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ANIMAL ORIGIN FOOD PRESERVATION AND ITS SAFETY ISSUES

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An analysis of consumer preferences on the food market in Poland indicates that freshness, sensory properties and healthiness play a key role among criteria influencing the choice of food products. Although the satisfaction of Polish consumers is still limited by economic restrictions, the quality and safety of food, particularly that of animal origin, represent factors of great importance. On the one hand, safety aspects have become especially significant by a growing demand for natural, non-changed, minimal processed food, *e.g.* food chilled only, or, on the other hand, by a demand for convenience food products demonstrating desirable quality and durability.

In relation to preservation of animal food like: meat, poultry, fish, milk or eggs *etc*., main interests are focused on the use of new physical methods, including high hydrostatic pressure, ultrasounds, pulsed electric fields with high voltage, electromagnetic radiation – especially ultraviolet light, pulsed light, ionizing radiation or even radio waves. New combined methods for food preservation based on the so-called *hurdle technology* are already proposed for practical use.

This manuscript is a brief presentation of innovative preservation methods of animal food mentioned above in respect of its safety issues. The authors emphasize a variety of new available food preservation techniques, illustrating their effectiveness with results of several studies, including results of own experiments.

INTRODUCTION

The growing awareness of the close interdependencies between agriculture, food and health results in a situation when meeting the requirements in terms of health safety of the produced food is at present one of the most important criteria used by the consumer while purchasing foodstuffs or even a *sine qua non* condition of the survival on the market for any food producer. Although meeting food demand of the Polish consumers is still affected by the pressure of economic limitations, criteria for the selection of foodstuffs, including those of animal origin, are based on such characteristics as freshness, sensory attributes and the effect on health [Kowrygo & Rejman, 2000; Świderski, 2003; Kijowski & Sikora, 2003].

An analysis of the food market in recent years indicates a dynamic increase in the interest in products characterized not only by high quality and novelty, but at the same time possibly convenient for easy preparation at home. The growing demand for products considered as the so-called convenience food, *i.e.* one with a high degree of processing, facilitating prompt preparation of meals, prompts both producers and retail operators to constantly implement new technologies, new packaging types and methods, as well as marketing and distribution methods. These are also reasons for research and development studies, requiring active involvement of specialists in food science and technology [Konieczny & Uchman, 2000].

Due to the possibility of inducing food poisoning over the entire chain of actions connected with the production and distribution of food, special emphasis is put on the prevention of risks connected with biological contamination, including microbiological contamination, as well as chemical and physical ones. A statistical analysis conducted on the basis of epidemiological investigations clearly shows that among pathogenic factors inducing food poisoning microorganisms rank first. Microbiological hazard from food results both from the potential presence of pathogenic bacteria, moulds and viruses in the food, and toxins produced by the microorganisms. According to German statistics, poisonings caused by pathogenic bacteria only to a limited extent exceed the number of poisonings caused by viruses [Kijowski & Maleszka, 2005].

Alternative food-preservation and processing technologies are being developed to a large extent as a reaction to consumers' requirements. To-day's need is food which is not only more convenient in use, as it has been mentioned above, but also nutritionally healthier, fresher (*e.g.* chill-stored), more natural (minimally processed, *e.g.* mildly heated), less preserved (*e.g.* with low contents of acids, salt, sugar) and less reliant on additive preservatives (*e.g.* sulfite, nitrite, benzoate, sorbate) than previously. A consequence of these trends is the 'minimal processing' concept, describing approaches to food safety and preservation that are designed to retain natural and fresh properties of foods [Manvell, 1997]. Unfortunately, the consumer might be more or less directly

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TABLE 1. Conventional and novel methods for food preservation.

Major existing technologies for food preservation	New emerging technologies for food preservation
Techniques that slow or prevent the growth of micro-organisms	**Physical processes**
Reduction in temperature	Gamma and electron-beam irradiation
Chill storage, frozen storage	High-voltage electric gradient pulses
Reduction in water activity	High hydrostatic pressure
Drying, curing with added salt, conserving with added sugar	Combined ultrasonic, heat and pressure ('manothermosonication')
Reduction in pH	Laser and non-coherent light pulses
Acidification (*e.g.* use of acetic, citric acids *etc.*), fermentation	High-magnetic-field pulses
Removal of O_2	**Natural additives**
Vacuum or modified-atmosphere packaging	Animal-derived antimicrobials
Modified-atmosphere packaging	Lysozyme
Replacement of air with CO_2 – N_2 –O_2 mixtures	Lactoperoxidase system
Addition of preservatives	Lactoferrin, lactoferricin
Inorganic (*e.g.* sulfite, nitrite)	Plant-derived antimicrobials
Organic (*e.g.* propionate, sorbate, benzoate, parabens)	Herb and spice extracts
Bacteriocin (*e.g.* nisin)	Microbial products
Antimycotic (*e.g.* natamycin)	Nisin
Control of microstructure	Pediocin
In water-in-oil emulsion foods	Other bacteriocins and culture products
Techniques that inactivate micro-organisms	
Heating	
Pasteurisation	
Sterilization	
Techniques that restrict access of micro-organisms to products	
Packaging	
Aseptic processing	

exposed to hazard from contaminated products, frequently from foods of animal origin [Gould, 2001].

Besides the already existing, conventional technologies of food preservation, there is therefore a growing interest in non-thermal processes, such as high hydrostatic pressure (HHP), pulsed electric fields, high-intensity ultrasound, oscillating magnetic fields, ultraviolet light *etc*. Innovative, advanced technologies provide attractive alternatives to conventional methods of thermal processing which, when applied separately, may often cause undesirable changes in foods, affecting the balance between high quality and safety [Gould, 2001; Knorr *et al*., 2002]. However, according to the 'hurdle technology' concept, it is possible that by combining two or more preservation techniques synergistic antimicrobial effects might be achieved, together with lowering the energy input. An intelligent application of the 'hurdle' method minimizes the impact of treatment on the sensory and nutritive properties of food [Leistner, 2000]. In a similar fashion, combinations of various non-thermal technologies with organic acids or natural antimicrobial compounds (bacteriocins) to control foodborne microorganisms have been recently proposed [Ross *et al*., 2003].

This study addresses a brief presentation of selected novel methods of food preservation, particularly food of animal origin, in respect of its safety issues. First of all, the paper reviews various literature sources, but also presents recent results of the authors. In relation to the preservation of animal origin products such as meat, poultry, fish or eggs, we focus our interest on antimicrobial efficiencies of selected non-thermal methods used individually or in a combination with other treatments.

NEW FOOD PRESERVATION TECHNOLOGIES: MAKING FOODS SAFE WITHOUT HEAT

In recent years much effort has been devoted by researchers to search for novel food preservation methods combining two objectives: maximum antimicrobiological effectiveness and minimal losses of nutritive value and sensory attributes, *i.e.* flavour and appearance. These activities result primarily from changes in the behaviour of consumers and the fact that microbiological safety of food produced nowadays is affected by numerous factors. Kołożyn-Krajewska [1998] mentioned among them for example an increase in the adaptive capacity of microorganisms, the development of international trade (bigger contact of people with previously unknown pathogens transported with food), centralized markets, increased range of the activity and distribution of companies, international travel, as well as changes in consumer preferences, feeding habits and eating out.

The development of microorganisms in processed raw materials and finished products may nowadays be inhibited or limited by the application of numerous methods (Table 1), but their use in practice is advanced to a different extent; in many cases they are at the research and development stage [Gould, 2001; Dehne *et al*., 2001].

Thermal processes, such as blanching, pasteurization or heat sterilization, have long been employed in food processing as economic, efficient, reliable and safe methods. However, in most cases thermal energy induces various chemical reactions and the result is often a loss of nutritional quality in certain foods. Therefore, alternative food preservation treatments that prolong shelf-life without quality deterioration are to be favoured. New emerging technologies for food preservation provide such an option because they offer fresh-like and minimally processed foods with little loss of colour, flavor and nutrients [Dehne *et al.*, 2001; Knorr *et al.*, 2002].

In the control of microbiological hazard of food, including that of animal origin, also packaging methods and types play an increasingly important role. In this respect there are numerous novel solutions being proposed, improving both the stability and quality of products, as *e.g.* filling packaging with inert gases CO_2– N_2–O_2, the application of active packaging, including covering products with bacteriostatic films, the application of substances absorbing moisture or oxygen, as well as intelligent (indicator) packaging, the role of which is to inform the potential buyer on the quality status of the packaged product [Pyrcz *et al*., 2001; Weber, 2004].

NEW METHODS IMPROVING STABILITY AND SAFETY OF MEAT (RED MEAT, POULTRY, FISH AND SEAFOOD)

Microorganisms exist in the environments in which red meat, poultry, fish and seafood are produced, processed, packed and stored. With reference to meat and most meat products, when fresh constituting an especially advantageous medium for the development of microorganisms, the issue of microbiological safety and stability becomes the most important technological and organization problem in the entire production cycle, starting from the procedures connected with the slaughter of animals and the handling of the carcass to the finished product.

The main aim of meat processing technology is the preservation of slaughter materials using traditional methods such as chilling, freezing, drying; however, in spite of considerable experience in the application of chilling methods still new potential applications are being investigated.

Conventional technologies, implemented into practice, connected with the limitation of the number of pathogenic microorganisms on beef carcasses, such as *e.g.* the application of steam at subatmospheric pressure, final washing of the carcass with hot water and chlorate spraying, are thus supplemented with new methods, such as *e.g.* the application of ionising radiation or pulsed light [Pyrcz *et al*., 2001; Anonymous, 2004a].

In addition, the microbiological condition of poultry carcasses stems from maintaining hygienic standards at all stages of production, and special hazards are connected with the handling of the material during commercial slaughter of poultry and carcass chilling. It is estimated that the contamination of the total of carcasses with microflora results in 70% from the carrier state of domestic poultry, while the other 30% is cross-contamination in abattoirs [Anonymous, 2004b].

On unchilled poultry carcasses *Listeria monocytogenes* may be found in 15–55% cases, while *Campylobacter* even in 80% carcasses [Grabowski & Kijowski, 2004]. The possibility to effectively reduce the surface contamination of carcasses with microorganisms using non-thermal methods was pointed out by Sams & Feria [1991]. Subjecting skin samples taken from poultry carcasses to the combined action of ultrasounds (47 Hz, 200 W) and chlorine (100-200 mg/dm^3) they obtained 99% inactivation of *Salmonella spp.* As has been shown in successive studies [Raso *et al*., 1998; Dolatowski *et al*., 2000; Piyasena *et al*., 2003], industrial application of the ultrasound method for the inactivation of microorganisms and enzymes in food, including meat products, is very likely, and waves with the frequencies from 20 to 50 Hz may also be used to improve tenderness and accelerate meat ageing [Allen *et al*., 2001].

Another novel preservation technique, recommended among other things for the meat industry, is the so-called "pasqualization", *i.e.* high pressure processing (HPP). The HPP, also referred to as high hydrostatic pressure (HHP) or ultra high pressure (UHP) processing, subjects liquid and solid foods, with or without packaging, to the pressures range of 100-800 MPa. Process temperature during the pressure treatment can be specified from below 32°F (0°C) to above 212°F (100°C). Commercial exposure times can range from a millisecond pulse to over 20 min. Chemical and microbiological changes in the food generally will be a function of the process temperature and treatment time. In general, HPP can inactivate vegetative microorganisms, yeasts and moulds, whereas bacterial spores appear to be resistant. However, several studies have indicated the possibility of reducing bacterial spores through a combination of mild heat and HPP [Hoover *et al*., 1989; Mermelstein, 1997; Ray, 2001; Dolatowski, 2003].

For example, as a result of investigations conducted on raw smoked sirloin with the application of high pressure (500 MPa, 30 min) *e.g.* no *coli* bacteria or anaerobic spore-forming bacteria were detected. It was observed that the applied procedure did not result in effective protection of sirloin against microbiological changes over the period of 6-8 weeks of cold storage [Grabowski & Kijowski, 2004].

In Spain cured pork ham is produced commercially, being subjected to the pressure of 400 MPa at a temperature of 12^{o}C, which makes it possible to prolong its shelf-life to 60 days when the cooling chain is maintained [Cheftel & Culioli, 1997]. Meat products may be subjected to the action of high pressure (500-700 MPa) when packaged [Grabowski & Kijowski, 2004], and using the hurdle technology concept this method may be combined with others, *e.g.* cold storage, lowered pH, and even the application of ionising radiation or pulsed light [Skrabka–Błotnicka, 1997; Ross *et al*., 2003]. Future applications for HPP in meat processing will be *e.g.* decontamination of natural casings and extension of shelf-life in the case of selected processed meat products, *e.g.* fresh onion mettwurst [Haack & Heinz, 2001].

TABLE 2. Influence of two different pulsed-light sources on the viability of a variety of microbial populations.

Treatment		No. of food-related microorganisms present ($\log_{10}$ CFU per plate [mean ± SD]) [a]						
Light Source	No. of pulses	*B. cereus*	*L. monocytogenes*	*S. aureus*	*E. coli*	*S. enteritidis*	*P. aeruginosa*	*S. cerevisiae*
Untreated control	0	8.3 ± 0.1 [B]	9.4 ± 0.2 [A]	9.4 ± 0.1 [A]	9.6 ± 0.3 [A]	9.7 ± 0.2 [A]	8.7 ± 0.1 [B]	8.4 ± 0.2 [B]
High UV	100	4.5 ± 0.3 [G]	5.8 ± 0.4 [E]	5.2 ± 0.3 [F]	4.5 ± 0.1 [G]	5.2 [F]	4.3 ± 0.2 [G]	4.7 ± 0.2 [G]
	200	3.4 ± 0.3 [H]	5.0 ± 0.2 [F]	4.3 ± 0.1 [G]	3.4 ± 0.1 [H]	4.1 ± 0.2 [G]	2.9 ± 0.3 [I]	3.5 ± 0.1 [H]
Low UV	100	8.0 [B]	9.3 ± 0.1 [A]	8.9 ± 0.2 [A]	9.1 ± 0.1 [A]	9.1 ± 0.2 [A]	6.9 ± 0.3 [D]	8.0 ± 0.3 [B]
	200	7.9 ± 0.4 [B]	9.2 ± 0.1 [A]	8.1 ± 0.4 [B]	7.8 ± 0.2 [C]	8.1 ± 0.1 [B]	6.5 ± 0.1 [D]	7.7 ± 0.2 [C]

[a] Measured as $\log_{10}$ CFU per plate, where counts are averages of four replicate trials. Values followed by the same letter do not differ at $p < 0.05$, whereas values followed by different letters differ at $p < 0.05$.

Extensive tests on a variety of meats have shown that the so-called ”pulsed light” technology can be used to enhance the product’s shelf-life and safety. Pulsed light is produced using engineering technologies that multiply power many fold. The spectrum of light for pulsed light treatment includes wavelengths in the ultraviolet (UV) to the near infrared region.

It was found that there were variations in the susceptibility of test cultures treated with two different UV pulsed-light sources (Table 2). The levels of resistance of the following bacteria differed (and are listed in order of decreasing resistance): *L. monocytogenes*, *Staphylococcus aureus*, *Salmonella enteritidis*, *E. coli*, *B. cereus*, *Saccharomyces cerevisiae*, and *P. aeruginosa* (the levels of resistance between *S. aureus* and *S. enteritidis* and those between *B. cereus*, and *S. cerevisiae* did not significantly differ at the $p < 0.05$ level) [Rowan *et al.,* 1999].

Several tests have demonstrated the microbial effectiveness of pulsed light on retail beef. Pulsed light is nonselective when used to treat meat, with all organisms exposed to the light being killed. In a test using chicken wings dipped in a pool of three strains of *Salmonella* (15 min allowed for attachment) contamination in samples inoculated at approximately 5 logs/cm^2 (high level) and 2 logs/cm^2 (low level) was similarly decreased by ~ 2 logs/cm^2 after the pulsed-light treatment [Dunn *et al*., 1995].

Microbiological hazards are the most important cause of unsafe fish and seafood products as well. However, it needs to be stated that the consumption of fish products in Poland is relatively low. In 2003 it was on average 10.5 kg fish live weight *per capita*, *i.e.* 5.3 kg commercial weight. This consumption level was 50% lower than the average for the other EU countries and by 1/3 lower than the worldwide average. The average yearly *per capita* seafood consumption worldwide has recently reached 16 kg, but it ranges from less than 1 kg to over 90 kg, depending on the country [Kuzebski, 2003].

There exist various methods of fish and seafood preservation, including pasteurisation, chilling, thermal sterilization, the use of processing aids and food additives, and packaging. Among countries with the highest availability of fish and seafood (Japan, Spain, Portugal), blue crab, smoked fish, crawfish tail meat, analog products and shrimp are the varieties of seafood which have recently received most attention regarding the use of moderate temperature thermal processing to extend the refrigerated shelf-life of pre-packaged seafoods. Future innovations may involve additional methods such as microwave, ohmic heating or *e.g.* ozone treatment.

Ozone is a strong and highly reactive antimicrobial agent. It has been extensively studied for its potential applications in the food industry to ensure the safety of food products such as meat, poultry, fish, fruits and vegetables, cheese, and many others. According to the literature data, ozone has been tested also in decontaminating hatcheries, hatching eggs, poultry chill water, and poultry carcasses [Grabowski & Kijowski, 2004].

Synergistic inactivation between ultrasounds, ozone, and citric acid treatments was used recently as a method to reduce *Vibrio vulnificus* in raw oysters. The organisms may be present in high numbers in shellfish such as oysters, mussels and clams, when these shellfish are harvested. This bacterium is usually transmitted to humans by ingestion of raw oysters. Of all food-borne diseases, *V. vulnificus* is one of the most serious in the United States, having a 50% mortality rate in susceptible consumers. Whole-shelled and half-shelled oysters were treated with either ultrasound, ozone in 2% saline, ozone in air, and citric acid solutions for 10 to 30 minutes. In whole-shelled oysters, these treatments were not effective; however, when compared with controls the half-shelled oysters treated with ultrasound, ozone in 2% saline, or 5% citric acid had 1, 1.5, and 3 log less *V. vulnificus*, respectively [Borazjani *et al*., 2002].

In recent years there has been an increased interest in the use of bacteriocins as all natural food preservatives and antimicrobial agents. From a wide spectrum of bacteriocins of various producers, most afford the potential to be used in meat processing as well [Jacobsen *et al.,* 2003]. Bacteriocins are biologically active proteins that have an antimicrobial activity against a wide spectrum of bacterial species such as *Lactobacilli, Leuconostoci, Staphylococcus aureus,* and *Enterococcus.* Nilsson *et al.* [1997] found that the addition of 1000 ppm nisin to cold-smoked salmon caused an initial reduction in the number of *L. monocytogenes*, but after 2 weeks, the growth in vacuum packs at 5°C (41°F) resumed as in the control. Practical application of bacteriocins will be hampered by several aspects. Firstly, only some countries allow the use of bacteriocins for certain products. Secondly, bacteriocin stability and activity in food products are unpredictable (bacteriocins may be degraded by proteases or absorbed to food matrix components). Finally, resistance to bacteriocins in *L. monocytogenes* has been shown to occur quite readily.

Another interesting example of a natural preserving agent is represented by lysozyme – an enzyme isolated from eggs. Lysozyme demonstrates antimicrobial activity against a limited spectrum of bacteria and fungi; however, its enzymatic activity can be enhanced by certain substances *e.g.* EDTA or tripolyphosphate. It was found that a modified form of lysozyme shows a significantly wider bacteriostatic activity, including Gram-negative bacteria, than the native lysozyme [Leśnierowski *et al*., 2001].

Among other things, the effect of lysozyme action on microbiological stability of confectioned raw poultry meat was investigated (Figure 1) [Kijowski *et al*., 2002].

In other studies high effectiveness was shown of the protective lysozyme action on such processed meat products as raw sausages and wiener sausages, as well as processed fish products [Kijowski & Grabowski, 2004].

The lysozyme may find interesting applications in the non-thermal preservation of foods by high pressure. Inactivation has been investigated of Gram-negative bacteria by lysozyme, denatured lysozyme, and lysozyme-derived peptides or a synthetic cationic peptide derived from either hen egg white or coliphage T4 lysozyme under high hydrostatic pressure. None of these compounds had a bactericidal or bacteriostatic effect on any of the tested bacteria under atmospheric pressure. Under high pressure, all bacteria except both *Salmonella* species showed higher inactivation in the presence of 100 mg of lysozyme/mL than without this additive, indicating that pressure sensitized the bacteria to lysozyme [Masschalck *et al*., 2001].

IMPROVING SHELL EGG SAFETY THROUGH ULTRAVIOLET

A constant increase in egg production is accompanied by an increasing consumption in many countries worldwide. In 2003 Poles consumed 215 eggs, *i.e.* by almost 2% more than in the previous year. an increased egg consumption up to 240 eggs in 2010 is now forecasted [Bell, 2005].

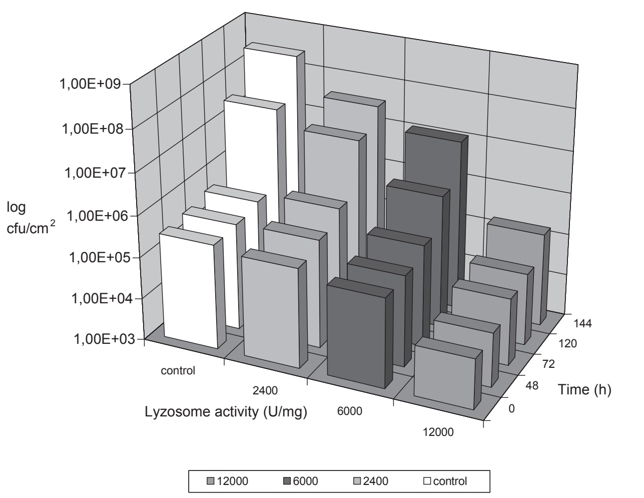

FIGURE 1. Effect of lysozyme on total viable count in chicken breast stored at 4°C.

Eggs are a nutrient-dense food that plays an important part in the diet, either alone or as an ingredient in other foods. However, eggs, like any other perishable product, need to be handled with care. Microorganisms on eggs such as *Salmonella enteriditis, S. typhimurium, E.coli* and others can cause serious health problems to humans. It is therefore important for poultry producers and processors of poultry products to maintain strict hygiene standards to prevent cross-contamination. According to some estimates, only 1 in 20,000 raw eggs in the United States is contaminated with *Salmonella enteritidis*; however, the Centers for Disease Control and Prevention (CDC) reported in 1997 a total of 300,000 cases of disease in USA attributable to *Salmonella enteritidis* [Buckner, 2000].

Cleaning by washing is a common practice, which is used to improve the microbial status of shell eggs. Hot water immersion or spraying eggs with water that contains commercially available sanitizers and detergents are currently used by the food industry. Thermal and chemical treatments have been developed to control or eliminate *Salmonella enteritidis* in eggs; however, these methods are time consuming, uneconomical and may be only partially effective. Other known decontamination methods include the use of the following: quaternary ammonium compounds, organic acids, high temperature and high pH, gamma irradiation, short-wave ultraviolet light, microwaves and ozone, used separately or as recently, due to the *hurdle concept,* in combined treatment [Ross, 2003; Yousef *et al*., 2004].

Irradiation of certain food products with short-wave ultraviolet (UV) light has been demonstrated to be effective for the inhibition of the growth of microorganisms on food surfaces, destroying airborne microorganisms and sterilizing liquids. The literature also indicates that UV-light effectively reduces the contamination of shell-eggs by aerobic bacteria, yeasts and molds, and *Salmonella typhimurium* [Plattel, 2003]. Several technical solutions of egg UV treatment are available. Antibacterial efficiency of this technique is illustrated by the following data for a typical hand operated irradiator (type UV 254, 30 eggs, UV light exposure: 40 sec): *Staphylococcus*: 90.1–98.2%, *Streptococcus*: 94.5–98.1%, *Bacillus*: 73.3–90.0%, *Escherichia coli:* 92.3–100.0%, and *Salmonella:* 92.0–100.0%.

ANIMAL FOOD PRESERVATION AND INNOVATIVE PACKAGING METHODS

The preservation of food is connected also with the problem of packaging types and techniques. Technological progress in this respect may be observed at every store shelf. The consumer demand for fresh foods without preservatives and with healthy appearance has caused a huge growth in the market for modified-atmosphere-packed (MAP) foods. Initially used for premium cuts of meat, MAP is now established in the meat, fish, dairy, bakery and vegetable sectors, and is said to be the fastest growing packaging technique [Philips,1996].

MAP is the replacement of air in a pack with a single gas or mixture of gases; the proportion of each component is

TABLE 3. Gas composition in modified atmosphere packaging (MAP) of food.

Product	Oxygen (%)	Carbon dioxide (%)	Nitrogen (%)
Red meat	60-85	15-40	-
Cooked/cured meats	-	20-35	65-80
Poultry	-	25	75
Fish (white)	30	40	30
Fish (oily)	-	60	40
Salmon	20	60	20
Hard cheese	-	100	-
Soft cheese	-	30	70
Dairy cakes	-	-	100

fixed when the mixture is introduced. No further control is exerted over the initial composition, and the gas composition is likely to change with time owing to the diffusion of gases into and out of the product, the permeation of gases into and out of the pack, and the effects of product and microbial metabolism [Church, 1994].

The normal composition of air is 21% oxygen, 78% nitrogen and less than 0.1% carbon dioxide. Modification of the atmosphere within the package by reducing the oxygen content while increasing the levels of carbon dioxide and/or nitrogen has been shown to significantly extend the shelf-life of perishable foods at chill temperatures. The recommended gas mixtures of MAP are presented in Table 3 [Parry, 1993]:

Modified atmosphere packaging (MAP) of fishery products has been shown to inhibit the normal spoilage flora and increase shelf-life significantly. However, the possibility that *Clostridium botulinum* type E and non-proteolytic type B strains will grow and produce toxin in low-oxygen atmospheres at refrigerated temperatures has caused great concern in studies on MAP of seafood [Church, 1994].

The main objective of packaging is to encourage a potential customer to buy the product. The so-called functional packaging is being used with increasing frequency, as it not only inform the consumer, but also help them *e.g.* in maintaining the quality of the packaged product. New packaging types need to be active and intelligent. An essential difference between traditional and active packaging is the protection of the packaged product. The barrier, which so far has been provided by the packaging, has been transformed to an active one, thus enabling product quality control, *e.g.* control of temperature during microwave cooking to control the product during the production or storage process [Weber, 2004].

Active packaging employs a packaging material that interacts with the internal gas environment to extend the shelf-life of a food product. Such new technologies continuously modify the gas environment (and may interact with the surface of the food) by removing gases from or adding gases to the headspace inside a package. Recent technological innovations for control of specific gases within a package involve the use of chemical scavengers to absorb a gas or alternatively other chemicals that may release a specific gas as required. Table 4 compiles some areas of atmosphere control in which active packaging is being successfully used.

TABLE 4. Uses of active packaging.

Active Packaging System	Application
Oxygen scavenging	Most food classes
Carbon dioxide production	Most food affected by moulds
Water vapour removal	Dried and mould-sensitive foods
Ethylene removal	Horticultural produce
Ethanol release	Baked foods (where permitted)

At the same time with active packaging the so-called intelligent, *i.e.* indicator, packaging has been developed. Its task is to inform the potential buyer on the quality status of the packaged product. Wholesomeness is monitored using indicators based on colour changes, which may occur continually *e.g.* in the case of the determination of the thermal dose which the product has received during transport and storage, or rapidly when required *e.g.* in the case of detection of occurring leaks [Weber, 2004]. Intelligent (diagnostic) packaging includes the following different technologies: (a) TTIs (Time Temperature Indicators) and TTB (Time Temperature Biosensors), (b) spoilage indicators, which are still in the early development stages, and (c) pathogen indicators: specific to the detection of one type of pathogen and still in the early development stage. Following statistical data for the USA market, the demand for intelligent packaging will grow by 80% by 2007. This growth will mainly be achieved with the new generation of TTIs. They are tools that can be used to monitor the time/temperature consequences of perishable refrigerated food products. The TTIs have been proposed today to monitor the time/temperature histories of refrigerated salmon, meat and poultry, and dairy products [Benner, 1999].

Zones with special microbiological hazards in the case of packaging sliced meat and processed meat products are *e.g.* sites where casings are removed, covering foil is placed, and during the portioning and transport of the product. Innovative solutions related to food packaging include therefore also the application of the 'Clean Room Environment' concept. The same high standards used to sterilize hospital operating rooms could soon be incorporated into meat processing plants as the best step eliminating *Listeria monocytogenes* in such ready-to-eat products as sliced deli meats, hams, hot dogs, pepperoni and salami. At the rate of 14-20 times an hour, the air in the room is re-circulated with "virtually sterile air." Filters are used to reduce bacteria to nearly-undetectable levels [Weber, 2004].

Examples of solutions in packaging types and methods are not the only novelties in this respect. It should be assumed that the trend of dynamic development in this segment will be developing and health safety of the product will remain one of the most important reasons for these advances.

FINAL CONCLUSIONS

A new challenge for animal origin food production is to ensure a comprehensive system ensuring health safety of food without a loss of desirable quality. The implementation of the effective, verified and updated GMP/GHP and HACCP systems is a necessary pre-requisite for the food producer. Only after this has been realized the possibility of applying mild methods of extending shelf-life may be considered, especially for food which was only chilled, for which it is not possible or possible only to a limited degree to apply procedures prolonging their wholesomeness (*e.g.* cooking meat, fresh chilled poultry, fresh fish, milk). In view of the contemporary customer, looking for convenience food and also increasingly frequently minimally processed food, possibly preserving its natural attributes, it is necessary to apply other preservation methods.

Among the new preservation methods for meat products and other animal origin foodstuffs, the hurdle technology has to be mentioned, together with the combination methods, where the summary effect of the application of several mild food preservation methods occurs, making it possible to maintain the natural attributes of food. The potential for such combined methods varies. An especially important and effective method to maintain safety and quality standards of possibly unchanged foodstuffs is the packaging system facilitating the application of sterile packaging with the additional effect of the produced vacuum, or even better with atmosphere modified with inert gasses. New generation packagings are active and intelligent systems, which on the one hand facilitate the action on the changing atmosphere of gas and water vapour between the packaging and the product surface, while on the other hand enable the unambiguous assessment by the consumer and receiving information on the quality status of the packaged product.

At present technologists may use numerous methods of food preservation, making it possible to produce foodstuffs not processed thermally. These are physical methods, such as high pressure, energy of pulsed electric field, ultrasounds, UV and ionizing radiation, radio waves, *etc*. A novel solution in food preservation is the application of bacteriostatic substances produced by bacteria (bacteriocins) or natural food components with bacteriostatic action, such as lysozyme.

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UTRWALANIE ŻYWNOŚCI POCHODZENIA ZWIERZĘCEGO I ASPEKTY JEJ BEZPIECZEŃSTWA

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Analiza zachowań konsumenta żywności w Polsce wskazuje, że kryteriami, którymi kieruje się przy wyborze produktu spożywczego w pierwszej kolejności są: świeżość, cechy sensoryczne oraz zdrowotność. Choć zaspokojenie potrzeb żywnościowych polskiego konsumenta pozostaje w dalszym ciągu pod presją ograniczeń ekonomicznych, jakość i bezpieczeństwo zdrowotne spożywanej żywności, zwłaszcza pochodzenia zwierzęcego, ma dla niego bardzo istotne znaczenie. Bezpieczeństwo zdrowotne staje się szczególnie ważne w narastającym zapotrzebowaniu na żywność z jednej strony możliwie naturalną, niezmienioną lub nisko przetworzoną, np. tylko schłodzoną, a z drugiej strony na żywność wygodną, trwałą, jednak o pożądanej jakości zdrowotnej.

W odniesieniu do utrwalania żywności pochodzenia zwierzęcego jak czerwone mięso, drób, ryby, mleko, jaja, w centrum zainteresowania jest wykorzystanie między innymi nowych metod fizycznych tj. wysokich ciśnień hydrostatycznych, ultradźwięków, pulsującego pola elektrycznego o wysokim napięciu, promieniowania elektromagnetycznego – zwłaszcza ultrafioletowego, energii pulsującego światła, promieniowania jonizującego, a nawet fal radiowych. Proponowane są już nowe, kombinowane metody utrwalania żywności wykorzystujące tzw. technologię płotków (*hurdle technology*).

Prezentowana praca jest próbą syntetycznego omówienia wymienionych powyżej innowacyjnych metod utrwalania żywności pochodzenia zwierzęcego z uwzględnieniem wybranych aspektów jej bezpieczeństwa zdrowotnego. Autorzy podkreślają różnorodność nowych dostępnych metod utrwalania, ilustrując ich efektywność wynikami licznych badań, w tym również badań własnych