Meta Science 98 (2014) 420–434

Contents lists available at ScienceDirect

Meat Science

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

Review

Advanced retorting, microwave assisted thermal sterilization (MATS), and pressure assisted thermal sterilization (PATS) to process meat products

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ARTICLE INFO

Article history:
Received 22 May 2014
Received in revised form 19 June 2014
Accepted 20 June 2014
Available online 30 June 2014

Keywords:
Sterilization
PATS
MATS
Retorting
Emerging food processing technologies

ABSTRACT

Conventional thermal processes have been very reliable in offering safe sterilized meat products, but some of those products are of questionable overall quality. Flavor, aroma, and texture, among other attributes, are significantly affected during such processes. To improve those quality attributes, alternative approaches to sterilizing meat and meat products have been explored in the last few years. Most of the new strategies for sterilizing meat products rely on using thermal approaches, but in a more efficient way than in conventional methods. Some of these emerging technologies have proven to be reliable and have been formally approved by regulatory agencies such as the FDA. Additional work needs to be done in order for these technologies to be fully adopted by the food industry and to optimize their use. Some of these emerging technologies for sterilizing meat include pressure assisted thermal sterilization (PATS), microwaves, and advanced retorting. This review deals with fundamental and applied aspects of these new and very promising approaches to sterilization of meat products.

Contents

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http://dx.doi.org/10.1016/j.meatsci.2014.06.027
0309-1740/

1. Introduction

Preservation of meat and meat products that will last for long periods of time, where overall quality is highly acceptable, has always been a challenge to processors. A good number of treatments have been adopted and optimized to attain high quality products where safety is the primary factor to consider. Typical treatments utilized by the meat industry include freezing, cooling, dehydration, and a number of thermal approaches; the use of hurdle technology, where some of the variables to consider include pH and water activity depressors (salts, sugars), antimicrobials, spices; smoking; irradiation; and active packaging, among many others. Quite often, shelf stable products require severe thermal treatments to warrant sterility, where retorting is the most popular approach. Retorting is a very energy intensive process where steam generation and effective cooling is required to offer long lasting products (Ibarz & Barbosa-Cánovas, 2003). In the case of combat rations, for example, three years is the target time for products to be stored at room temperature. Recently, processors have been looking into even longer shelf lives for selected food products, including meat products, e.g., those required by Mars expeditions where the target shelf life is 5 years.

1.1. Conventional sterilization methods

Sterilization is necessary to ensure the safety of packaged low-acid food products. At the same time, extreme conditions during processing significantly decrease quality characteristics of the product. The technology most commonly used to sterilize food in different kinds of containers, e.g., cans, pouches, polymeric trays, jars, cups, and bowls, is known as static or still retort processing (Ibarz & Barbosa-Cánovas, 2003). The purpose of this type of process is to reach a target sterilization temperature, for example 121 °C, for a given time, where versatility comes via a variety of heating media such as water immersion, steam/air, and steam/water spray, among many others. In these treatments, the containers are held in position and processed according to specifications where the only two variables that can be manipulated are temperature and time, raising significant limitations in ensuring the quality of the final product (Ibarz & Barbosa-Cánovas, 2003). The aim of sterilization is to ensure that all cold points (worst case processing scenario) in the food product receive thermal treatment capable of reducing a *Clostridium botulinum* load 12 log cycles. The time required to reach this final microbial load is known as 12D, where D is the treatment time required to reduce the number of microorganisms to the tenth. These processing conditions allow the ability to ensure shelf stable low-acid products. However, texture, taste, flavor and nutritional value of the food deteriorate significantly because of the extreme processing conditions. An alternative to still retorting for a selected group of containers, such as cans, is to provide agitation. This approach is suitable for foods containing liquids or semi-liquids because convection heating speeds up the heating process. The level of convection depends on viscosity of the product, headspace, geometry of the container, the way containers are placed in the retort, as well as type of retort motion (Ibarz & Barbosa-Cánovas, 2003).

A number of heavily used retorts with agitation exist, such as hydrostatic cookers, continuous and semi-continuous agitating retorts, and end-over-end processing, to name a few. They are used for a limited type of containers, most with some type of symmetry, such as cans and jars, and are negatively criticized because opportunities for thermal processing optimizations are limited. With the ever growing diversity of food products and containers, the trend is to use multi-process mode retort systems to provide greater processing flexibility, which all of the abovementioned retorts lack.

Another alternative for conventional thermal processing of food is aseptic processing, where the products are first thermally treated, then carried to a container that was previously sterilized, and finally sealed under sterile environmental conditions. This technique is used in fluids such as milk and fruit juices, as well as fluids containing chunks, such as soups and stews. Aseptic processing offers advantages when compared to traditional thermal treatment in containers since the food undergoes less deterioration, processing times are shorter, energy consumption is reduced and the quality of the treated product is improved and more uniform. Some constraints of the process are the inability to process placeable food products such as filets; semi-solid foods such as tuna in chunks. Additionally, the packaging materials are expensive and they are available in limited shapes and capacities, while a lack of versatility of the fillers is noticeable (Ibarz & Barbosa-Cánovas, 2003).

Food irradiation in its three forms, i.e., gamma, electron beam and X-rays, offers a sound alternative for processing certain types of foods, including all types of meats. It is scientifically considered to be a safe process, but some consumers have a negative perception about irradiation, and as such, some countries have restricted its use to herbs and spices. In the US, irradiation became more frequently used a few years ago to guarantee the safety of beef carcasses, among many other products. While irradiation is still an option, there is a growing public concern about this process due to mass media focus on this topic, thus adding hurdles to much broader utilization (Zhang et al., 2011).

1.2. Typical sterilized meat products

Commercially sterilized meat and poultry products are generally considered as shelf stable and are categorized as "canned" despite the various flexible containers such as retortable pouches or semi-rigid containers used in production. The definition provided by the USDA Food Safety and Inspection Service (FSIS) for these products in their Draft Compliance Guidelines for Ready-to-Eat Meat and Poultry Products is, "A meat food product with a water activity above 0.85 that receives a thermal process either before or after being packed in a hermetically sealed container." (FSIS, 2001). These thermally processed commercially sterile meat products fall into the category of ready-to-eat products. Conventional manufacturing processes for thermally sterilized muscle foods include canning and retorting in pouches. Thermal processing of muscle foods in retortable pouches yields favorable sensory characteristics with longer shelf-life, lower nutrient loss, as well as increased commercial value, safety and convenience (Bindu et al., 2004, 2007; Gopal et al., 2001; Shankar et al., 2002). Examples of thermally processed commercially sterile muscle foods, including red meats, poultry meats and seafood, are summarized in Table 1.

1.3. Quality changes

Conventional retorting at high temperatures for long periods of time for processing of meat and meat products, while providing safety through elimination of microorganisms, particularly pathogens, negatively influences consumer quality attributes such as nutrient composition, flavor, color and texture (Bindu et al., 2004, 2007). These changes take place in biochemically important components such as proteins, lipids, as well as vitamins and minerals. The most important changes occur in meat proteins, affecting texture, flavor, color and nutritional value of the product. Proteins undergo two types of biochemical changes during thermal treatment, one of which is alterations in secondary, tertiary and quaternary structures resulting in unfolding of proteins that increase protein bioavailability by means of formation of readily absorbed amino acids. On the other hand, changes in primary structures lower the digestibility and bioavailability of proteins, which is also due to the loss of amino acids (Bindu et al., 2004, 2007). Structural changes due to heating give rise to a decrease in the water-holding capacity of the meat as well (Tornberg, 2005). An additional effect of heating is that it causes oxidation of muscle proteins by increasing free radical production, thus negatively affecting sensory and nutritional quality of the product (Traore et al., 2012).

Another important change when using heat treatment is due to the denaturation of collagen, which causes changes in the structure of