

Review Article

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Effect of Various Drying Methods on Drying Time and Quality of Pomegranate (*Punica granatum* L.) Arils

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ABSTRACT

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The fruit of pomegranate (*Punica granatum* L.) is consumed fresh or it can be processed into juice, syrup, jam (anar rub), wine or anardana. Commercialization of process technology and pomegranate products in market is very important to improve economy. The seed are dried along with pulp *i.e.* aril, which constitutes the product “anardana”. The anardana has good keeping qualities along with certain advantages such as flavour and stability at room temperature over a long storage period, protection from enzymatic and oxidative spoilage, light weight for transport beside elimination of costly refrigeration. Dried pomegranate (anardana) finds its utility as a condiment in the acidification of chutneys and adds a peculiar taste to some famous north Indian delicacies. The traditional healers used a number of formulations of anardana as ayurvedic medicines in the treatment of dysentery, diarrhoea, stomachache, inflammations, hymenoleitidosis, dyspepsia, bronchitis and cardiac problem. In this review we discussed about various effect of drying methods on quality of pomegranate arils.

Introduction

Pomegranate (*Punica granatum* L.) is a well-known table fruit of tropical and subtropical regions of the world. The fruit of pomegranate is consumed fresh or it can be processed into juice, syrup, jam (anar rub), wine or anardana. The juice is valued for its medicinal properties mainly for leprosy patients. Juice is also used as cooling ingredient refrigerant of mixtures and some medicines for dyspepsia. The bark and rind of the fruits and seeds are used as astringent in cases of diarrhoea and dysentery. In peninsular India, a kind of wine is prepared from pomegranate juice which is considered superior to grape wine. The sweet types of pomegranate are said to be mildly laxative,

while the less sweet types are believed to be good in inflammation of stomach and in heart pain. The seeds are considered to be stomachic and the pulp cardiac and stomachic. Despite all these advantages, the consumption of pomegranate seeds is limited to the crop season due to problems of preservation (Defilippi *et al.*, 2006). Drying is the most widely employed method for preserving food materials, which is based on reduction of the water activity values through moisture removal to achieve physicochemical and microbiological stability (Gorjian *et al.*, 2011). Dried products have almost unlimited shelf-life in proper packages and substantially lower transportation, handling and storage

costs compared to foodstuffs produced with other preservation methods (Ertekin and Yaldiz, 2010).

The seed of pomegranate are dried along with pulp *i.e.* aril, which constitutes the product “anardana”. The anardana has good keeping qualities along with certain advantages such as flavour and stability at room temperature over a long storage period, protection from enzymatic and oxidative spoilage, light weight for transport beside elimination of costly refrigeration. Dried pomegranate (anardana) finds its utility as a condiment in the acidification of chutneys and adds a peculiar taste to some famous north Indian delicacies. The traditional healers used a number of formulations of anardana as ayurvedic medicines in the treatment of dysentery, diarrhoea, stomachache, inflammations, hymenoleitidosis, dyspepsia, bronchitis and cardiac problem. During drying many changes take place; structural and physico-chemical modifications affect the final product quality, and the quality aspects involved in dry conversion in relation to the quality of fresh products and applied drying techniques. In this review discussion were made about various effect of drying methods on quality of pomegranate arils.

Effect of drying methods on drying time

Singh and Kingsly (2008) conducted an experiment on effect of convective drying on quality of anardana. Drying temperature is optimized in this study for getting better end product with quality retention during storage. The arils were dehydrated at 50°, 55°, 60°C and packed in polyethylene bags. In all the drying temperature selected, higher temperature had shorter drying time. Minimum time was recorded in case of cabinet drying at 60°C followed by 55°C. Aggarwal *et al.*, (2010) conduct a study on drying of various hill crops (Pomegranate, Ginger, Turmeric and

Red chili) in open sun, oven and solar dryer for quality comparison. The dried products were tested in the post harvest technology laboratory for value addition. The time taken to dry the pomegranate was 21 h in solar dryer and the quality of the product is better as compared to other drying methods.

Santra and Jain (2012) found that the initial moisture content of pomegranate arils were in the range of 377.09 to 442.68 percent (db) which reduced to 5.69 to 9.62 percent (db) after 26.5, 17.5, 14 and 7.5 h for drying air temperature of 45, 50, 55 and 60°C, respectively. The drying time was reduced to 17.5 h when the drying air temperature was increased to 50°C, showing 33.96 percent reduction in time. When the drying temperature further increased to 55°C, the drying time for same moisture reduction was decreased to 14 h showing 47.16 percent for the reduction in time. Finally for 60°C, the drying time was found to be 7.5 h which was 71.69, 57.14 and 46 percent less than 45, 50 and 55°C drying air temperature, respectively.

Bhat *et al.*, (2014) conducted a study on the effect of drying methods and packaging on shelf life of dried wild pomegranate arils. Pre-treated arils were dried in different drying modes like mechanical cabinet dryer (62±2°C), solar cabinet dryer (50-55°C) and open sun (18-24°C). Mechanical cabinet dryer was found to be most suitable on the basis of faster drying rate, physico-chemical and sensory characteristics. Sample dried in mechanical cabinet dryer took 10h time to dry with lowest moisture content (9%) and highest total soluble solids (39.6° Brix).

Yilmaz *et al.*, (2015) found that fastest drying of pomegranate leather was completed in vacuum dryer followed by cabinet dryer and open air drying. The drying process in cabinet dryer was completed in 35 min at 70°C for the samples at 1 mm and 60 min and 65 min for 2

and 3 mm samples, respectively, at the same temperature level. The drying time significantly increased together with the lowering of drying temperature. Drying process was completed in 150 min and in 290 min for the 3 mm samples at 60°C and 50°C temperature levels, respectively.

Effect of drying methods on dry aril recovery (%)

Recovery percent of pomegranate arils were maximum in sun drying (32.9%) followed by solar cabinet dryer (32.4%) and mechanical cabinet dryer (32%), Bhat *et al.*, (2014).

Effect of drying methods on moisture content

Santra and Jain (2012) carried out an experiment on convective drying of pomegranate arils to observe the effect of temperature on drying characteristics and physicochemical properties of pomegranate arils. The drying is done at 45°, 50°, 55° and 60°C to reduce initial moisture content 377.09-442.68 percent (db) to final moisture content of 5.7-9.62 percent (db) in 26.5, 17.5, 14 and 7.5 h, respectively.

Bakshi *et al.*, (2013) found that of all the drying treatments, oven drying (42±2°C) for 16.5 h as well as drying at room temperature (23± 2°C) for 10-12 days resulted in maximum loss of moisture from the fresh seeds of wild pomegranate *i.e.* 75.12%. This was followed by vacuum drying for 13 h (42±2°C) which resulted in 73.88% reduction in moisture content of the pomegranate seeds. The least reduction in moisture percentage of the fresh pomegranate seeds were observed in drying under poly-tent house where only 71.27% reduction in moisture content was recorded. Patil *et al.*, (2013) found that the moisture content of anardana prepared from cabinet drying of pomegranate arils of

cultivar Ganesh was 10.20% and Arakta was 10.50%.

Bhat *et al.*, (2014) conducted a study on the effect of drying methods and packaging on shelf life of dried wild pomegranate arils and found least content of moisture (9%) in case of mechanical cabinet dryer and maximum moisture content was reported in case of sun drying (10.72%).

Singh and Dayal (2015) dried pomegranate seeds (Bassien Seedless) under different conditions to produce value added product known as anardana. Mean values for moisture differed significantly in sun-dried (15.73%) and cabinet-dried (9.33%) samples. Organoleptic evaluation also gave overall mean score for cabinet dried samples were significantly higher (7.42) than sun dried samples (6.27). In general, drying was faster and quality was better in a cabinet dryer as compared to sun drying and statistically significant difference was noticed.

Effect of drying methods on TSS

Dadarao *et al.*, (2010) conducted an experiment on effect of intermittent drying technique on quality of anardana. The TSS was found in the range of 32.16 to 36.98°B.

Santra and Jain (2012) reported that maximum value of TSS of dried pomegranate arils were found to be 38.73 percent at 50°C, followed by 37.63 percent at 45°C, 30.56 percent at 60°C and 30.2 percent at 55°C. An analysis of variance was carried out to study the effect of drying temperatures on TSS and which showed that temperature had non-significant effect at 5 percent level of significance.

The maximum TSS of dried pomegranate arils were found to be 39°B in case of mechanical cabinet dryer followed by solar

cabinet dryer (37.24°B) and sun drying (37°B), Bhat *et al.*, (2014).

Effect of drying methods on acidity

Aggarwal *et al.*, (2010) reported maximum titratable acidity (13.71%) in the arils dried in oven, whereas minimum titratable acidity of 12.40% was observed in the arils dried in open sun. Bhat *et al.*, (2014) found maximum acidity of 13.72% in case of mechanical cabinet dryer followed by solar cabinet dryer (13%) and sun drying (12.4%) for anardana prepared from wild pomegranate.

Santra and Jain (2012) reported that maximum acid value of dried pomegranate arils were 0.605 percent at 45°C, followed by 0.5 percent at 50°C, 0.409 percent at 60°C, and 0.395 percent at 55°C.

Patil *et al.*, (2013) carried out experiment to standardize the recipe for preparation of pomegranate anardana powder by using selected processing techniques and explore the prepared anardana powder with spices in mouth freshner. The mouth freshner was prepared by sun drying and cabinet drying. For acidity, sample of Ganesh and Arakta prepared by sun drying had highest acidity *i.e.* 1.4% and 1.6% respectively. For cabinet dried sample of Ganesh and Arkata cultivars acidity was 1.3% and 1.5% respectively.

Singh and Dayal (2015) found that anardana samples had 3.4% more acidity in cabinet dried product than sun dried product irrespective of pretreatment used.

Effect of drying methods on ascorbic acid

Singh and Kingsly (2008) found that pomegranate arils dried at 55⁰ C drying air temperature (drying time, 7 h) retained desirable and acceptable quality parameters (titratable acidity 7.8%, vitamin C as ascorbic

acid 15.16 mg/100g) up to 180 days of storage.

Opera *et al.*, (2009) studied physico-chemical properties, vitamin C content and antimicrobial properties of pomegranate fruit. A significant variation in vitamin C content was found among the five varieties of pomegranate studied, ranging from 52.8 to 72.0 mg/100g fresh weight (fw) for arils and 76.8 to 118.4 mg/100g fw for peels. Irrespective of the variety of pomegranate, vitamin C content in the peel was significantly higher than the aril, with differences ranging from 24.4% to 97.0% depending on variety. Sun drying of fruit peel significantly enhanced vitamin C retention and antimicrobial effects in comparison with oven drying presumably due to lower rate of moisture removal associated with low temperature drying over longer duration in comparison with short time high temperature oven drying.

Data on the effect of drying modes on the ascorbic acid content of pomegranate arils shows that indirect solar dried arils had maximum (12.09 mg/100g) ascorbic acid, whereas open sun dried arils had minimum (7.85 mg/100g) ascorbic acid, Aggarwal *et al.*, (2010).

Patil *et al.*, (2013) carried out experiment to standardize the recipe for preparation of pomegranate anardana powder by using selected processing techniques and explore the prepared anardana powder with spices in mouth freshner. Ascorbic acid content was higher in cabinet dried sample (6.7 mg/100g and 7 mg/100g) for both cultivars. Whereas in sun dried samples of Ganesh and Arakta varieties ascorbic acid content was 6 mg/100g and 6.5 mg/100g respectively.

Bhat *et al.*, (2014) found maximum ascorbic acid content of 12.1 mg/100g in case of mechanical cabinet dryer followed by solar

cabinet dryer (9.4 mg/100g) and sun drying (7.85 mg/100g) for anardana prepared from wild pomegranate.

Effect of drying methods on sugars

Dadarao *et al.*, (2010) conducted an experiment on effect of intermittent drying technique on quality of anardana. The reducing sugars, non reducing sugars, total sugars were found in the range of 12.72 to 16.21%, 1.86 to 2.27%, 14.87 to 18.14% respectively.

Based on the experiment conducted by Aggarwal *et al.*, (2010), drying results of pomegranate reveal that reducing sugars were found maximum (21.70%) in the arils dried in indirect solar dryer while minimum (20.25%) was in open sun. The total sugars were found maximum (24.18%) in arils dried in indirect solar dryer and minimum (22.60%) in open sun.

Calin-Sanchez *et al.*, (2013) reported that pomegranate aril sugars were more stable with softer drying conditions (low temperature and long time). Soft cabinet dryer conditions (50°C) provided the best results, followed by 150 min CPD-VMFD (Combined drying consisted of convective pre-drying (CPD) at temperature 60°C for 90 or 150 min, followed by vacuum microwave finish drying (VMFD) with microwave wattage of 360 W). An increase in the product temperature caused important degradation of fructose and glucose (45%), mainly because of Maillard and browning reactions was found in onion (Mota *et al.*, 2010).

Patil *et al.*, (2013) found that total sugars for anardana prepared from Ganesh and Arakta cultivar were 30.20% and 30.50% respectively. Reducing sugars content for Ganesh cultivar was 29% and 29.52% for Arakta variety. Non-reducing sugar content for Ganesh cultivar was 1.20% and 0.98% for Arakta variety.

Bhat *et al.*, (2014) conducted a study on the effect of drying methods and packaging on shelf life of dried wild pomegranate arils and found

maximum content of total sugars (24.2%) and reducing sugars (21.2%) in case of mechanical cabinet dryer followed by solar cabinet dryer and sun drying.

Singh and Dayal (2015) found the mean values for total sugars of pomegranate was higher in cabinet dried samples (50.55%), which differed significantly from sun-dried samples (47.72%).

Effect of drying methods on anthocyanin content

Singh and Sethi (2003) evaluated physico-chemical characteristics of seven pomegranate types in the production of anardana. Compared to fresh pomegranate arils, anardana demonstrated an increase in anthocyanin by weight. The authors felt that the increased levels of ascorbic acid may play a role in anthocyanin retention.

The levels of anthocyanin in anardana were studied by Jaiswal *et al.*, (2010). Noting that polyphenoloxidase (PPO) may oxidize anthocyanin, drying effects on anthocyanin and PPO were studied. Sun drying was found to cause a greater loss of anthocyanin and a lesser reduction of PPO than oven drying in comparison to amounts present in fresh arils.

Bchir *et al.*, (2012) investigated the drying of pomegranate seeds at 40°, 50° and 60°C with air velocity of 2 m/s. Both anthocyanin and total phenolic contents decreased when air drying temperature increased. The final product has 40, 24, 20 mg/100g of anthocyanin for drying temperatures of 40°, 50° and 60°C respectively. Bhat *et al.*, (2014) conducted a study on the effect of drying methods and packaging on shelf life of dried wild pomegranate arils and found maximum anthocyanin content of 33.08 mg/100g in case of mechanical cabinet dryer followed by solar cabinet dryer (28.22 mg/100g) and sun drying (25.56 mg/100g).

Muharrem Golukcu (2015) reported highest contents of anthocyanin (679.76 mg/kg), in

freeze dried sample, followed by vacuum, convective, and sun dried samples in descending order. The result of present study indicated that freeze drying was the best method for dried pomegranate aril production.

Singh and Dayal (2015) found anthocyanin content (as OD) differed significantly amongst different samples and was maximum (0.907) in steam-blanching cabinet-dried samples and minimum in sun-dried control samples.

Anthocyanin content was significantly affected by drying method, drying temperature and product thickness reported by Yilmaz *et al.*, (2015).

Effect of drying methods on phenols

Bchir *et al.*, (2012) investigated the drying of pomegranate seeds at 40°, 50° and 60°C with air velocity of 2 m/s. Total phenolic contents decreased when air-drying temperature increased. The radical diphenylpicryl-hydrazyl activity showed the lowest antioxidant activity at 60°C. The final product has 151, 141 and 134 mg gallic acid equivalent/100g fresh matter (fm) of total phenolics for drying temperatures of 40°, 50° and 60°C respectively.

Bhat *et al.*, (2014) found maximum phenols of 110.7 mg/100g in case of mechanical cabinet dryer followed by solar cabinet dryer (96.8 mg/100g) and sun drying (90.5 mg/100g) for anardana prepared from wild pomegranate.

Muharrem Golukcu (2015) reported highest contents of phenolic matter (5580 mg/kg), in freeze dried sample of pomegranate, followed by vacuum, convective, and sun dried samples in descending order. The result of present study indicated that freeze drying was the best method for dried pomegranate aril production

In conclusion, the pomegranate fruit is considered as the suitable fruit for the processing and utilization due to its excellent flavour, colour, physicochemical constitution and therapeutic properties. It is referred as the

‘*Super fruit*’ due its high nutritional value, high antioxidant capacity and consumer appeal. The pomegranate processing and product diversification has played important role in the increased consumption and utilization of pomegranate. The fruit of pomegranate (*Punicagranatum* L.) is consumed fresh or it can be processed into juice, syrup, jam (anar rub), wine or anardana. These products are not yet popularized in large scale due to lack of the commercially viable processing technologies. Drying is the most widely employed method for preserving food materials. It is well known fact that drying methods, drying conditions and product thickness strongly influence the quality of final product. From an engineering point of view, drying operations should be handled by considering many aspects such as economy, final quality of product, consumer and preference. The efficiency of the process can be enhanced by optimizing drying conditions.

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