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Shelf-life and kinetics of quality change of dried pomegranate arils in flexible packaging

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ARTICLE INFO

Article history:
Received 30 September 2013
Received in revised form
25 April 2014
Accepted 30 April 2014
Available online 14 May 2014

Keywords:
Accelerated storage
Dried pomegranate arils
Shelf-life
Zero order kinetics

ABSTRACT

Pomegranate arils were dried by microwave-vacuum drying technique and later packaged in pouches of high density polypropylene (HDPP) and aluminum laminated polyethylene (ALP). The shelf-life of dried pomegranate arils was predicted on the basis of change in color of the product under accelerated storage conditions (38 ± 1 °C, 90 ± 1% relative humidity (RH)) which was estimated to be 96 and 187 days in HDPP and ALP, respectively. The changes in quality parameters such as anthocyanin, phenolics, total soluble solids (TSS) (°brix) and titrable acidity (TA) were studied in the selected packaging materials. The magnitude of quality change of dried pomegranate arils measured during storage suggested that ALP has better protective effect than the HDPP. The kinetics of quality parameter change was of zero order.

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1. Introduction

Pomegranate (*Punica granatum L.*) is a popular fruit of tropical and subtropical regions, belonging to family punicaceae. It is extensively cultivated in Mediterranean countries, Middle East, Iran, Spain, Egypt, Russia, France, Argentina, China, Japan, USA and India (Patil & Karade, 1996). India is one of the leading pomegranate producing country with 0.82 million - tones annual production (Anonymous, 2010). The most commonly grown varieties in India are Ganesh, Maridula, Kandhari, G-137 and Muskat Red. Surface color of fruit varies from yellow with a crimson check to brownish or bright red. Indian pomegranate has good demand in Germany, England, Gulf and SAARC countries.

Pomegranate is commercially grown for its sweet acidic taste. Owing to its high yielding potential and higher nutraceutical value; popularity of pomegranate has increased among the cultivators and consumers worldwide. Apart from its demand as fresh fruit and juice, the processed products such as *anardana*, carbonated drinks, syrup, wine and candy are also gaining importance in world trade. The edible part of the fruit is called arils and constitutes 52% of total fruit, comprising 78% juice and 22% seeds (Kulkarni, Aradhya, & Divakar, 2004). The fresh juice contains 85.4% moisture and considerable amounts of TSS, total sugars, reducing sugars, anthocyanins, phenolics, ascorbic acid and proteins (El-Nemr, Ismail, & Ragab, 1990) and has also been reported to be a rich source of antioxidants (Gil, Tomas-Barberan, Hess-Pierce, Holcroft, & Kader, 2000).

The shelf-life of pomegranate is about 12–14 days at ambient conditions, leading to spoilage and post-harvest losses. Drying is the oldest and most popular method used in food preservation. It prevents the growth of microorganisms responsible for the spoilage of food and alleviates many moisture related deleterious reactions. In addition to enhancing the shelf-life of the product, drying also reduces bulk, minimizes packaging, storage and transportation cost. Drying

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http://dx.doi.org/10.1016/j.fpsl.2014.04.005
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Nomenclature

θ	shelf-life days, days
W_s	weight of dry solids, kg
P^*	saturated vapor pressure of water at 38 ± 1 °C, Pa
K_p	permeability of packaging material, kg/m^2 day Pa
A	area of the package, m^2 ($A = 2LB$)
L	length of pouch, cm
B	width of pouch, cm
RH	relative humidity of environment in which package is placed
X_i	initial moisture content of dried sample before storage, g water/g dry matter
X_c	critical moisture content of dried sample during storage, g water/g dry matter
m	moisture content, g water/g dry matter
a_w	water activity, fraction
m_0	constant
C	constant
K	constant
$\frac{dw}{d\theta_p}$	slope of the straight line plot between the time θ_p (days) and weight (kg) of silica gel kept within packaging material
C_0	initial value of quality parameter
C_t	value of quality parameter at pre-specified time
k_0	kinetic constant
t	storage period, months
ALP	aluminum laminated polythene
HDPP	high density polypropylene
ANOVA	analysis of variance
TSS	total soluble solids, °brix
p	probability level
TA	titrable acidity
R^2	coefficient of determination
S.E.	standard error
SPCA	standard plate count agar
MGYP	malt-extract-glucose-yeast extract-pepton
MRBA	martin rose bengal agar
BCP lactose broth	bromcresol purple lactose broth

of pomegranate arils with hot air convective drying method, causes several problems like discoloration, longer drying time, poor rehydration characteristics, and loss of nutritive values (Singh & Kingsly, 2008). Microwave-vacuum drying overcomes these drawbacks by incorporating microwave radiation in conventional vacuum drier which greatly reduces the drying time and energy consumption without quality degradation (Giri & Prasad, 2007; Sutar & Prasad, 2007).

The dehydrated sweet pomegranate arils give good mouthfeel and are used as dessert in many food preparations. Incidence of internal browning of arils is one of the major problems in pomegranates, which usually occurs in over-ripe fruits (Waskar & Roy, 2000). Internal browning of arils leads to reduction in TSS, acidity, ascorbic acid and reducing sugar contents but increase in non-reducing sugar and tannins. Browning of tissues is generally attributed to oxidation of phenolics (Desai Prabhu, 1989). Keeping quality and hygroscopic properties of dried fruits and vegetables are influenced by their water activity. Common effects of improper storage conditions on food products are browning and development of off-flavor. This is caused by formation of insoluble compounds from the maillard reaction, lumpiness, loss of nutritive value, moisture gain, microbial growth etc. under normal as well as accelerated storage conditions (Van den Berg, 1992).

In the present paper, the shelf-life and kinetics of quality change of dried pomegranate arils were investigated in flexible packaging materials under accelerated storage conditions (38 ± 1 °C, 90 ± 1% RH). Two different types of flexible packaging material viz. HDDP and ALP were selected. For commercially available *anardana*, the use of HDPP is currently in practice in market. Being transparent, it provides consumer with an easy access to assess the product quality. ALP has low permeability to water vapor, thus longer shelf-life of dried product have to be established.

2. Materials and methods

2.1. Sample preparation

Fresh pomegranates (*Punica granatum L.*) of ''Maridula'' variety were procured from local market of New Delhi and stored at 10 °C in cold storage. Pomegranates were thoroughly washed with water to remove the dirt and then sorted to remove damaged or decayed fruits. The arils were manually separated using a stainless steel knife, giving vertical cut to the fruits. The initial moisture content in arils was found in the range of 354.5–455.5% (d.b.) using a hot air oven method (LSIO-1, Shambhavi Impex, Mumbai, India) (Ranganna, 1997). The arils were used for drying experiment without any pretreatment and then dried to a moisture content of 5–6% (d.b.) in a laboratory scale microwave-vacuum drier BPL 800G (BPL Sanyo Utilities & Appliances Ltd., Bangalouru, India). The optimized drying conditions were 80 W of microwave power, 7.99 kPa of vacuum pressure and 193.7 g sample mass.

2.2. Packaging and storage of dried pomegranate arils

The dried pomegranate arils samples (20 g) were filled in aluminum laminated polythene (10.5 cm × 12 cm) and high density polypropylene (10.5 cm × 7.5 cm) pouches which were closed by heat sealing taking care that minimum possible air space remained in pouches. The sealing was carefully inspected to avoid any possibility of leakage. The sealed sample pouches in duplicates were placed in desiccators, maintained at 90 ± 1% RH using saturated salt solution of potassium nitrate. The dessicators were placed in incubator (LSI-I-9, Shambhavi Impex, Mumbai, India) maintained thermostatically at 38 ± 1 °C for a period of 3 months. Pouches were placed in vertical pouch holder to ensure that the pouches do not contact each other and all of them are exposed to the same environment.

2.3. Assessment of dried pomegranate arils quality

One pouch of dried pomegranate arils was taken out from desiccator at a regular interval and analyzed for quality parameters during accelerated storage for a period of three

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