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Effect of drying methods and pre-drying treatments on physical quality of wood apple pulp powder

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Abstract
The mature wood apple was procured from the local market at bolpur district of West Bengal. Some of the wood apple were treated with hot water and some of them were treated with normal water, then scooped out the pulp with seed from hard shell with the help of spoon, dried the pulp by sun drying and hot air oven drying at 450C and ground the dried pulp in the mixer grinder and formulate the powder. KMS of concentration 0.5% and 1% are added to the powder. By this research it was found that, a good quality value added product produced from this fruit in the form of dried powder, as this fruits have some special medicinal and nutritive value. The prepared wood apple (*Limonia acidissima* L.) pulp powder were compared for its drying characteristics, physical properties like bulk density, true density and porosity and nutritional properties. The wood apple pulp gets completely dried within 25-30 hours in both of the drying methods. The wood apple pulp gets completely dried within 25-30 hours in all drying methods. The dehydration ratio is more in oven dried sample (2.81) and rehydration ratio is more in sundried sample (1.40). So, sun drying is proved to be better than oven drying in terms of drying characteristics. So, dried wood apple pulp powder retains more nutrients than the fresh one. There is no more such of pre-drying treatments on the qualities of wood apple pulp powder. The quality is mainly effected by the drying methods. Sun drying is cheaper, easier and cost-effective than oven drying and also remove more moisture than oven drying. Organoleptically, the hot air oven dried sample was liked very much in terms of its appearance, color and flavor. The low bulk density of sundried wood apple pulp powder would be advantageous in the use of product for preparing complementary foods. So, in terms of drying characteristics and physical properties sun dried wood apple pulp powder exhibited highest index than oven dried. Hence the wood apple pulp could be dried effectively using sun drying, preserved as dried powder and value added for its industrial exploitation. Since sun drying is also cost effective, the wood apple pulp could be sun dried, formulated into powder and utilized for the preparation of jam, jelly and other products with good gelling nature even during off-season.

Keywords: Sun drying, oven drying, wood apple pulp powder

Introduction
Wood-apple is a medium-sized deciduous tropical tree belongs to family Rutaceae. It is common to the dry districts of India as well as the dry and (some of the wet) territories of Sri Lanka (Simons *et al*., 2005) [5]. The fruit is a hard-shelled many seeded berry with its pinkish brown aromatic sour – sweet pulp being the edible portion, the seeds embedded in it. The ripe fruit pulp can be consumed either fresh or processed into high value and extremely popular products such as jams, jelly, chutney, sherbet and cordials.100 grams of wood apple pulp contains 140kcal. The fruit contains carbohydrates and proteins. It is also rich in beta carotene, vitamin B, vitamin C, thiamin and riboflavin. Wood apple fruits that grow in the wild tend to have more tannin than those cultivated for commercial purposes. Wood apple is a nutrient rich fruit which contains a surprisingly high amount of protein (3-7) and low levels of sugar and carbohydrates compared with many other fruits. Additionally the pectin content of the fruit pulp is 3-8. The fruit pulp contains 31g% of carbohydrate and 2g% of protein, which adds up to nearly 140 calories. The wood apple is rich in Beta carotene, a precursor of vitamin–A which also contains significant quantities of the B vitamins such as thiamine and riboflavin and small amounts of vitamin C. Wood apple is useful in preventing and curing scurvy and in reliving flatulence. Wood apple fruit contains flavonoids, glycosides, saponins and tannins. There are reports that some coumarins and tyramine derivatives were also isolated from the fruits of Limonia (Ilango and Chitra, 2009) [4]. All the parts of Limonia are prescribed in indigenous system of medicine for the treatment of various ailments. Fruits are refrigerant, stomachic, stimulant, astringent, aphrodisiac, diuretic, cardiotonic, tonic to liver and lungs, cures cough, hiccup and good for asthma, consumption, tumours, opthalmia and leucorrhoea. Unripe fruit is astringent while seeds are used in heart diseases.

The fruits are used as a substitute for bael (*Eagle marmelos)* in diarrhea and dysentery.

Realizing the importance of fruits as a significant contributor to human wellbeing, as a cheaper and better source of protective foods, their perishable nature and seasonality in production calls for preservation of them to be supplied throughout the year for human consumption. This study was planned keeping in view the nutritional importance of wood apple, to utilize them by preserving them as fruit pulp powder. While considering all these, the present work was carried out to prepare wood apple pulp powder by different methods of drying and evaluate its physical quality characteristics on drying. Keeping this view in mind the experiment was undertaken with the following objectives:

- To analyze the proximate composition of wood apple
- To prepare wood apple pulp powder by different methods of drying and to determine the best method of drying as per the physical quality characteristics on drying
- To evaluate the physical quality of the prepared fruit pulp powder on drying

Materials and Methods

Fruits

The mature wood apple was procured from the local market at bolpur district of West Bengal.

Wood apple pulp powder

The pulp was scooped out with seed from hard shell with the help of spoon, dried pulp by using sun drying and hot air oven drying at 45°C, then ground the dried pulp into mixer grinder to formulate the fine powder. KMS of concentration 0.5% and 1% are added to the powder.

Treatments

Two types of drying method was used, one is sun drying and theanother one is hot air oven drying, in combination with hot water treatment and normal water treatment. Two KMS concentrations 0.5% and 1% were used. Therefore, 12 treatment combinations with 3 replications were used in this experiment.(T_1=$H_1D_1K_1$=Hot water treatment + sun drying + KMS 0.5%,T_2=$H_1D_1K_2$=Hot water treatment + sun drying +KMS 1%,T_3= $H_1D_2K_1$=Hot water treatment + oven drying + KMS 0.5%,T_4=$H_1D_2K_2$=Hot water treatment + oven drying +KMS 1%,T_5=$H_2D_1K_1$=Normal water treatment + sun drying + KMS 0.5%,T_6 =$H_2D_1K_2$=Normal hot water treatment + sun drying + KMS 1%,T_7 =$H_2D_2K_1$=Normal water water treatment + oven drying +KMS 0.5%,T_8 =$H_2D_2K_2$=Normal water treatment + oven drying +KMS 1%,T_9=$H_1D_1K_0$=Hot water treatment + sun drying +without KMS,T_{10}=$H_1D_2K_0$=Hot water treatment + oven drying +without KMS,T_{11}=$H_2D_1K_0$=Normal water treatment + sun drying +without KMS,T_{12}=$H_2D_2K_0$=Normal water treatment + oven drying + without KMS)

Methodology

The fruit pulp powders were determined for its physical properties such as bulk density in g/ml (method suggested by Wang and Kinsella, 1976) [7] and true density in g/ml (ASAE, 2001) [2], porosity (Thompson and Issac, 1967).

Dehydration and rehydration ratios

Dehydration ratio was determined as the ratio of weight of the sample before drying to the dried weight of sample. Whereas rehydration ratio was determined as the ratio of the weight of the rehydrated sample to that of dehydrated sample (Kalra, Tandon, & Singh, 1995).

Moisture (%)

$$\text{Moisture percent by weight} = \frac{100(M_1-M_2)}{M_1-M}$$

Where,

M_1= weight in gm of dish with material before drying

M_2 = weight in gm of dish with dried material

M = weight in gm of empty dish

Bulk density (g/ml)

Bulk density = mass (g)/volume (ml)

Porosity (%)

The porosity (ε) was determined according to the methodology described by Silva (2008) with modifications.

True density (%)

True desity = (bulk density / 1-porosity) (Mohsenin, 1986)

Statistical analysis

The experiment was laid out in Complete Randomized Design. Data obtained on various characters were analyzed statistically according to the analysis of variance techniques. The analysis of variance for different parameters is presented in appendices. The critical difference (CD) was calculated to access the significance or non-significance of difference between treatment means. Wherever, it was found significant through 'F' test at 1 per cent level of significance, marked as star in ANOVA Tables.

Result and Discussions

Dehydration and rehydration ratio

It was observed that the dehydration ratio of T_{12} (2.81) is found to be highest among other treatments followed by T_4(2.78) and T_3(2.76).The lowest dehydration ratio was found in T_{11}(1.78) followed by T_2(1.86).The rehydration ratio of T_{11}(1.40) is highest followed by T_5(1.39).The dehydration ratio of sundried powder is slightly lower than the hot air oven powder, and rehydration ratio of hot air oven powder is slightly higher than the sundried powder. This difference may be due to the slight difference of the weight of dehydrated and rehydrated sample of different drying. The low rehydration ratio of hot air oven dried sample could be due to high amount of concentrated solids following drying, which in turn would not permit absorption of water on account of pre-occupation of the pore spaces as quoted by Akubor (2003) [3]. There was no significant effect of pre water treatments and KMS concentration on dehydration and rehydration ratio of dried product.

Moisture (%) and drying time (hrs)

The moisture loss was faster during oven drying than during uncontrolled sun drying. The oven dried fruit slices required about 25 hrs to reach 5-6% moisture content while sun drying took 28-30 hrs to attain the moisture content of 5-6%. This result agrees with the finding of Rahman and Lamb (1991) who reported that oven drying enhances moisture loss from the fruit and vegetables when compared with sun drying. Sun drying requires longer drying time and depends on the environmental conditions such as ambient air temperature and relative humidity (Rajkumar 2007). There is significant effect of drying methods on moisture content of dried powder. The highest moisture content was in T_4(6%),T_8(6%) and

T_{12}(6%).Lowest moisture content was found in T_5(5.25%) and T_{11}(5.25%).The loss of moisture in case of sun drying is more in compared to oven drying, it may be due to extended time of drying in case of sun drying. There was also no any effect shown on moisture content due to pre water treatments and KMS concentration.

Bulkdensity (g/ml), truedensity (g/ml) and porosity (%)

There is no significant difference in bulk density, true density and porosity of all treatments. The results are similar to other experiments.The highest bulk density, true density and was found in T_4, T_8 (0.67) and lowest in T_5 (0.61). The minor difference may be due to the different weight and porosity of the samples. Drying methods and pre-drying treatments had no significant effect on the bulk density, true density and porosity of wood apple powder (Vijaya kumar *et al*, 2013). Bulk density and the true density decreases along the drying process. It is also concluded by Douglas 2014 that the bulk density and true density, as well as volumetric shrinkage of crambe fruit mass, decrease over the drying process. The highest porosity was found in T_7 and T_8(50.5%) and lowest in T_{11}(49.5%).This difference may be due to difference in mass of samples. Since the rate of volumetric shrinkage increases with a reduction of moisture content; and inter granular porosity shows sharp reduction with increasing drying temperature and the inter-granular porosity decreased sharply with the increasing drying temperature.

Table 1: Chemical composition of fresh wood apple fruit pulp

Fresh pulp	Composition
Moisture Content (%)	65
Ascorbic acid (µg/100g)	3200
TSS (%)	19
Titrable acidity (%)	2.94
TSS/acidity ratio	6.46
ASH (g/100g)	1.9
Totalphenol content (mg/100g)	2.35
pH	5.2
Reducing Sugar (%)	2.19
Non-reducing sugar (%)	5.21
Total sugar (%)	7.33

Table 2: Drying time (in hours) of different drying methods and pre-dry treatment of wood apple pulp powder

Treatments	Drying Time (hours)
T_1	30
T_2	30
T_3	25
T_4	25
T_5	30
T_6	30
T_7	25
T_8	25
T_9	30
T_{10}	25
T_{11}	30
T_{12}	25

Table 3: Effect of different drying methods and pre-dry treatment on dehydration ratio, rehydration ratio and moisture content of wood apple pulp powder

Treatments	Dehydration ratio	Rehydration ratio	Moisture content (%)
T_1	1.98	1.38	5.50
T_2	1.86	1.36	5.75
T_3	2.76	1.23	5.75
T_4	2.78	1.25	6.00
T_5	1.90	1.39	5.25
T_6	1.90	1.31	5.50
T_7	2.54	1.29	5.50
T_8	2.48	1.30	6.00
T_9	2.11	1.33	5.75
T_{10}	2.64	1.29	5.75
T_{11}	1.78	1.34	5.25
T_{12}	2.81	1.29	6.00
GM	2.30	1.31	5.67
SE(m)	0.02	0.01	0.07
SE(d)	0.02	0.02	0.10
CD	0.05	0.04	0.20
CV (%)	1.26	1.63	2.06

Table 4: Effect of different drying methods and pre-dry treatment on Bulk density, true density and porosity of wood apple pulp powder

Treatments	Bulk density (g/ml)	True density (g/ml)	Porosity (%)
T_1	0.63	1.16	49.70
T_2	0.65	1.24	49.97
T_3	0.65	1.27	50.40
T_4	0.67	1.35	50.50
T_5	0.61	1.08	49.77
T_6	0.63	1.16	49.80
T_7	0.63	1.18	50.40
T_8	0.67	1.35	50.50
T_9	0.65	1.22	49.67
T_{10}	0.65	1.27	50.30
T_{11}	0.61	1.36	49.50
T_{12}	0.67	1.31	50.20
GM	0.64	1.28	50.06
SE(m)	0.01	0.01	0.15
SE(d)	0.01	0.02	0.21
CD	0.02	0.04	0.43
CV (%)	2.22	1.94	0.51

Conclusions

There is no more such of pre-drying treatments on the qualities of wood apple pulp powder. The quality is mainly effected by the drying methods. Oven dried fruit powder had the highest moisture (6.0%) and shorter time of drying. Sun dried fruit powder had lower moisture (5.25%) and longer time of drying (Workneh *et al*., 2012). Sun drying is cheaper, easier and cost-effective than oven drying and also remove more moisture than oven drying. Organoleptically, the hot air oven dried sample was liked very much in terms of its appearance, color and flavor. The low bulk density of sundried wood apple pulp powder would be advantageous in the use of product for preparing complementary foods as mentioned by Akubor (2005). So, in terms of drying characteristics, physical, functional, nutritional and non-nutritional quality, sun dried wood apple pulp powder exhibited highest index than oven dried. Hence the wood apple pulp could be dried effectively using sun drying, preserved as dried powder and value added for its industrial exploitation. Since sun drying is also cost effective, the wood apple pulp could be sun dried, formulated into powder and utilized for the preparation of jam, jelly and other products with good gelling nature even during off-season.

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