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Effects of ozone treatment on microflora of dried figs

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Abstract

Ozone application to control odour, bacteria, germ, virus and mould is widely used in many fields of food processing. To inactivate microbial flora on dried figs ozone was applied in gas form for three and five hours at 5 and 10 ppm. A statistically significant reduction in the total bacterial, coliform and yeast/mould counts were obtained ($P < 0.05$). *Escherichia coli* was not found on the samples. Results indicate that to reduce microorganism count on dried figs minimum three hours treatment at 5 ppm is required. Decrease in total aerobic mesophyllic microorganism and yeast/mould counts was approx. 38% and 72% at this level where all coliform bacteria were inactivated.

Keywords: Dried figs; Ozone treatment; Microbial flora

1. Introduction

Figs are grown in all countries around the Mediterranean. Today, Turkey, Spain, the United States, and Greece are the primary producing countries of dried figs. Turkey grows close to a quarter of world's fig production (Anonymous, 2004a). In 2003, 42,095 tons of dried figs were exported from Turkey with a total value of US $ 78 million (Anonymous, 2004b). The main problems of dried figs are decreases in food quality and safety because of the hazardous microorganisms, aflatoxin B_1, and some storage pests such as *Ephestia* or *Plodia*. The main reasons are the traditional harvest and post-harvest practices. Dried figs are allowed to ripen fully on the tree for the best quality. If ripe fruits hang on the tree longer, the risk of spoilage or souring caused by microorganisms, insect and bird attack could increase, although they will be sweeter. In that case ripe figs can fall on the ground and the risks of damaging of fruit skins can increase. Obviously the best way is to pick the fruit as soon as it reaches ripeness. Although the removal of overripe and damaged-spoiled figs can greatly reduce the quality related problems, daily harvest and selective drying can not be practiced regularly due to lack of manpower. All hand picked and fallen fruits are collected and sun dried on wooden frames at the ground level. Since export companies must provide documentary evidence of laboratory analyses for aflatoxin B_1 and other microorganisms, primary control for each lot is performed by sampling at the purchasing stage.

After acceptance dried figs are strictly examined on tables under UV light where the contaminated parts reflect a different color from the uncontaminated parts.

Until recently, for safe storage dried figs have usually been treated with Methyl bromide. As its use is strictly forbidden by national and international rules, the search for alternatives has increased. One of the important methods from the consumer and environmental points of view is ozone treatment which has been already applied in disinfection of municipal water, process

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water, bottled drinking water and swimming pools (Anonymous, 2004c). Ozone treatment of waste water, dairy and swine effluent, cooling towers, hospital water systems and equipment, aquariums and aquaculture are relatively new applications.

One of the important usages of ozone in agriculture is the post harvest treatment of harvested crops. Ozone can be applied to foods as a gas or as a dissolved form in water. The main purposes of ozone application at the postharvest stage are given below:

- Inactivation of bacterial growth (Sharma, Demirci, Beuchat, & Fett, 2002; Achen & Yousef, 2001; Kim & Yousef, 2000; Xu, 1999).
- Prevention of fungal decay (Palou, Crisosto, Smilanick, Adaskaveg, & Zoffoli, 2002; Perez, Sanz, Rios, Olias, & Olias, 1999).
- Destruction of pesticides and chemical residues (Hwang, Cash, & Zabik, 2001; Ong, Cash, Zabik, Siddiq, & Jones, 1996).
- Control of storage pests (Mendez, Maier, Mason, & Woloshuk, 2002; Kells, Mason, Maier, & Woloshuk, 2001).

The objective of this research was to determine the influence of ozone treatment in gas form on microbial flora, aflatoxin B_1 and *Ephestia kuhniella* in dried figs. This paper contains only the results on microbial flora.

2. Materials and methods

Dried Sarıop–Calimyrna–figs, the main cultivar for drying in Turkey were obtained from a commercial company in Izmir, Turkey (Selcuk Gıda). Dry fruits were stored in a cold room at 4°C.

An experimental setup for ozone application consisting of an ozone generator, monitor-controller and ozone detector was obtained from the company Ozomax Inc., Canada (http://www.ozomax.com). Ozone gas was generated using a laboratory corona discharge ozone generator (Model OZO-1VTT) from purified extra dry oxygen feed gas. The output of the generator was 5 grams per hour. The amount of ozone in the fumigation chamber was controlled by a monitor-controller having a plug-in sensor on board which is changed for different ranges of ozone concentration. A wheel in the monitor-controller allows controlling the concentration in a selected range. The ozone monitor was placed outside the treatment chamber and the fan of the ozone monitor draws the air from inside the chamber. An incubation chamber having a 50 l volume was used for ozone treatment. The ozone concentration was measured by a portable ozone detector (Model OZO21ZX) in the range between 0–10 ppm with the accuracy of 0.01. An ozone detector and a small pivoting fan powered by a 12 V DC motor for better contacting the ozonated air and the dried figs were placed in the chamber.

Microbial analyses were carried out aseptically by mixing 10.0 g of dry fig with 90.0 ml sterile 0.1% peptone water using a blender. Serial dilutions from 10^{-1} to 10^{-5} levels were made. The surface spread method was used for total aerobic mesophyllic bacteria (Nutrient agar-Merck), coliform bacteria (Violet red Bile agar-Merck) and yeast/moulds (potato dextrose agar-Merck) at 30°C for 48 h, 37°C for 24 h and 25°C for 3–5 days, respectively (Messer, Rice, Johnson, & Williams, 2000). *E. coli* was determined by the MPN method (3 tube) on Florocoult Lauryl Sulfate Broth (Merck) at 37°C for 24 hours (Williams & Busta, 2000).

The data were statistically analyzed by analysis of variance (ANOVA) using SPSS 11.0. Duncan's multiple range (DMR) test was used at a significance level of 0.05 (Steel & Torrie, 1994).

3. Results

3.1. Total aerobic mesophyllic microorganisms

The results of Duncan's Multiple Range (DMR) tests based on the analysis of variance are presented in Table 1. Three hours ozone treatment at the level of 1, 5 and 10 ppm reduce the total aerobic mesophyllic microorganism counts of dried figs to initial values of 2.57 to 2.51; 2.07 and 2.00 log cfu/g, respectively. By increasing the exposure time to five hours for 1, 5 and 10 ppm the counts of mesophyllic microorganisms decrease to 2.11; 1.97 and 1.59 log cfu/g, respectively. Statistical analyses show that both of the concentration levels and exposure times can be considered significantly different at the 0.05 confidence level. Kim, Yousef, and Chism (1999) also obtained similar results by washing shredded lettuce with ozonated water. They obtained

Table 1
Effect of exposure time and ozone concentration on microorganism count on dried figs (log cfu/g)

	Exposure time (hours)	Ozone concentration (ppm)		
		1	5	10
Total Aerobic Mesophyllic Microorganisms	0	$2.57^{a\ (a)*}$	$2.57^{a\ (a)}$	$2.57^{a\ (a)}$
	3	$2.51^{a\ (a)}$	$2.07^{b\ (b)}$	$2.00^{b\ (b)}$
	5	$2.11^{a\ (a)}$	$1.97^{b\ (a)}$	$1.59^{b\ (b)}$
Coliform	0	$1.46^{a\ (a)}$	$1.46^{a\ (a)}$	$1.46^{a\ (a)}$
	3	$0.39^{b\ (a)}$	$0.00^{b\ (a)}$	$0.00^{b\ (a)}$
	5	$0.23^{b\ (a)}$	$0.00^{b\ (a)}$	$0.00^{b\ (a)}$
Yeast/mould	0	$1.46^{a\ (a)}$	$1.46^{a\ (a)}$	$1.46^{a\ (a)}$
	3	$1.30^{ab\ (a)}$	$0.73^{a\ (a)}$	$0.57^{ab\ (a)}$
	5	$1.00^{b\ (a)}$	$0.57^{a\ (a)}$	$0.40^{b\ (a)}$

* The same letters are not significantly different ($P < 0.05$) by DMR test: Letters denote the variance among the concentration level; Letters in parenthesis denote the variance among the exposure times.

about 2 log cfu/g reduction in total plate counts. Kondo, Utoh, and Rostamibashman (1989) obtained more than 90% reduction in total bacterial counts for Chinese cabbage by the same washing method.

3.2. E. coli and coliform

Escherichia coli was not detected in dried fig samples. The initial mean value of coliform bacteria was 1.46 log cfu/g (Table 1). After three and five hours ozone treatment at the 1 ppm concentration level coliform counts were reduced to 0.39 and 0.23 log cfu/g, respectively. At the 5 and 10 ppm level no *coliform* bacteria were found.

3.3. Yeast and mould

The initial yeast/mould count was 1.46 log cfu/g (Table 1). It decreased significantly as ozone concentration level increased. Three hours of ozone treatment at concentration levels of 1, 5 and 10 ppm reduced the yeast/mould count 1.30; 0.73 and 0.57 log cfu/g, respectively. Decreases in yeast/mould count at five hours ozonation for 1, 5 and 10 ppm concentration were 1.00, 0.57 and 0.40 log cfu/g, respectively. Statistical analyses showed that the concentration level can be considered significantly different influence at the 95% confidence interval. But the selected exposure times have no influence on the counts of yeasts/moulds.

To reduce yeast/mould activity, ozone could be applied either for longer periods at low concentration, or conversely for short period with higher concentrations. Literature studies shows that low concentrations and long exposure times were usually preferred for ozone applications. In the study of Palou et al. (2002) Elegant Lady peaches were treated for a four week period by ozone at 0.3 ppm concentration in cold storage conditions at 5°C temperature and 90%.relative humidity. Although aerial mycelia growth and sporulation are prevented at the given storage conditions, they started to increase in normal atmospheric conditions again.

4. Conclusion

Microbiological analyses showed that the treatment with ozone gases reduced the total aerobic mesophyllic microorganisms, coliform and yeast/mould counts which were statistically lower than those of untreated control samples at the 95% confidence interval. No significant difference between two exposure times, namely three and five hours has been found except for the total aerobic mesophyllic microorganisms,. It can be concluded that a minimum of three hours ozone treatment at 5 ppm could be successfully used for reducing the microbial count of dried figs. Decreases in total aerobic mesophyllic microorganism and yeast/mould count were approx. 38% and 72% at the suggested conditions where all coliform bacteria were inactivated. Fumigation by ozone reduces the microbial spoilage risk. The destroying yeast and moulds just after harvesting will certainly reduce the possibility of aflatoxin formation before the next processing steps. From a food quality and safety point of view prevention is a better strategy than detoxification which is much more complicated. As ozone should be used not only to inactivate microorganisms, but also for degradation of aflatoxin B_1 and pest control, detailed advice on application parameters and methods such as treatment in atmospheric or vacuum conditions will be discussed in further reports. On the other hand sensitivity of microorganisms to ozone could be influenced by many factors including crop species, moisture content, location of microorganisms in the food, forms of fruit, interactions among different parameters, etc. Therefore, a general recipe for ozone application for all kind of dried fruits, which is often requested by the food industry, can not be given. Each dried fruit must be studied separately. Ozone treated foods should be also be packaged using proper methods such as hermetic or vacuum storage.

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