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Nut pasteurization
Minimising impact on appearance, colour, and flavour

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ABSTRACT: Following several major product recalls, nuts are now increasingly viewed as high risk products. These low moisture foods do not support the growth of microorganisms, however Salmonella survives very well on nuts and may cause severe illness. Dry or moist thermal processes are already validated to pasteurize nuts, but new technologies combining steam and vacuum have improved the outcome of the process helping to preserve the raw attributes of the nuts. The vacuum allows precise control of saturated steam conditions and treatment temperature parameters. By programming profiles specific to each nut, steam and vacuum are combined optimally to protect the characteristics of each product. This batch process is available in a modular range of sizes suitable for processors large or small whether handling a large volume of a single product or a large range of products.

CONTAMINATION ISSUES IN NUTS

Peanuts, almonds, pistachios, pecans, pine nuts, macadamias, hazelnuts, Brazil nuts, and walnuts have all been involved in product recalls due to salmonella. These have prompted food safety authorities to assess their microbiological safety (1). As a consequence major changes in food safety management are taking place, to insure continued consumer confidence in the health benefits of nuts, and to protect the brands and reputation of companies in the industry.

Low moisture foods have been, until recently, considered safe because they do not support the growth of microorganisms. However, research conducted on almonds, has shown that Salmonella is a bacteria of particular concern because it can be pathogenic at low doses (2) and can survive in adverse conditions for a very long time (3, 4). The young, the elderly and the immuno compromised are most at risk from exposure to Salmonella, and the infection may require hospitalization and even result in fatalities.

Industry reliance on sampling and testing is inadequate except to reflect the overall cleanliness of a product. Salmonella is difficult to detect on nuts with existing microbiological sampling plans because it may be present in very low doses and unevenly distributed in the product. Because salmonella has a very low infective dose in dry foods such as nuts a process control is the only way to ensure a safe product. The Almond Board of California conducted a risk assessment and decided in 2007 to mandate the pasteurization of almonds (5).

As a consequence almond processors were required to have their equipment validated for a 4 $\log_{10}$ kill performance (10'000 fold reduction in Salmonella), or have their product treated by a validated third party. Although fumigation with Propylene oxide (6) is most widely used, some continuous steam processes exist and new batch steam technologies are entering the market.

RISK ASSESSMENT

Risk assessments are currently underway for nuts other than almonds, but already the industry is taking steps toward pasteurizing all their products. The target microbial reduction goal should be determined for each nut taking into account the frequency and level of occurrence of salmonella, production and storage conditions, and consumption patterns. The almond risk assessment showed that the consumption of raw almonds carried a 78 percent risk of one or more cases of salmonellosis per year. This risk could be reduced to <1 percent with a 5 $\log_{10}$ reduction process (7). Subsequently the almond Board of California determined that a 4 $\log_{10}$ reduction would provide the consumer with adequate protection.

Validation is required in each case because the bacteria does not survive pasteurization in the same way on different nuts. Finally the impact of the thermal process on appearance, colour, and flavour is different for each nut and requires determining the most suitable treatment parameters to achieve adequate decontamination while minimizing impact on product characteristics.

THERMAL PROCESSES

Microorganisms are killed by heat which is the basic process behind pasteurization, a natural process that uses no chemicals and leaves no residues. Thermal processes include oil roasting, hot air roasting, blanching, or steam treatment.

In a continuous process the product is in movement on a belt, in a bath, or in a screw, and conditions are inherently in-homogenous. With steam there is a more efficient heat transfer than with dry heat but, at ambient pressure a lot of moisture is added to the product requiring a drying step which may affect product quality.

New technologies combining vacuum and steam now allow treatment of nuts at lower temperatures which preserve the natural qualities of a raw product and do not necessitate a drying step.

STEAM VACUUM PROCESSES

A vacuum based process requires a closed chamber (shown in Figure 1), and is a batch process. The product is placed in an autoclave in which a deep vacuum is first established to remove all the air. When the steam is introduced in the autoclave, it fills the vacuum and reaches the product raising its temperature. Steam continues to be introduced into the chamber until a target pasteurization temperature is reached. In the autoclave pressure and temperature are precisely controlled to insure that saturated steam conditions are

SHELF LIFE OF WALNUTS

Walnuts, with their high oil content, are sensitive to high temperatures which affects their colour. Microbiological reduction performance criteria have to be reached with lower pasteurization temperatures.

Pasteurization has a beneficial effect on the shelf life of walnuts (9). Because of their high oil content they are particularly susceptible to rancidity. In the shelf life study data plotted in Figure 3 a 20 percent reduction in peroxide values is obtained through pasteurization and this difference is maintained over the duration of the study.

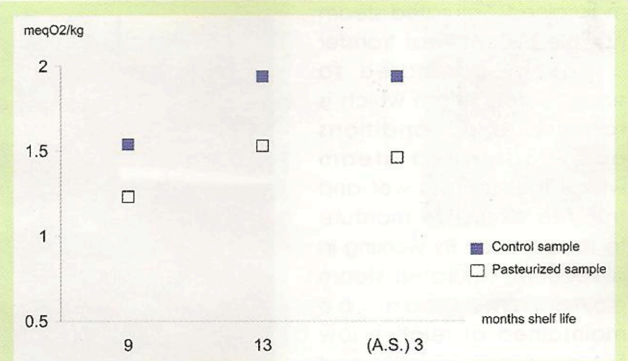

Figure 3. Shelf life study of peroxide values in pasteurized walnuts. Plot of peroxide values at 9 months and 13 months storage, and in accelerated shelf life conditions in a climatic chamber for 3 months at 30°C and 90 pecent humidity (A.S. 3 months). (Figure courtesy of Napasol AG).

NATURAL PASTEURIZATION IN HOUSE

The steam vacuum process offers a solution for the decontamination of nuts while preserving their natural appearance, colour, and flavour. Some nuts are unaffected by higher pasteurization temperatures while others need a lower temperature and/or longer treatment time to reach decontamination objectives. Others still require the flexibility of the technology to ramp up in temperature slowly to avoid skin lifting (almonds, peanuts), or control the final vacuum phase to avoid fats leaching from the nuts (pine nuts, macadamias).

More precise control of temperature, no drying step, homogeneous treatment, flexibility, and programs specific to each nut are the key features of this technology. Pasteurization autoclaves are modular, compact units, designed to be integrated in the product flow of nut processing facilities. Here is an alternative which brings a solution to processors, who now have the possibility of keeping this critical step in food safety management in house.

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maintained. Saturated steam has the highest heat transfer capability compared to superheated steam which is too dry, and conditions below saturated steam where the steam is wet and transfers excessive moisture to the product. By working in a vacuum, saturated steam conditions can be maintained at relative low temperatures, quickly and effectively pasteurizing the product without affecting product quality.

Because of the universality of the physics of the process it can be applied to large and small autoclaves. Products to be pasteurized can be loaded in trays, bags, or on belts, and the process is suitable to handle both small volumes of a large range of products and large volumes of a single product.

Figure 1. A 4m3 Steam vacuum pasteurization unit with tray loading system used for treating a range of nuts. The product is never in contact with the autoclave reducing cross contamination risks and eliminating risk of scorching on metal surfaces. Trolleys are loaded into the autoclave and a vacuum is created before steam is injected in the chamber. No subsequent drying step is necessary. (Photo courtesy of Napasol AG).

DISTRIBUTION OF TEMPERATURE

A critical parameter for the pasteurization process is temperature distribution. It is the combination of vacuum and steam that allow homogeneous conditions to be rapidly established in the autoclave. Because the steam is injected in a deep vacuum the temperature of the product is uniformly raised up to the target pasteurization temperature. Saturated steam conditions are maintained to optimize heat transfer and minimize moisture pick up. The process finishes with a deep vacuum removing residual moisture and cooling down the product.

NOT ALL NUTS ARE CREATED EQUAL

Nuts are a group of products with very different characteristics. Moisture, heat and vacuum affect each one differently, and require a specific treatment profile. In addition, the thermal resistance of the contaminant is not the same on different nuts and testing and validation is required for each of them. The optimisation of the process for a specific nut should take into consideration the log reduction suitable to address the risk level for that nut, while minimising the impact of the process.

CHALLENGE TEST ON PISTACHIO KERNELS

A biological challenge test (8) is conducted to assess the effectiveness of a thermal process on the reduction of the microbial load. In the example below (Table 1) pistachio kernels are artificially inoculated with high levels of a bacteria, *Enterococcus faecium*, a non pathogenic Salmonella surrogate. Samples are inoculated to a level above 10'000'000 cfu/g and are embedded in product in the autoclave at 12 different locations. Lethality is then determined at a treatment temperature of 88°C by increasing exposure time from 3' to 4.5 minutes. Laboratory analysis of pasteurized inoculated samples shows that 4 minutes at 88°C is sufficient to achieve a reduction of at least $4\log_{10}$ in all samples.

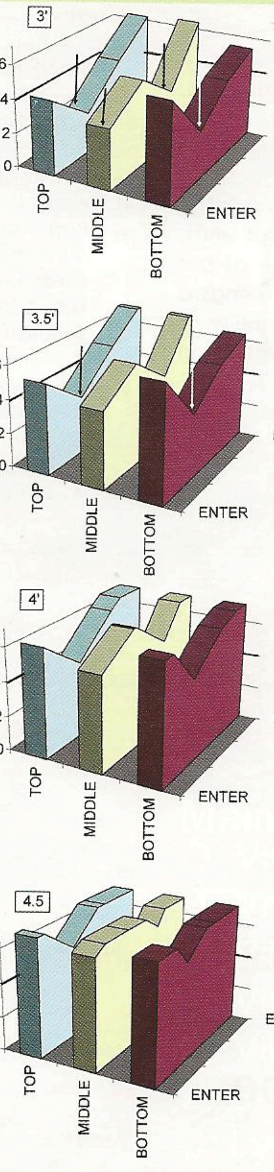


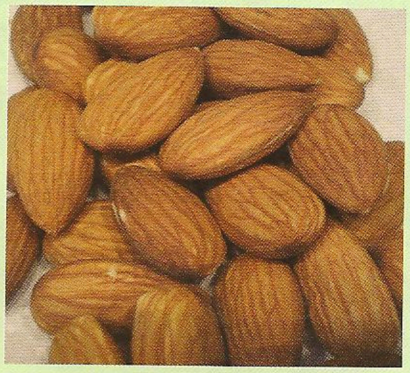
Table 1. Log10 reduction level at a pasteurization temperature of 88°C with increasing exposure times: 3, 3.5, 4, and 4.5 minutes. Vertical axis: logarithmic scale of reduction in microbial count of the bacteria. Left to right: top, middle and bottom locations in the autoclave. Front to back: loading side, middle and unloading side of the autoclave. (Table courtesy of Napasol AG).

SKIN LIFTING IN ALMONDS

A typical problem for almonds treated with steam is skin lifting and subsequent flaking which exposes peeled surfaces of the nut. To avoid this phenomenon almonds require a specific steam injection profile that allows the meat of the nut and the skin to expand at the same time. Pasteurization temperatures for almonds are lower than for pistachio kernels but a longer treatment time is require achieving a 4 $\log_{10}$ reduction in *Enterococcus faecium*.

Figure 2. Photograph of almond samples showing that the pasteurized process did not produce any skin lifting. (Photo courtesy of Napasol AG).

Control sample.



Pasteurized sample.