Safety of frozen vegetables: A case study on carrots

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Abstract

Consumers are confident in frozen foods, which is a consequence of proven safety and quality characteristics of the products. However, safety depends strongly on the quality of the raw materials, the hygienic conditions when handling both at industrial and home processing, and on the temperature conditions during the entire logistic chain. Bacteria survival depends upon a number of factors, such as type of microorganism, freezing process, rate of freezing, storage temperatures and freeze-thaw cycles.

The goal of this work was to quantify the impact of the freezing operation *per si* and frozen storage, at two temperatures (-7º and –20 ºC), on total aerobes, yeast and moulds levels on shredded carrots (*Daucus carrota* L.).

Results showed that, for both temperatures analyzed, the freezing operation itself had a significant effect (p<0,05) in reducing microbial counts, when compared with the initial levels. Storage temperature did not influence significantly mesophilic aerobic flora levels (p<0,05). However, yeasts counts in samples stored at –20ºC presented a gradual decline along the storage period, being significantly lower than samples at -7ºC, after 10 days of storage. Moulds were not detected in all analyzed samples.

Keywords: Shredded carrots, freezing storage, microbiology, safety

1. Introduction

Soil is the primary source of vegetables contamination. Soils frequently contain as many as 10^8 bacteria per gram. Around 10^6 may be in spore state. Many of these microorganisms may contaminate plant tissues during harvesting and/or handling. Therefore, before vegetables processing, it is essential to remove adherent soil and dust through surfaces washing (Stumbo, 1965). Another important group that could contaminate raw vegetables is fungi. Different genus of fungi, like *Alternaria* in cabbage and cauliflower, or *Fusarium* in root vegetables, may cause tissue breakdown due to pectolytic enzymes production (Hayes, 1985).

Freezing is one of the most effective processes of food preservation. Consumers are confident in frozen products, however the final quality/safety of the products depends on the raw materials, hygienic procedures and operating temperatures along the whole process and distribution chain.

Aiming at maximum quality retention of foods, several pre-treatments may precede a freezing process. As an example, it can be mentioned that most frozen vegetables suffer a mild heat treatment known as blanching (Arthey, 1995). Blanching reduces microbial content of foods, and acts at enzymatic level reducing activity of several enzymes responsible for quality degradation during storage. Nevertheless, food sensory attributes may be sacrificed. Typically, vegetables' blanching is done with steam or hot water, within

the temperature range 75-95 ºC for 1-10 minutes. The time/temperature combination depends on the vegetables (Lund, 2000).

Freezing may be fast or slow. Besides the proven influence of the freezing velocity on food quality attributes, it also affects microbial activity. In fast freezing processes a greater temperature shock occurs, drip loss is reduced, thus yielding less microbiological problems (Brock, 1994).

The storage temperature of frozen foods greatly affects their final characteristics, both from a quality and safety point of view. The minimum growth temperatures for bacteria are generally higher than storage in frozen conditions. Foods stored at –5 ºC to –10 ºC present a greater reduction in viable microbial count than foods at lower temperatures. At temperatures around –20 ºC, losses in cell viability are evident, particularly in the early days of storage. However, higher storage temperatures promote deterioration rates of the food resulting from other causes. Even when microbial growth is completely inhibited, the product can still deteriorate due to the continued activity of released microbial enzymes (Hayes, 1985).

The effect of different operations involved in a freezing process of peas is shown in Table 1. It can be observed that after washing and blanching bacteria counts drop sharply. These numbers suffer an increase till peas enter the freezer, which indicate product contamination between blanching and freezing processes.

Table 1. Effect of different operations, during peas freezing, on bacteria (Canet, 1989).

Sampling points	Thousands of bacteria per gram of peas
Platform	11 346
After washing	1 090
After blanching	10
End of inspection belt	410
Entrance to freezer	736
After freezing	560

Repeated freeze-thaw cycles disrupt and destroy bacteria. However, the effects of cyclic freezing on most microbial pathogens are not well documented. Lund (2000) refers that bacterial spores are extremely resistant to the effects of freezing and repeated freeze-thawing.

It is obvious that the effect of freezing and frozen storage on microorganisms is an interaction of many factors, some of them not fully understood, and perhaps some of them not discovered at all.

The main objective of this work was to evaluate the effect of freezing operation per *si* and frozen storage at two temperatures (-7 ºC and –20 ºC), on total aerobes, yeast and moulds levels on shredded carrots (*Daucus carrota* L.).

2. Material and methods

Samples preparation

Shredded carrots were obtained from a producer. At its arrival at the laboratory, carrot samples were frozen in a vertical forced air freezer (Refriger). The average air temperature was –40 ºC and samples were frozen till –35 ºC (temperatures monitored with thermocouples). Frozen carrots (~100g) were packed into polyethylene bags (22X35 cm), sealed and stored in laboratory freezers at –7ºC and –20º ±1ºC (S550 BT, Fitotherm). Raw carrots, samples immediately after frozen, and samples along storage in frozen conditions, were analyzed.

Microbiological analysis

Twenty grams of each sample were mixed with 180 mL of tryptone-salt broth (Biokar) and homogenized in a Stomacher for 1.5 minutes. Samples suffered a ten-fold dilution for subsequent microbiological analyses: (i) enumeration of total aerobic mesophilic flora on plate count agar (Biokar) according to ISO 4833:2003 (five replicates); (ii) enumeration of yeasts and moulds on rose bengal chloramphenicol agar (Biokar) according to ISO 7954:1987 (five replicates).

Data was compared by analysis of variance (ANOVA, Statistica 6.1, StatSoft, Inc., Tulsa, OK, USA). A least significant difference test ($p<0.05$) was performed for mean comparisons.

3. Results and discussion

Results of total aerobic mesophilic counts on shredded raw carrots, after freezing and during storage at -7 and –20ºC, are shown in Figure 1. The number of microorganisms detected in raw carrots suffered a significant decrease of 30%, after the freezing operation. For samples stored in frozen conditions, an even higher reduction was observed, specially notorious for storage periods higher than 3 days. No differences were distinguished between results obtained at –7 and –20 ºC (i.e. no significant effect of stored freezing temperatures was observed).

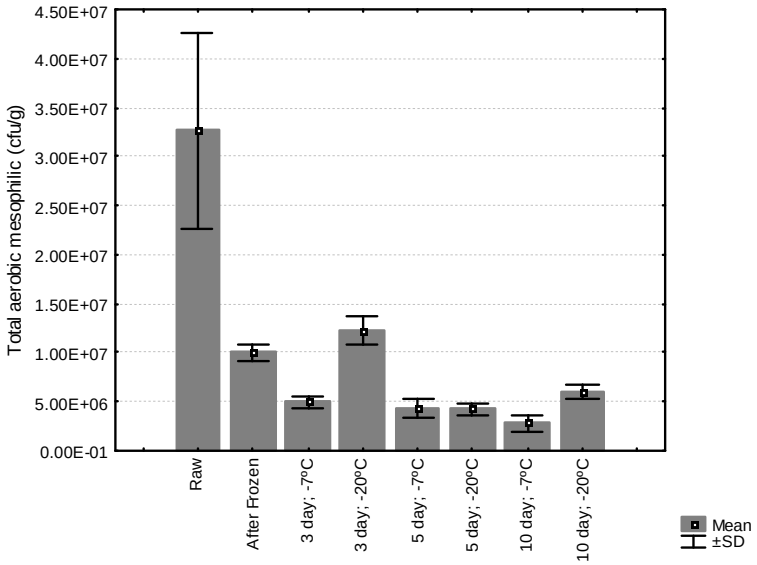

Figure 1. Total aerobic mesophilic counts in shredded raw carrots, after freezing and during storage at –7 ºC and –20 ºC. Vertical bars denote standard deviation (SD) of experimental data.

Results of yeast counts are presented in Figure 2. Initial yeast counts in raw carrots suffered a significant (p<0,05) decrease when compared to frozen carrots stored -7 and –20ºC.

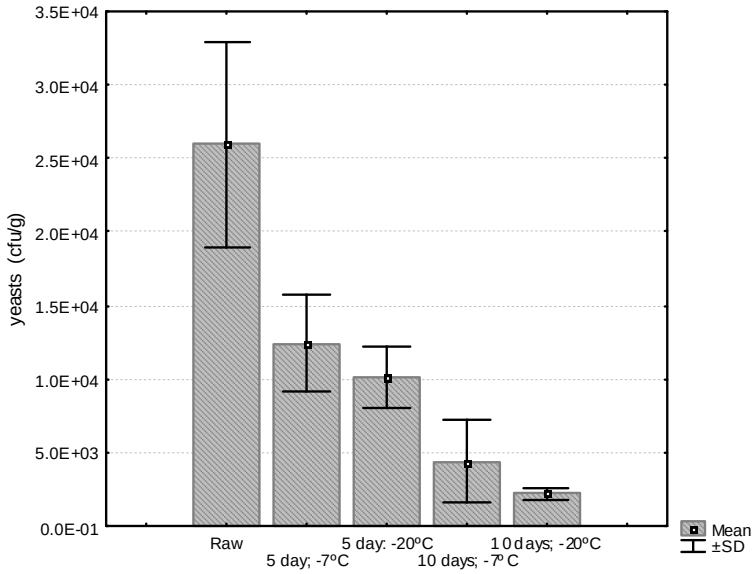

Figure 2. Yeasts counts in shredded raw carrots and during storage at –7 ºC and –20 ºC. Vertical bars denote standard deviation (SD) of experimental data.

Frozen storage reduced yeast counts, indicating that the combination of freezing and frozen storage adversely influenced the survival of yeasts in shredded carrots. A gradual decline along storage time can be perceived at both temperatures. Samples at –20 ºC presented significant lower yeast counts ($p<0.05$) than samples at –7 ºC, at the tenth day of storage.

Moulds were not detected in all analyzed samples.

Experimental data obtained in this work clearly indicate the influence of freezing and frozen storage on microbial load of shredded carrots.

4. Conclusions

Freezing operation reduced significantly total aerobic mesophilic microorganisms in raw shredded carrots. If frozen samples were storage at –7 ºC or –20 ºC, greater reductions would be observed.

For yeasts, the lower the frozen storage temperature the better the preservation effect, as the number of colonies decreased.

5. References

ARTHEY, D. 1995. Freezing of vegetables and fruits. In Frozen foods technology (Ed. C.P. Mallet), Blackie Academic & Professional, Glasgow, p. 237-269.

BROCK, G. 1994. Microbiology of frozen foods. Congresso “Refrigeração, congelação e descongelação na indústria alimentar”. Escola Superior de Biotecnologia. Porto. 5 a 7 de Dezembro de 1994.

CANET, W. 1989. Quality and stability of frozen vegetables. In Developments in food preservation (Ed. S. Thorne), vol.5, Elsevier Science Publishing Inc., New York.

HAYES, P.R. 1985. Food microbiology and hygiene. (Ed. P.R. Hayes), Elsevier Applied Science Publishers, London and New York.

LUND, B.M. 2000. Freezing. In: Lund, B.M.; Baird Parker, T.C.; Gould, G.W. (Eds), The Microbiological safety and quality of food, vol.I Aspen Publishers, Gaithersburg, MD, pp.122-145.

STUMBO, C.R. 1965. Thermobacteriology in food processing (Ed. M.L. Anson, E.M. Mrak, C.O. Chichester, G.F. Stewart), Academic Press Inc., New York and London.