Food Chemistry 174 (2015) 356–364

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Effects of different sorbic acid and moisture levels on chemical and microbial qualities of sun-dried apricots during storage

Sümeyye Alagöz [a], Meltem Türkyılmaz [b], Şeref Tağı [a], Mehmet Özkan [a,*]

[a] Department of Food Engineering, Faculty of Engineering, Ankara University, Diskapi, 06110 Ankara, Turkey
[b] Institute of Food Safety, Ankara University, Diskapi, 06110 Ankara, Turkey

ARTICLE INFO

Article history:
Received 13 August 2014
Received in revised form 5 November 2014
Accepted 11 November 2014
Available online 18 November 2014

Keywords:
Preservative
Microbial growth
Browning
Colour
Carotenoid

ABSTRACT

Effects of different sorbic acid (SA) (0, 488–530 and 982–1087 mg/kg) and moisture [intermediate (271–278 g/kg) and high (341–344 g/kg)] levels on the chemical and microbiological qualities of sun-dried apricots during storage at different temperatures (4, 10, 20 and 30 °C) for 10 months were evaluated. Moisture content and SA concentration showed significant effect on brown colour formation, β-carotene oxidation and microbial load ($p < 0.05$). As moisture content increased, brown colour formation decreased. Moreover, SA oxidation protected β-carotene from oxidation. Although no microbial spoilage was observed in the samples with intermediate moisture content, control group with high moisture was spoiled by yeast and mould in 1–3 months of storage at all temperatures studied; 488 mg SA/kg was sufficient to prevent the spoilage. Regardless of moisture content, 500 mg SA/kg was found to be effective for the prevention of brown colour formation and inhibition of microbial growth.

1. Introduction

Turkey is the major producer of apricots in the world, followed by Iran, Uzbekistan, Algeria and Italy (FAOSTAT, 2012). A significant portion of apricots produced in Turkey (ca. 16%) is dried (Asma, 2011). According to FAO statistical data, 90,321 tonnes dried apricots were exported from Turkey in 2011 and Turkey generated $361 million revenue from the export of dried apricots.

Dried apricots are presented to the market at moisture contents ranging from 200 to 370 g/kg. At moisture content less than 250 g/kg, they are marketed without any preservative [such as sulphur dioxide or sorbic acid (SA)] but at moisture content greater than or equal to 250 mg/kg, they do need preservatives (Unece Standard DDP-15, 1996). The safety of sulphite-containing foods has been questioned because of the adverse effects of sulphur on health, especially on asthmatic patients. This concern has resulted in the substantial increase in the demand for unsulphured sun-dried apricot (SDA) in recent years.

At high moisture contents, SDA containing no preservatives can easily be spoiled by yeast and mould especially at high storage temperatures. The use of antimicrobial preservatives is inevitable to prevent microbial deterioration after rehydration of SDAs (Sofos & Busta, 1993). For this purpose, SA, especially its water-soluble salts, such as potassium sorbate (K-sorbate), is widely used in high-moisture dried fruits, including apricots. As compared to other antimicrobial preservatives such as benzoic acid and propionic acid, sorbic acid salts are preferred by the food industry due to the following advantages: (1) antimicrobial activity even at high pH values (6.0–6.5), (2) acceptable daily intake (ADI) of as high as 25 mg/kg body weight and (3) no shown significant impact on human health (Sofos & Busta, 1993).

The primary microorganisms which cause microbial spoilage in a_w level of dried, intermediate and high moisture apricots are yeast and moulds (El Halouat, Gourama, Uyttendaele, & Debevere, 1998) and SA is particularly effective against these two groups (Sofos & Busta, 1993). Various opinions on the mechanism of SA on microorganisms are elaborated in the literature (Holyoak et al., 1996). The most accepted opinion is the inactivation of enzymes necessary to sustain the vital activities of microorganisms by the formation of covalent bonds between the double bonds of SA and SH groups of enzymes. As a result of the inactivation of enzymes, the metabolic activities of microbial cells cease (Furrer, Mayer, & Gurny, 2002).

Studies have shown that SA was very effective on microbial growth in prunes and raisins (El Halouat et al., 1998). However, to date, the effect of SA on the chemical and microbiological qualities of dried apricots has not been studied. Moreover, while Codex Alimentarius Commission allows a maximum limit of 500 mg SA/

* Corresponding author. Tel.: +90 (312) 203 3300/3621; fax: +90 (312) 317 8711.
E-mail address: mozkan@ankara.edu.tr (M. Özkan).

http://dx.doi.org/10.1016/j.foodchem.2014.11.075
0308-8146/

kg dried apricots (Codex Alimentarius Commission, 1981), Turkish Food Codex Regulation allows a maximum limit of 1000 mg SA/kg (Turkish Food Codex Regulation on Food Additives, 2011). Therefore, the minimum SA concentration sufficient for preventing microbial growth in dried apricots rehydrated to intermediate and high moisture content (up to 370 g moisture/kg dried apricots, Unece Standard DDP-15, 1996) needs to be determined. The objectives of this study are to determine (1) the effects of different SA and moisture concentrations on the physical, chemical and microbiological qualities of SDAs during storage at different temperatures, and (2) the minimum SA concentrations to prevent microbial spoilage at different moisture contents and storage temperatures.

2. Materials and methods

2.1. Materials

Commercially unsulphured SDAs (*Prunus armeniaca* L., var. Hacıhaliloğlu) were obtained from a major producer of dried apricots (Hasanbey Apricot Co.) in Malatya. Dried apricots were specially produced for this study in July 2012 and contained no preservatives. A flow diagram of SDA processing is shown in Fig. 1. The bruised as well as high moisture apricots were discarded to obtain a sound and homogenous sample in terms of moisture content. The selected apricots were left in an enclosed container to equilibrate for moisture in a cooled room at 20 °C for a month. Then, following the manufacturer's guideline, 100 kg of SDAs placed in plastic crates were fumigated with 6 g (2 tablets) 57% (v/v) aluminium phosphide (Tamtoxin, Platin Kimya, Istanbul) in a closed and gas-tight chamber (1 m^3) made up with double layers thick plastic material at 24 ± 2 °C for three days to suffocate any insects present.

2.2. Rehydration

After fumigation, SDAs containing 161 g/kg moisture were rehydrated on a spray wash conveyer system. First, dried apricots were uniformly spread on the stainless steel band system and water at 20 °C was sprayed onto the apricots by sprinklers. After rehydration, excess surface water on the apricots was removed by hand-shaking with a sieve for 1 min and then the partially rehydrated apricots were left in closed containers to absorb the water remaining on the surface of the apricots for 2 days at 20 °C. This relatively long rehydration procedure was carried out to prevent the peeling of apricot skin. Many pre-trials for the rehydration of apricots were carried out. For each rehydration cycle, 30–35 g moisture increases was found per kg dried apricots. To obtain apricots with 270 and 340 g moisture per kg of dried apricots, dried apricots at 161 g/kg moisture content were rehydrated two and four times, respectively. At the end, the moisture levels of rehydrated apricots reached 232.5 and 305.4 g/kg. Right after rehydration, apricots at very high moisture levels were removed from the trial sample to obtain a homogenous sample in terms of moisture content.

2.3. Potassium sorbate dip

Rehydrated apricots (200 g) were dipped into 1000 g of potassium sorbate (K-sorbate) solutions at various concentrations (1, 2, 3 and 4%, w/v) at 20 °C for 1.5 min. At the end of this period, the apricots were removed from the dip solution. The excessive K-sorbate solution on the apricot surface was removed with a sieve by hand-shaking for 1 min and then the SDAs were left in closed plastic containers for the absorption of SA on their surface at 20 °C for 2 days. Then, the correlations between "K-sorbate solution concentrations" and "sorbic acid contents passing into the samples from the solutions" were investigated and strong correlations were found ($y = 282.6x + 39.13$ $r = 0.996$ and $y = 332.1x + 15.9$ $r = 0.999$ for the samples with intermediate and high moisture, respectively). Therefore, to reach the desired sorbic acid content (ca. 500 and 1000 mg/kg) for each moisture levels, we calculated required K-sorbate solution concentrations by the equation obtained from this correlation. Then, the samples were dipped into K-sorbate solutions at the calculated concentrations. High moisture apricot samples were dipped into K-sorbate solution at lower

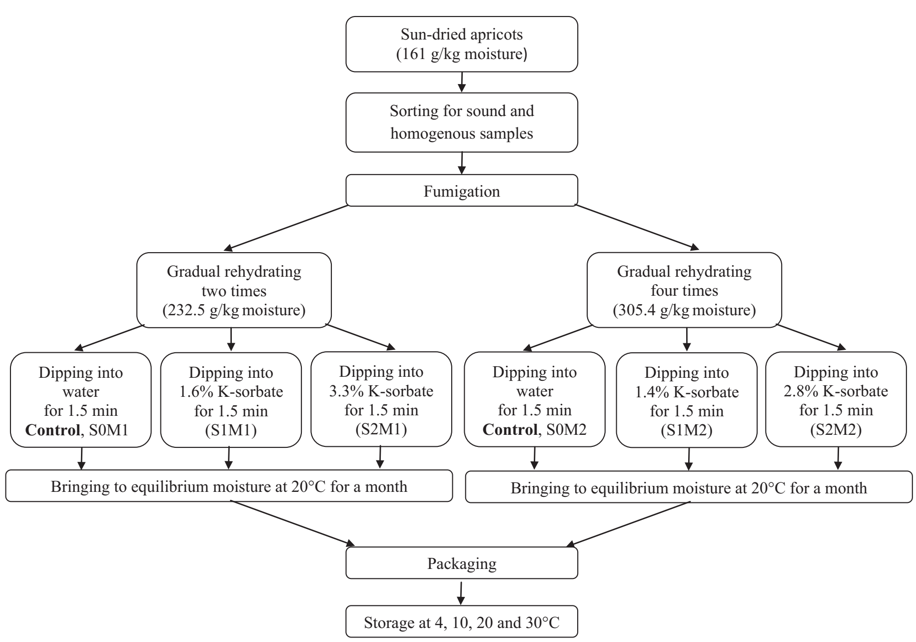

Fig. 1. Flow diagram of SDA processing.