

Drying characteristics of mulberry fruit according to storage condition using far-infrared ray dryer for the production of semi-dried mulberry fruit

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Abstract

Using the relatively low-cost, far-infrared dryer inhibiting the destruction of a variety of physiologically active components of the mulberry fruit, we have studied to make semi-dry mulberry fruit that can be kept at room temperature for a long time. By adjusting the temperature of the far-infrared dryer step-by-step, we developed a semi-dry method of maintaining the shape of the mulberry fruit. In addition, by drying the coating of honey after removing the juice generated by the mulberry fruit thawing process improved the acceptability of the taste of fruit. We conducted heat treatment mulberry fruit into a 95°C infrared dryer 5 hours to thaw the frozen mulberry fruit. After 10 to 20% of honey coating, the primary drying (95°C, 5 hours) was implemented. then, the secondary drying was conducted after controlling the temperature of the far infrared dryer 60 °C, for 10 hours. These manufacture process was able to obtain semi-dried mulberry fruit. Dry weight ratio and moisture content were around 25%, and around 16% level respectively. It was to enable long-term storage at room temperature. Therefore, it is suggested that the method of using the far-infrared drying machine to manufacture semi-dried mulberry fruit can be a way to improve the farm income if applied to the farm.

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Introduction

Since 2002, the National Institute of Agricultural Sciences has been analyzing the functional ingredient content of mulberry fruit according to the mulberry variety / strain and developing food processing technology using it. As a result, many studies on the functional components of mulberry fruit have been reported that mulberry fruit contained a large amount of various functional

ingredients such as cyanidin-3-glucoside (C3G) (Kim and Kim, 2003), rutin (Kim and Kim, 2004), γ -aminobutyric acid (GABA) (Kim *et al.*, 2004), linoleic acid(Kim *et al.*, 2003), resveratrol (Kim *et al.*, 2005) and so on.

However, there is a limit to refrigerated storage because the moisture content of mulberry fruit is very high. Therefore, it is generally frozen immediately after harvest to maintain the quality and easy storage of the mulberry fruit. However, some studies

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have been reported to extend the shelf life to satisfy consumers' desire for fresh fruit.

Doymaz (2004) developed the 'Sun drying' method as a preservation technology for drying the mulberry fruit produced in Turkey. It is a method to prevent the loss of quality by inhibiting the growth of microorganisms by reducing the water content. However, there is a problem that the sensual characteristics of the mulberry fruit's quality are severely impaired during the sun exposure time.

As a technology for improving this, a method of treating chlorine dioxide (ClO₂) used as a food additive has been studied. In particular, Chen *et al.* (2011) have reported nutrients and shelf-life effects of ClO₂ treatment on mulberry fruit. They insisted that treatment with ClO₂ (60 mg / l, 15 min) on mulberry is a convenient, low-cost practical storage method than Lin *et al.* (2006) method (5 g / l potassium sorbate, 5 g / l sodium benzoate, or 30 g / l sodium propionate, 2 min treatment). In addition, 60 mg / l and 15 min treatment were effective in prolonging the shelf-life of the fish for 6 days (from 8 days to 14 days).

In 2013, the National Institute of Horticultural and Herbal Science (RDA, 2013) has announced that it is possible to distribute for 11 days when stored at a temperature of -1°C and a humidity of 60 ~ 70%. On the other hand, to maintain the quality of the frozen mulberry fruit, the cold and low temperature distribution container was used to freeze and circulate immediately after harvesting. As a result, the complete and retention rate was improved from 75% to 96% (RDA, 2010).

However, all of these techniques have been pointed out as a fundamental problem for the storage stability of mulberry fruit, which has a high moisture content, as a technique for extending refrigeration distribution. Therefore, as a method for improving the storage stability of the mulberry fruit, there are some methods of drying using a vacuum freeze dryer or a hot air dryer. In general, the freeze vacuum dryer is very limited in terms of the cost of purchasing the expensive equipment and processing, and drying of hot air can't solve the problem of difficulty in keeping shape due to external deformation, discoloration due to pigment degradation, destruction of texture and nutrients, by drying at high temperature.

As the demand for solving the problems of the completely dried mulberry fruit is increased from the agricultural field,

the National Institute of Agricultural Sciences has attempted to manufacture semi-dried mulberry fruit using the hot air dryer, vacuum freeze dryer, and far infrared ray dryer etc. As a result, a method of simultaneously producing extraction juice, jam, and semi-dried mulberry fruit by mixing mulberry fruit, sugar and citric acid using a hot air drier (Kim, 2013), and a vacuum freeze dryer method (Kim, 2014) of producing a semi-dried mulberry fruit which retains the functional ingredients and the original taste, aroma and form of the product were developed.

In addition, in order to solve the problem of rejection due to the use of sugar in the hot air drying method and to solve the problem of lowering the preference degree due to the relatively low sugar content of the vacuum freeze drying method, we have studied a method of manufacturing semi-dried mulberry fruit which is stored at room temperature and retained its shape using a far-infrared dryer.

Materials and methods

Experimental material

The species used for this experiment was 'Iksuppong' (*Morus alba* L.), which was harvested from the National Institute of Agricultural Sciences. According to the storage condition of the mulberry fruit, the fresh fruit was used immediately after the harvest and the refrigerated fruit was stored at 10°C until the experiment (1-2 days) after harvest. Frozen fruit was kept in a deep freezing cryocooler (Ilshin Lab Co., Ltd, Korea) at -60°C after harvesting.

Far-infrared dryer

The far-infrared dryer used in this experiment was commissioned and manufactured by Hanbaek Scientific, Korea. The size of the far infrared ray dryer (HB-505S) is 600x630x950 (H) mm and the temperature range is 40 ~ 120°C, equipped with a far infrared ceramic heater.

Moisture content measurement

Moisture content of semi-dried mulberry fruit was measured 10 times randomly for each treatment using a simple type moisture meter (SK-840A, SATO, Japan) and the

average value was used.

Observation of mulberry fruit's characteristics according to drying time

The condition of the semi-dried mulberry fruit was observed by visual observation, and the presence of fungi during drying and storage and the occurrence of odor were investigated. After the drying, the weight ratio (%) of the dry weight to the weight before the drying was calculated.

$$\text{Dry weight ratio (\%)} = \frac{\text{Weight after drying}}{\text{Audi weight before drying}} \times 100$$

Taste and palatability evaluation

The taste and palatability of the far-infrared semi-dried mulberry fruit was evaluated. Considering age and gender, 10 persons were selected for each age group. Each item was evaluated using a 9-point scoring method.

Results and discussion

After removing the juice from the thawing process, fruit is coated with honey and dried again in a dryer. In conclusion, we succeeded in developing the semi-drying method that maintains the morphology of mulberry fruit by controlling the treatment temperature step by step.

Semi-drying characteristics of juicy mulberry fruit

In the process of producing extraction juice, jam, and semi-dried mulberry fruit at the same time (Kim, 2013), the juicy fruit was recovered using a sieve, and dried in a far-infrared dryer. The semi-drying characteristics of juicy fruits were investigated by varying the drying temperature (Table 1).

In case of low temperature treatment at 50°C, there was no difference in morphological and sensory characteristics of semi-dried mulberry fruit. The moisture content of juicy fruit dried at 50°C for 72 hrs, 111 hrs was 15.3%, 13.2%, respectively. The moisture content was suitable for room temperature distribution. Also, the morphology and taste of mulberry fruit were maintained the characteristics of semi-dried fruit. In other words, at a low temperature of 50°C, it was gradually lowered instead of abruptly decreasing the moisture content, and the shape of the appearance remained unchanged.

On the other hand, when dried at a high temperature of 95°C for 7.5 hrs, the moisture content decreased sharply, but the moisture content of 15.7% was suitable for the room temperature distribution and the change of the fruit's shape was not significant.

This makes it possible to easily produce semi-dried mulberry fruit by using juicy fruit in farms equipped with a far-infrared dryer, and the dry weight ratio of mulberry fruit is also 65 to 71%, which is also expected in the yield of semi-dried fruit production.

Table 1. Dry characteristics of semi-dried mulberry fruit with juicy fruit using the far-infrared dryer.

Condition of mulberry fruit	Initial weight of mulberry fruit(kg)	Dry temperature (°C)	Dry time (hr)	Moisture content (%)	Ratio of dry weight (%)
Juicy fruit	1.5	50	72	15.3	71.1
	1.5	50	111	13.2	65.4
	1.5	95	7.5	15.7	70.4

Table 2. Dry characteristics of semi-dried mulberry fruit with fresh fruit using the far-infrared dryer.

Condition of mulberry fruit	Initial weight of mulberry fruit(kg)	Dry temperature (°C)	Dry time (hr)	Moisture content (%)	Ratio of dry weight (%)	Remarks
Fresh fruit	1.2	50	91	-	17.1	Rancidity
Fresh fruit (Keep refrigerated)	0.57	90/70/50	64.5	13.8	17.9	-

Table 3. Dry characteristics of semi-dried mulberry fruit with frozen fruit using the far-infrared dryer.

Condition of mulberry fruit	Initial weight of mulberry fruit (kg)	Dry temperature (°C)	Dry time (hr)	Moisture content (%)	Ratio of dry weight (%)	Remarks
Frozen fruit	1.5	95	11	21.0	10.4	Vapidity, Mold occurs during storage
Frozen fruit (Honey coating)	1.0	95/60	10/10	14.8	26.1 (Honey 10%)	Maintaining shape
	1.0	95/60	10/10	16.7	23.9 (Honey 20%)	Maintaining shape

Table 4. Taste and palatability evaluation of semi-dried mulberry fruit according to treatment condition using the far-infrared dryer.

Item	Shape	Taste	Overall acceptability
Control(High temperature dry)	3.6±0.84	3.4±0.70	3.5±0.53
Juicy fruit(frozen)	5.9±0.88	8.5±0.71	8.0±0.47
Change temperature, Honey 10%	7.5±0.53	7.9±0.57	7.7±0.67
Change temperature, Honey 20%	8.3±0.67	8.8±0.42	8.5±0.53

Semi-drying characteristics of fresh fruit

The semi-drying characteristics using fresh fruit was investigated (Table 2). It was found that when dried at a temperature of 50°C for 91 hours, there were a rotten odor and a browning color in the experimental materials, making it unsuitable to dry the fresh fruit in a low temperature.

On the other hand, the refrigerated fruit which was stored for 1 ~ 2 days in the refrigerator was heat treated for 64.5 hrs. As a result, it was possible to produce a semi-dried mulberry fruit with a moisture content of 13.8% and a dry weight ratio of 17.9%.

However, when applied to farms, it would be ineffective to dry semi-drying in large quantities due to the limited size of the dryer.

Semi-drying characteristics of frozen mulberry fruit

The characteristics of semi-drying was investigated by using frozen mulberry fruit (Table 3). When the frozen materials was dried at 95°C for 11 hrs, moisture content was 21.0% and dry weight ratio was 10.4%, respectively. Dried products had little sweetness and had mold during storage.

However, when the drying temperature was changed from 95°C to 60°C and dried for 10 hrs each, the moisture

content was about 15%, which was suitable for storing at room temperature.

Especially, when semi-dried mulberry fruit was prepared by varying the content of honey added after the separation of juice by 10% and 20%, it was possible to produce semi - dried fruits regardless of the amount of honey added.

However, the higher the content of honey, the longer the drying time and the higher the moisture content, the lower the drying efficiency. Also, it is not desirable to add more than 20% because it increases the cost of honey input and lowers the economic efficiency.

Taste and palatability evaluation

The taste and palatability evaluation of the semi-dried mulberry fruit produced by different treatment was carried out (Table 4). As a result, the preference of semi - dried fruit prepared by heat treatment with 20% honey coating method was the highest. This result showed that in determining the preference degree, it was given to taste rather than to the form of production materials.

Manufacture of semi-dried mulberry fruit coated with 20% honey

The manufacture process for 20% honey-coated semi-

dried mulberry fruits with the best palatability in Table 4 is summarized in Fig. 1, which is the most suitable for the far-infrared drying machine. In other words, the frozen materials was immediately put into a far-infrared dryer at about 95°C, and was thawed for 5 hrs to separate the juice. The juicy fruit was added to with 20% honey coating. Next, the temperature of the far-infrared dryer was adjusted to 60°C, and then the second drying (10 hours) was performed to produce a semi-dried mulberry fruit having the undistorted shape (Fig. 2).

The dry weight of the semi-dried fruit is about 25% and the moisture content is about 15%, so that it can be stored at room temperature for a long time.

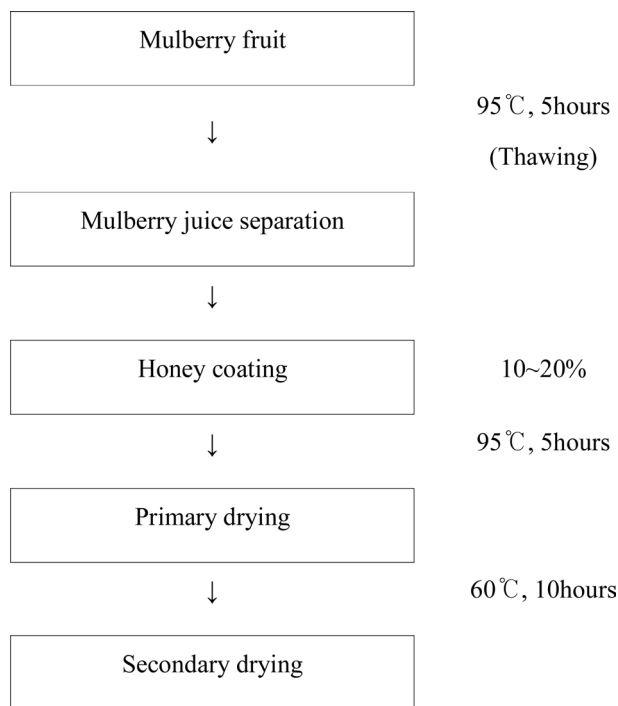


Fig. 1. Manufacturing process.

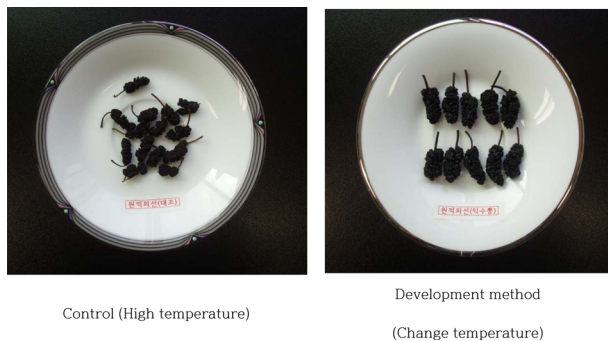


Fig. 2. Semi-dried mulberry fruit maintaining shape with far-infrared dryer.

As described above, in order to solve the problems of the hot air drying method and the vacuum freeze drying method, a method of manufacturing a semi-dry mulberry fruit using a far-infrared ray dryer was studied. As a result, by controlling the dry temperature and coating the honey in the middle of the drying process, it succeeded in the production of semi-dried fruits.

Therefore, we expect that farmers who own far-infrared dryers will be able to improve their farm income instead of burden of frozen storing by selling it to the market by applying this technology to the semi-dried farm.

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References

- Chen Z, Zhu C, Han Z (2011) Effects of aqueous chlorine dioxide treatment on nutritional components and shelf-life of mulberry fruit (*Morus alba* L.). *J Biosci Bioeng* 111(6), 675-681.
- Doymaz I (2004) Pretreatment effect on sun drying of mulberry fruits (*Morus alba* L.). *Journal of food engineering* 65, 205-209.
- Kim HB (2013) Manufacturing method of semi-dried mulberry improved stability of cyanidin-3-glucoside and semi-dried mulberry manufactured using the same. Korea Patent. 10-1316580.
- Kim HB (2014) Manufacturing method for semi-dried mulberry improved taste and semi-dried mulberry manufactured using the same. Korea Patent. 10-1367995.
- Kim HB, Kim JB, Kim SL (2005) Varietal analysis and quantification of resveratrol in mulberry fruits. *Korean J Seric Sci* 47(2), 51-55.
- Kim HB, Kim SL (2003) Identification of C3G (cyanidin-3-glucoside) from mulberry fruits and quantification with different varieties. *Korean J Seric Sci* 45(2), 90-95.
- Kim HB, Kim SL (2004) Quantification and varietal variation of rutin in mulberry fruits. *Korean J Seric Sci* 46(1), 1-5.
- Kim HB, Kim SL, Kang SW (2004) Varietal analysis and quantification of amino acid in mulberry fruits. *Korean J Seric Sci* 46(2), 47-53.
- Kim HB, Kim SL, Sung GB, Nam HW, Chang S, Moon JY (2003) Quantification and varietal variation of fatty acids in mulberry fruits. *Korean J Seric Sci* 45(2), 75-79.

Lin Q, Zhang H, Zhang L (2006) Research on the preservation method of mulberry fruit. *Journal of Anhui agricultural sciences* 34. 1209-1210. (in Chinese)

Rural Development Administration (RDA) (2010) Development of the postharvest technologies for the bottleneck-solving in the field and food processing technologies for agricultural production. 2009 R&D

National Agricultural Research Project report-agenda 14. National Academy of Agricultural Science. Korea. pp.1305-1369.

Rural Development Administration (RDA) (2013) Improvement of postharvest technology and development of processed food products of medicinal fruits. The final project completion report. National Institute of Horticultural and Herbal Science. Korea. pp.1-122.