness. This can be removed by some pre-treatments before drying and the pre-treatments are necessary pre-requisites for a successful drying process. The processing of lime in the dehydrated form either as a whole fruit or only its rind is a viable alternative for this fruit. Considering the importance of dehydrated lime fruits the present investigation was undertaken for standardization of protocol for the preparation of dehydrated whole lime fruits.

Material and Methods

The present investigation was conducted in the Department of Postharvest Management, College of Horticulture, Bagalkot, with an objective of standardization of protocol for preparation of dehydrated whole lime fruits. Fully matured, yellow coloured 'Kagzi'lime fruits of uniform size were harvested with the help of a harvesting pole. Soon after harvest, the fruits were brought to the laboratory, pre-cooled under fan for half an hour and only good fruits were selected for the study. Whole lime fruits were blanched with or without salt solutions (4%, 8% and 12%) at two different temperatures (85^{o}C and 95^{o}C) for 8 minutes (Table 1). The fruits were then taken out for draining to remove the excess water and dried in a cabinet tray drier at a temperature of 60^{o}C for 7 days. After drying, fruits were packed in polythene bags of 200 gauge thickness and stored in an airtight container.

Titrable acidity was estimated by titrating against standard NaOH (0.1 N) using phenolphthalein indicator and the value was expressed in terms of citric acid as % titrable acidity (Anon., 1984). Ascorbic acid content was estimated titrimetrically using 2, 6-dichlorophenol indophenol dye as per the modified procedure of AOAC and the ascorbic acid content was expressed as mg 100ml^{-1} (Anon., 1984). The water activity of dried lime fruit was measured using a water activity meter (Model: Novasina AG, Switzerland). The colour of the samples was measured using the Lovibond colour meter (Model: Lovibond RT300, Portable spectrometer, The Tintometer Limited, Salisbury, UK) fitted with an 8mm diameter aperture. The moisture content of dehydrated lime fruit was estimated by using a Radwag moisture analyzer (Model: MAC 50, Make: Poland). Sensory evaluation of the dehydrated lime fruit was carried out at regular intervals by using a panel of 8 -10 semi-trained judges consisting of teachers and PG students of College of Horticulture, Bagalkot (9 points Hedonic rating test-Ranganna, 1997). The microbial count on dehydrated lime fruit powder was taken at bi-monthly intervals during storage as per the method of Harrigan and McCance (1966).

Result and Discussion

In the present investigation, different pre-treatments were employed to remove the bitterness in dried fruit *viz.,* blanching in hot water and blanching in salt water at different concentrations and different temperatures. The results obtained in this study are discussed hereunder.

The moisture content in the final dehydrated whole lime fruit was found significantly different with the different pre-treatments (Table 2). However, the moisture content found in all the treatments ranged from 11.75 to 12.56% at the initial stage. Significantly minimum moisture content was recorded in T_8 (12.14%) at 6 MAS, which was on par with T_1 (12.29%), T_4 (12.04%), T_6 (12.27%) and T_7 (12.24%). Whereas, the maximum moisture content was recorded in T_9 (12.65%) which was on par with T_2 (12.42%) and T_3 (12.36%). Water activity plays an important role in determining physical properties such as texture and shelf life of foods. Dehydrated lime produced by employing different pre treatments showed significant differences in water activity (Table.2). At 6 MAS, the minimum water activity was recorded in T_4 which was on par with T_2, T_3, T_6, T_7 and T_8 whereas, the maximum was noticed in T_9 (Control) and which was on par with T_1 and T_5. Both moisture content and water activity are directly correlated and they play an important role in the growth of micro organisms. Both these parameters slightly increased with the progression of the storage period. This increase in the moisture content might be due to the absorption of moisture during storage at room temperature.

Ascorbic acid is one of the major nutritional components of lime fruit which also contributes to the acidic taste of fruit. Ascorbic acid (34.11 to 29.71 mg100g^{-1}) and acidity (6.53 to 6.10) content of dehydrated lime were found to decrease with an increase in storage period (Table 3). The decrease in acidity might be attributed to bioconversion of acid to sugar and also there is a formation of complex compounds such as citrate with salt (Singh *et al.*,

2012). However, the decline in the ascorbic acid content might be due to thermal oxidation during processing and subsequent oxidation in storage (Deen, 1992). The maximum ascorbic acid retention was noticed in T_8 which was on par with T_4 and T_7 at 6 MAS. The maximum acidity was recorded in T_8 whereas, the minimum was in T_9 (Control) which was on par with T_1, T_2, T_3, T_5 and T_6.

The maximum *L** value was recorded in T_9 (37.33) which was on par with T_1 (36.10). The minimum was noticed in T_4 (32.07) which was on par with T_3 (32.77) and T_8 (33.18). The lightness (*L**) value was decreased with an increase in blanching temperature and an increase in salt concentration. It means that salt treated fruits give dark brown or black colour while, the fruits treated in hot water were brownish in colour. This might be due to the breakdown of ascorbic acid during processing (Srivastava and Kumar, 2022). The higher concentration of the salt solution and higher blanching temperature may directly influence the colour of dried fruit.

Organoleptic evaluation plays a key role in deciding the superiority of a product with respect to consumer acceptability (Table. 5). Negligible changes were recorded with respect to the taste of dehydrated fruit (decoction). The mean initial taste (5.56) further declined (5.50) after 6 months of storage. Whereas, flavour quality (7.50 to 7.06) and overall acceptability (6.53 to 6.28) were decreased as the storage period increased. The fruits blanched at 95°C in different salt concentrations (4, 8 and 12%) recorded maximum values (minimum bitterness) than the fruits blanched at 85°C with different salt concentrations.

The minimum score (maximum bitterness) was recorded in the untreated control. The decrease in the bitter taste of salt treated lime fruits might be due to the flavonoids which are responsible for bitter taste however become water soluble at higher temperature in salt (basic) solutions. Pinzon *et al*. (2013) reported that the bitter taste of orange peel is due to the presence of hespiridin and naringin. These flavonoids are water soluble at 80°C in a basic solution. Jose *et al*. (2004) reported that sometimes blanching removes undesirable bitter flavours from the product. The maximum flavour retention was observed in fruits blanched at 95°C in different salt concentrations (4, 8 and 12%) than fruits blanched at 85°C with different salt concentrations.

The microbial count was recorded after dehydrating the lime fruit at bimonthly storage (Table. 6). The microbial count showed a slight increase in their number during the storage period of six months. However, such a marginal increase did not affect the wholesomeness of the product. The increase in the bacterial and fungal population of the dried product during storage was noticed by Adsure *et al.* (2023) in cauliflower and fenugreek. The minimum bacterial and fungal count was attributed to the higher drying temperature and blanching with a higher concentration of salt solution which inhibits microbial growth. Blanching with high salt concentration makes fruits free from the attack of fungi and blanching inactivates enzymes. The dehydrated lime fruits in these treatments showed less water activity which makes an unfavorable condition for microbes.

Conclusion

The best quality of dehydrated whole lime fruits was obtained by blanching the fresh yellow-coloured fruits in water containing 12% NaCl for 8 minutes followed by drying them in an electric tray drier at 60°C.

Table 1 : The pre-treatment imposed for preparation of dehydrated whole lime

T1	:	Blanching @ 85°C for 8 minutes in normal water
T2	:	Blanching @ 85°C for 8 minutes in 4% salt solution
T3	:	Blanching @ 85°C for 8 minutes in 8% salt solution
T4	:	Blanching @ 85°C for 8 minutes in 12% salt solution
T5	:	Blanching @ 95°C for 8 minutes in normal water
T6	:	Blanching @ 95°C for 8 minutes in 4% salt solution
T7	:	Blanching @ 95°C for 8 minutes in 8% salt solution
T8	:	Blanching @ 95°C for 8 minutes in 12% salt solution
T9	:	Control (drying without treatments)

Table 2 : Effect of pre-treatments on moisture content and water activity of dehydrated whole lime fruits

Treatments	Moisture content (%)				Water activity			
	Initial	2 MAS	4 MAS	6 MAS	Initial	2 MAS	4 MAS	6 MAS
T_1- Blanching @ 85^{0}C for 8 minutes in normal water	12.44	12.23	12.26	12.29	0.45	0.45	0.47	0.47
T_2- Blanching @ 85^{0}C for 8 minutes in 4% salt solution	12.23	12.33	12.34	12.42	0.41	0.41	0.43	0.43
T_3- Blanching @ 85^{0}C for 8 minutes in 8% salt solution	12.20	12.28	12.31	12.36	0.40	0.41	0.42	0.41
T_4- Blanching @ 85^{0}C for 8 minutes in 12% salt solution	11.78	11.86	11.89	12.04	0.35	0.38	0.40	0.40
T_5- Blanching @ 95^{0}C for 8 minutes in normal water	12.20	12.45	12.47	12.56	0.40	0.42	0.46	0.45
T_6- Blanching @ 95^{0}C for 8 minutes in 4% salt solution	12.19	12.21	12.24	12.27	0.39	0.41	0.43	0.43
T_7- Blanching @ 95^{0}C for 8 minutes in 8% salt solution	12.18	12.20	12.23	12.24	0.37	0.40	0.42	0.43
T_8- Blanching @ 95^{0}C for 8 minutes in 12% salt solution	11.75	12.02	12.08	12.14	0.34	0.39	0.40	0.41
T_9- Control (drying without treatments)	12.56	12.59	12.61	12.65	0.46	0.49	0.50	0.50
Mean	**12.17**	**12.24**	**12.27**	**12.33**	**0.40**	**0.42**	**0.44**	**0.44**
SE ±	**0.224**	**0.190**	**0.930**	**0.550**	**0.007**	**0.007**	**0.005**	**0.009**
CD at 1%	**NS**	**NS**	**0.538**	**0.315**	**0.041**	**0.040**	**0.031**	**0.050**

MAS: Month After Storage

Table 3 : Effect of pre-treatments on acidity and ascorbic acid of dehydrated whole lime fruits

Treatments	Acidity (%)				Ascorbic acid (mg100g^{-1})			
	Initial	2 MAS	4 MAS	6 MAS	Initial	2 MAS	4 MAS	6 MAS
T_1- Blanching @ 85^{0}C for 8 minutes in normal water	6.40	6.32	6.24	5.92	32.22	32.22	29.26	28.15
T_2- Blanching @ 85^{0}C for 8 minutes in 4% salt solution	6.48	6.40	6.24	6.08	34.13	33.33	30.00	29.26
T_3- Blanching @ 85^{0}C for 8 minutes in 8% salt solution	6.56	6.48	6.32	6.16	34.92	33.33	32.22	30.00
T_4- Blanching @ 85^{0}C for 8 minutes in 12% salt solution	6.72	6.56	6.48	6.24	35.71	34.92	33.33	31.11
T_5- Blanching @ 95^{0}C for 8 minutes in normal water	6.48	6.40	6.08	6.00	33.33	31.11	30.00	28.15
T_6- Blanching @ 95^{0}C for 8 minutes in 4% salt solution	6.56	6.40	6.16	6.16	34.13	34.92	32.22	30.00
T_7- Blanching @ 95^{0}C for 8 minutes in 8% salt solution	6.64	6.48	6.24	6.24	35.71	35.71	33.33	31.11
T_8- Blanching @ 95^{0}C for 8 minutes in 12% salt solution	6.67	6.64	6.56	6.32	35.71	35.71	34.92	33.33
T_9- Control (drying without treatments)	6.24	6.08	5.84	5.76	31.11	29.26	27.04	26.30
Mean	**6.53**	**6.42**	**6.24**	**6.10**	**34.11**	**33.39**	**31.37**	**29.71**
S.E. m±	**0.077**	**0.084**	**0.075**	**0.060**	**0.696**	**0.689**	**0.912**	**0.751**
CD at 1%	**NS**	**NS**	**0.434**	**0.343**	**4.006**	**3.969**	**5.251**	**4.323**

MAS: Month After Storage

Table 4 : Effect of pre-treatments on *L**, *a** and *b** values of dehydrated whole lime fruits

Treatments	*L**				*a**				*b**			
	Initial	2 MAS	4 MAS	6 MAS	Initial	2 MAS	4 MAS	6 MAS	Initial	2 MAS	4 MAS	6 MAS
T_1	36.10	35.48	35.45	35.31	9.10	9.09	9.07	9.07	18.71	18.72	18.70	18.67
T_2	35.60	34.14	34.30	34.09	8.80	8.78	8.71	8.62	19.06	19.06	19.05	19.03
T_3	32.77	32.59	32.53	32.33	8.65	8.65	8.63	8.58	17.08	17.12	17.08	17.00
T_4	32.07	32.04	32.09	32.03	8.66	8.66	8.62	8.60	15.08	15.16	15.16	15.08
T_5	35.78	34.34	33.96	33.84	8.54	8.54	8.46	8.41	16.14	16.21	16.20	16.14
T_6	34.60	32.78	32.52	32.31	8.32	8.27	8.23	8.20	16.42	16.41	16.39	16.34
T_7	34.38	32.30	32.11	32.26	8.47	8.40	8.39	8.31	17.50	17.52	17.47	17.46
T_8	33.18	32.18	32.06	31.99	8.51	8.48	8.46	8.43	16.62	16.43	16.39	16.32
T_9	37.33	36.97	36.97	36.63	9.01	8.96	8.90	8.84	19.50	19.05	19.01	18.99
Mean	**34.65**	**33.65**	**33.55**	**33.42**	**8.67**	**8.65**	**8.61**	**8.56**	**17.35**	**17.30**	**17.27**	**17.23**
S.E. m±	**0.262**	**0.250**	**0.198**	**0.213**	**0.083**	**0.085**	**0.088**	**0.085**	**0.027**	**0.112**	**0.114**	**0.045**
CD at 1%	**1.507**	**1.440**	**1.139**	**1.229**	**0.048**	**0.490**	**0.504**	**0.489**	**0.154**	**0.646**	**0.659**	**0.261**

MAS: Month After Storage

T_1- Blanching @ 85^{0}C for 8 minutes in normal water
T_2- Blanching @ 85^{0}C for 8 minutes in 4% salt solution
T_3- Blanching @ 85^{0}C for 8 minutes in 8% salt solution
T_4- Blanching @ 85^{0}C for 8 minutes in 12% salt solution
T_5- Blanching @ 95^{0}C for 8 minutes in normal water
T_6- Blanching @ 95^{0}C for 8 minutes in 4% salt solution
T_7- Blanching @ 95^{0}C for 8 minutes in 8% salt solution
T_8- Blanching @ 95^{0}C for 8 minutes in 12% salt solution
T_9- Control (drying without treatments)

Table 5 : Effect of pre-treatments on organoleptic quality of decoction prepared out of dehydrated whole lime fruits

Treatments	Taste				Flavour				Overall acceptability			
	Initial	2 MAS	4 MAS	6 MAS	Initial	2 MAS	4 MAS	6 MAS	Initial	2 MAS	4 MAS	6 MAS
T_1	5.00	5.00	4.50	4.50	7.00	7.00	6.50	6.50	6.00	6.00	5.50	5.50
T_2	5.50	5.50	5.50	5.50	7.00	7.00	7.00	7.00	6.25	6.25	6.25	6.25
T_3	5.50	5.50	6.00	5.00	7.00	7.00	7.00	7.00	6.25	6.25	6.50	6.00
T_4	6.00	6.00	5.50	5.50	7.50	7.50	7.00	7.00	6.75	6.75	6.25	6.25
T_5	5.00	5.00	6.00	5.00	7.00	7.00	6.50	6.50	6.00	6.00	6.25	5.75
T_6	6.00	6.00	5.00	6.50	8.00	7.50	7.50	7.00	7.00	6.75	6.25	6.75
T_7	6.00	6.00	6.00	5.50	8.00	8.00	7.50	7.50	7.00	7.00	6.75	6.50
T_8	7.00	7.00	6.00	6.50	9.00	9.00	8.00	8.50	8.00	8.00	7.00	7.50
T_9	4.00	4.00	7.00	5.50	7.00	7.00	9.00	6.50	5.50	5.50	8.00	6.00
Mean	5.56	5.56	5.72	5.50	7.50	7.44	7.33	7.06	6.53	6.50	6.53	6.28
S.E. m±	**0.236**	**0.373**	**0.236**	**0.304**	**0.096**	**0.136**	**0.167**	**0.192**	**0.136**	**0.159**	**0.118**	**0.167**
CD at 1%	**1.357**	**2.145**	**1.357**	**1.752**	**0.554**	**0.783**	**0.959**	**1.108**	**0.783**	**0.919**	**0.678**	**0.959**

MAS: Month After Storage

T_1- Blanching @ 85^0C for 8 minutes in normal water
T_2- Blanching @ 85^0C for 8 minutes in 4% salt solution
T_3- Blanching @ 85^0C for 8 minutes in 8% salt solution
T_4- Blanching @ 85^0C for 8 minutes in 12% salt solution
T_5- Blanching @ 95^0C for 8 minutes in normal water
T_6- Blanching @ 95^0C for 8 minutes in 4% salt solution
T_7- Blanching @ 95^0C for 8 minutes in 8% salt solution
T_8- Blanching @ 95^0C for 8 minutes in 12% salt solution
T_9- Control (drying without treatments)

Table 6 : Influence of pre-treatments on microbial load of dehydrated whole lime fruits

Treatments	Bacteria No. x 10^5 (CFU g^{-1})			Fungi No. x 10^3 (CFU g^{-1})		
	2 MAS	4 MAS	6 MAS	2 MAS	4 MAS	6 MAS
T_1- Blanching @ 85^0C for 8 minutes in normal water	2.35	3.00	4.31	1.50	2.00	2.45
T_2- Blanching @ 85^0C for 8 minutes in 4% salt solution	2.00	2.50	3.65	1.25	1.88	2.30
T_3- Blanching @ 85^0C for 8 minutes in 8% salt solution	1.56	2.00	3.00	1.25	1.50	2.00
T_4- Blanching @ 85^0C for 8 minutes in 12% salt solution	1.33	2.00	3.18	1.00	1.25	1.88
T_5- Blanching @ 95^0C for 8 minutes in normal water	2.15	3.25	4.68	2.00	2.25	3.00
T_6- Blanching @ 95^0C for 8 minutes in 4% salt solution	2.00	2.80	3.50	1.50	1.68	2.00
T_7- Blanching @ 95^0C for 8 minutes in 8% salt solution	1.50	2.00	2.45	1.00	1.22	1.50
T_8- Blanching @ 95^0C for 8 minutes in 12% salt solution	1.50	2.00	2.32	1.00	1.00	1.25
T_9- Control (drying without treatments)	2.50	3.00	5.85	2.50	3.00	3.50

MAS: Month After Storage

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