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Effects of drying temperature on quality of dried Indian Gooseberry powder

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Abstract: A study was conducted using a laboratory scale mini spray dryer to produce instant Indian gooseberry drink using maltodextrin as an encapsulating agent. The effects of two inlet temperatures, 120°C, and 160°C on the quality of powder were investigated. The dried Indian gooseberry powders were analysed for moisture content, water activity, dissolution time and vitamin C content. As inlet drying temperature increased, the moisture content and subsequently the water activity decreased significantly at 0.05 level. The results also show that an increase in the inlet drying temperature results in a lower vitamin C content. The changes in water activity of instant drink samples packed in an aluminium foil with an inner layer of LDPE and vacuum sealed were compared with those of non vacuum sealed control samples. The vacuum sealed samples did not change in water activity as opposed to the control samples which increased.

Keywords: Spray drying, Indian gooseberry, maltodextrin, powder quality, shelf life

Introduction

Indian gooseberry or emblic myrabolan or amla (*Phyllanthus emblica*) is a deciduous tree of the *Phyllanthaceae* family. The fruit has the reputation of being a remedy for a variety of disorders including diabetes, atherosclerosis, acidity, asthma, constipation, inflammation and obesity.

Indian gooseberries are very rich in anti-oxidants and abundant in vitamin C. Dharmananda (2003) reported a vitamin C content of 625 mg per 100 g of fruit. They also contain chromium which is believed to give it the ability to temper diabetes. The fruit is highly beneficial for women who suffer from alopecia areata (hair loss) due to Polycystic Ovarian Syndrome (PCOS). It is very effective in shedding weight when supplemented by good diet, nutritional supplements and a healthy lifestyle. It stimulates the liver and helps it to flush out accumulated toxins efficiently; this is particularly useful in patients whose symptoms are side-effects of long-term use of birth-control pills and other hormonal drugs (Anonymous, 2008). Studies were conducted on the effects of supplementation of the diet with the Indian gooseberry on total serum cholesterol and its lipoprotein fractions (Jacob *et al*., 1988). These studies have shown that the Indian gooseberry can

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reduce serum cholesterol levels in normal and hypercholesterolaemic men aged 35-55 years.

In Thailand, Indian gooseberry is called "Ma-Khaam-Pom" and is considered to be an excellent herb for soothing and curing a sore throat. However, the fruits have a complex taste: sweet, sour, bitter, astringent and pungent and thus are not particularly liked as fresh fruit by the consumers. Indian gooseberry is a seasonal fruit and thus, various preservation techniques have been developed such as freezing, and pickling with salt, oil and spices and drying. However, there are concerns that there may be changes in vitamin C content during the drying process. As a result of these concerns it was proposed to study the effects of drying on the vitamin C content in the powder produced from Indian gooseberries using a spray dryer. This powder is the raw material for production of an instant drink.

The objective of the study was to determine the vitamin C content and the physical properties of the instant Indian gooseberry powder produced by a spray dryer operating at 120 and 140°C.

Materials and Methods

Fruit samples

The samples of Indian gooseberries were purchased from a local market in Nakornpathom, Thailand in March and April 2007. The fruits were selected manually according to their appearance. The damaged and spoiled fruits were discarded. The fruits were separated for preliminary studies and drying experiments. The fruits selected for drying experiments were kept frozen at -18°C until required. They were then taken out and thawed at 30°C.

Determination of optimum fruit: water extraction ratio

Fresh fruit samples were washed, deseeded and cut into small segments. The segments were blended with water using fruit: water ratios of 1:1, 1:2 and 1:3. The total soluble solid (TSS) of the extract was measured using a refractometer.

Determination of the extraction yield

The extraction yield was calculated using equation (1):

$$Y = \frac{W_e}{W_t} \times 100 \qquad (1)$$

Where Y is the extraction yield (%), W_e is the weight of the extract after filtration and W_t is the weight of the sample and water.

Drying experiments

A laboratory scale mini spray dryer (Model SD04, Labplant Ltd., USA) was used in the experiments. The pressure dryer was set to 2.4×10^2 kPa. Two inlet temperatures were used in the experiments namely 120 and 160°C. The outlet temperature was set to 80°C. The feed rate for the spray dryer was set to 1.2 ml/min.

The fruit extracts were prepared as described above and mixed with maltodextrin until 19% total soluble solids were reached. The solution was dried using the spray dryer.

Moisture content and water activity of the powder were measured at the end of each drying run.

Moisture content determination

Sample of dried powder were placed in a forced draft oven at 130ºC for 1 hour. The moisture content was measured triplicate and calculated by using equation (2):

$$MC_{wb} = \left[\frac{(W_i - W_f)}{(W_i - W_a)}\right] \times 100 \qquad (2)$$

Where MC_{wb} is the moisture content wet basis (%), W_i is the initial weight of samples before dry plus aluminium dish and lid, W_f is the final weight of dried samples plus aluminium dish and lid, and W_a is the weight of aluminium dish and lid.

Water activity determination

The water activity of the samples was determined using a portable water activity analysis set (Model 0409001, Aqua Air Technology Co. Ltd.). Triplicate samples were measured at 25ºC.

Vitamin C analysis

The vitamin C content of the powder was determined using 2, -dichloroindophenol titrimetry (AOAC Method 967.21 in AOAC, 2000, cit. in Nielson, 2003)

Dissolution test

A sample of 50 mg of dried power was mixed with 1 ml distilled water in a test tube. The solution was mixed in a vortex (Model S0100-220, National Labnet Co., Inc) at a moderate speed. The time for the powders to dissolve in water was recorded. The test was carried out in triplicate.

Shelf life determination

Samples of dry powder were packed in aluminium foil with an inner layer of LDPE. Two sealing methods were used, one with vacuum and another without vacuum, considered as a control treatment. The samples were stored for one month at room temperature (30-34°C, relative humidity 50-90%). Triplicate samples were taken every week for water activity measurement.

Statistical analysis

Statistical analysis was performed using an SPSS program. All data were expressed as mean from triplicate samples. Differences were considered statistically significant at $p<0.05$ level.

Results and Discussion

Selection of optimum fruit: water extraction ratio

The results of the extraction experiments with different fruit: water ratio in terms of yield and TSS are shown in Table 1. The TSS of the extracts with the fruit: water ratio of 1:1, 1:2 and 1:3 were 3.2, 2.4 and 1.5 ºBrix, respectively. There was no significant difference between the three extracts at 0.05 significance level. The TSS of all extract was too low to undergo spray drying. If TSS is too low, the powder from spray drying process will not be able to form due to the lack of encapsulating agent whereas too high TSS results in a sticky powder (Cambell and Reece, 2002). Thus, maltodextrin was added to the extracts to adjust the TSS to 19% $\pm$ 1. A lower TSS needed a larger amount of maltodextrin. Thus, the extract with the fruit: water ratio of 1:3 required the highest amount of maltodextrin.

After completion of the spray drying process, the extraction yield was determined. The yields varied significantly ($p<0.05$) between the three extraction treatments. The extraction yields of treatments with the fruit: water ratios 1:1, 1:2, and 1:3 were 69.2, 78 and 86 %, respectively. The yields were increasing with increasing proportion of water in the ratio. However, the flavour of the dried powder declined as the ratio was increasing. Thus, the 1:1 ratio of the fruit: water was selected to be used in the drying experiments.

Drying experiments

Moisture content and water activity are essential parameters affecting the shelf life of a food product. Further parameters of importance for the acceptance of the Indian

Table 1. The yield and TSS of the fresh Indian gooseberry juice extract

The ratio of juice extract and water	Yield (%)	TSS (° Brix)
1:1	69.2[a]	3.2[a]
1:2	78[b]	2.4[a]
1:3	86[c]	1.5[a]

Table 2. Properties of Indian gooseberry powder

Drying T (°C)	Moisture content (%wb)	a_w	Dissolution time (s)
120	5.99[a]	0.336[a]	73[a]
140	3.24[b]	0.334[a]	78[a]

Table 3. Changes in water activity of Indian gooseberry powder dried at 120^{0}C during storage

Storage time (week)	Water activity (a_w)	
	Vacuum sealed	Control
1	0.336[a]	0.336[a]
2	0.334[a]	0.451[b]
3	0.337[a]	0.556[c]
4	0.335[a]	0.612[d]

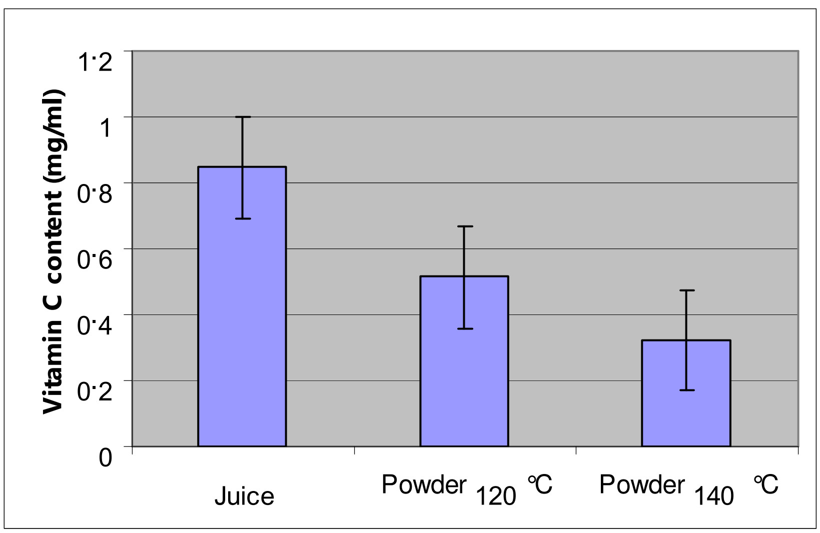

Figure 1. The vitamin C content of the fresh Indian gooseberry juice and powder at two different drying temperatures. Values are means ± SE

gooseberry powder as a raw material for the production of instant drink is the rapidity of dissolution in water and its sensory properties. The effects of spray drying on these properties are shown in Table 2.

Moisture content

The moisture content of the powder was lower at the higher inlet drying as seen in Table 2. This is because at higher inlet drying temperature, the rate of heat transfer to the particle is greater, favouring the moisture evaporation (Halliday and Walker, 2001).

Besides the effect of drying temperature, addition of maltodextrin also affected moisture content. A study on the dried watermelon powder using a spray dryer showed that an increased amount of maltodextrin resulted in a lower moisture content of the final powder (Quek *et al*., 2007). In a spray drying system, the water content of the feed has an effect on the final moisture content of the product (Halliday and Walker, 2001). With higher initial water content in the feed, the final product will also have higher moisture content. This phenomenon is not related to the temperature. As maltodextrin was added, TSS increased in the feed and reduced the water content.

Water activity

Table 2 shows that the final powder of the Indian gooseberry has the water activity in the range of 0.331-0.337 at every inlet drying temperature, which is considered microbiologically stable (Reid *et al*., 2008). However, the powder was hygroscopic due to the amount of maltodextrin added. Thus, the powder should be packed in an air-tight pouch and kept in a cool-place (Campbell and Reece, 2002).

Dissolution test

The dissolution test measures the time requires to dissolve the powder in water. The time is determined in the vortex without stirring. The results in Table 2 show that the dissolution times for the Indian gooseberry powder dried at 120 and 140 °C were 73 and 78 seconds, respectively. There is no significant effect ($p<0.05$) of the drying temperature on the dissolution time within this range of drying temperatures.

The time taken from the dissolution test can be related to the moisture content of the powder. From Table 2 and Figure 2, the higher the moisture content of the final powder, the easier that particular powder to reconstitute in water. Therefore, at lower inlet temperature, the evaporation rate is slower, producing powder with higher moisture content. Higher the moisture content of the powder, results in higher tendency towards agglomeration of the powder (Chegeni and Ghobadian 2005). However, the powder was hard to dissolve at room temperature. As a result, it is recommended to dissolve it in hot water and to stir it moderately.

Sensory properties

The overall appearance of powder samples was similar for both drying temperatures (120 and 140ºC). The powder was very dry and had a smooth touch like a milk powder. The colour of the powder was white and milky. It had a strong Indian gooseberry aroma and taste.

Vitamin C content in the Indian gooseberry powder

Vitamin C content of the Indian gooseberry powder dried at different temperatures is shown in Figure 1. A significant loss in vitamin C content at the level of 0.05 was found in the samples dried at 140^0C. The vitamin C content of the powder dried at 120^0C was 0.513 mg/ml while in the powder dried at 140^0C was 0.321 mg/ml. When compared with the fresh juice (0.846 mg/ml), the loss of vitamin C at 120^0C and 140^0C was 39.4% and 62.1% respectively.

The loss in vitamin C content during drying involves oxidation and hydrolysis.

The ascorbic acid is oxidised to dehydroascorbic acid, followed by hydrolysis to 2,3-diketogulonic acid and further oxidation and polymerisation to form a wide range of other nutritionally inactive products (Gregory III, 2008).

Besides the effect of high temperature on the loss of vitamin C, the loss can occur by chemical degradation during preparation step. Because of the high solubility of vitamin C in aqueous solution, there was potential for significant losses by leaching from freshly cut fruit. The loss can also occur during storage and handling (Gregory III, 2008).

Shelf life determination

Water activity was selected as a criterion to determine the shelf-life of the dried Indian gooseberry powder. As long as the water activity remains below 0.6, the product is microbiologically stable. Table 3 shows that the water activity remains constant throughout the whole month in the vacuum sealed aluminium foil with the inner layer of LDPE. LDPE is an excellent barrier protecting against water and water vapour (Robertson, 1993).

The outer aluminium layer can also prevent the light from entering, which may preserve the vitamin C in the powder. Most importantly however, the package was vacuum sealed and thus no oxygen was inside the packages after sealing.

In contrast, if air can enter the package, the powder will pick up moisture. As a result, an increase in the water activity in the non vacuum sealed control sample was observed. The water activity has increased significantly ($p<0.05$) from 0.336 to 0.556 after storage for three weeks and then exceeded the safe storage limit in the fourth week of storage ($a_w = 0.612$). Besides the moisture in the air, another reason for the highly increasing water activity in each week of storage was the presence of maltodextrin. Maltodextrin causes the powder to be hygroscopic, allowing it to pick up moisture more easily. However, the powder that was vacuum sealed in an aluminium foil liner with LDPE showed a longer shelf-life.

Conclusion

The aim of this study was to determine the vitamin C content together with physical properties in samples of Indian gooseberry powder produced using a mini laboratory scale spray dryer at drying temperatures of 120 and 140ºC. The result showed that drying at 120°C contributed to lesser loss of vitamin C content compared to drying at 140°C.

In addition to that, the shelf life of Indian gooseberry powder was studied. The results show that the powder that was vacuum sealed in an aluminium foil liner with LDPE has a longer shelf life. No significant changes in water activity were observed during one month storage at room temperature.

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