

APPLICATION OF MODIFIED ATMOSPHERE PACKAGING (MAP) ON FRESH FISH

Aplikasi Pengemasan dengan Atmosfir Termodifikasi (MAP) pada Ikan Segar

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ABSTRACT

Packaging has many functions, e.g. as containment, to protect products from physical damage, and from H₂O, O₂, and CO₂ exposure, as well as to attract the consumers. Based on the technology, packaging can be divided into 3 types i.e. passive packaging, active packaging, and smart packaging. Modified Atmosphere Packaging (MAP) is the most common active packaging found in the market. MAP has been used to extend the shelf life of several fish such as raw whiting (cod family), mackerel, salmon fillet, cod fillet, fresh bluefin tuna fillet, etc. MAP which was combined with freeze-chilling has been proved to extend the shelf life of raw whiting, mackerel, and salmon fillet. MAP also increased cod fillet's shelf life up to 20 days, whiting fillets packed in 100% CO₂ and stored at 4°C temperature up to 15 days. MAP combined with antioxidant on fresh bluefin tuna fillets stored at 3°C for 18 days was able to extend products shelf life from 2 days (control) to 18 days, meanwhile 100% N₂ in packaging has protective effect on haemoglobin and lipid oxidation. Packaging innovations and ingenuity will continuously develop MAP that is oriented for consumer, enhance the product, environmentally responsive, friendly, and cost effective.

Keywords: active packaging, modified atmosphere packaging, fresh fish product

ABSTRAK

Pengemasan memiliki banyak fungsi, yaitu sebagai wadah, melindungi produk dari kerusakan fisik, paparan H₂O, O₂, dan CO₂, dan untuk menarik konsumen. Berdasarkan teknologi pengemasannya, kemasan dapat dibagi menjadi 3, yaitu kemasan pasif, kemasan aktif, dan kemasan pintar. Salah satu contoh pengemasan aktif yang sudah dikenal di masyarakat adalah *Modified Atmosphere Packaging* (MAP). MAP telah banyak digunakan untuk memperpanjang umur simpan beberapa jenis ikan segar, seperti *whiting* (sejenis cod), mackerel, filet salmon, filet cod, filet tuna sirip biru, dan yang lainnya. Penggunaan MAP yang dikombinasikan dengan penyimpanan beku dapat memperpanjang umur simpan *whiting*, mackerel, dan filet salmon. Filet ikan cod yang dikemas dengan MAP memiliki umur simpan 20 hari sedangkan umur simpan filet whiting yang dikemas dalam 100% CO₂ dan disimpan pada suhu 4°C bisa mencapai 15 hari. MAP yang dikombinasikan dengan antioksidan pada filet tuna sirip biru yang disimpan pada suhu 3°C selama 18 hari dapat memperpanjang umur simpan dari 2 hari (kontrol) menjadi 18 hari, dan kandungan 100% N₂ dalam kemasan memiliki efek protektif terhadap haemoglobin dan oksidasi lemak. Inovasi dan kreativitas dalam pengembangan teknologi pengemasan akan terus menyediakan MAP yang berorientasi pada keinginan konsumen, pengembangan produk, ramah lingkungan, dan hemat biaya.

Kata Kunci: pengemasan aktif, pengemasan atmosfer termodifikasi, produk ikan segar

INTRODUCTION

Food packaging serves to protect the products against deteriorative effects, containing the product, communicating to the consumer as a marketing tool, and provide consumers with ease of use and convenience. Main paradigm that changes in packaging is the change from passive packaging into

active packaging (Yam *et al.*, 2005). Moreover search for innovation in food and beverages packaging always continued, due to consumer's needs and demands that is affected with changes in global trend, like the increasing of life expectancy (Lord, 2008).

Active packaging is an innovative concept that described as a packaging form where packaging,

product, and environment interact to extend product's shelf life, safety and sensory properties. This type of packaging usually becomes very important in fresh food (Labuza & Breene, 1989 in Hutton, 2003). Active packaging leads to the combination of several additives into packaging system. These additives can be attached into inner packages or combined with the packaging materials, aimed to maintain or increase product quality and shelf life. Active packaging has a role in product preservation besides providing inert barrier from the environment (Hutton, 2003). Active packaging is not a new thing, but its advantages in terms of quality and economic value is the latest development in food packaging industry. One of active packaging type is Modified Atmosphere Packaging (MAP). MAP is the removal and/or replacement of the atmosphere surrounding the product before sealing in vapor-barrier materials (McMillin *et al.*, 1999). MAP can be vacuum packaging (VP), which removes most of the air before the product is enclosed in barrier materials, or forms of gas replacement, where air is removed by vacuum or flushing and replaced with another gas mixture before packaging sealing in barrier materials. The headspace environment and product may change during storage in MAP, but there is no additional manipulation of the internal environment (McMillin *et al.*, 1999)

The example of active packaging on fisheries product is the combination of MAP with antioxidant-based active packaging on fresh bluefin tuna fillets stored at 3°C for 18 days. Active packaging films were produced by embedding α -tocopherol into an unstabilized low density polyethylene (LDPE) matrix at three concentrations (0.1%, 0.5%, 1%). The ratio between the volume of gas and weight of food product (V/W ratio) was 2.5:1. The result shows that MAP can extend product shelf life from 2 days (control) to 18 days. 100% N₂ in packages has protective effect on haemoglobin and lipid oxidation. Active film packaging can reduce lipid oxidation, and combination effect of MAP and antioxidant can be used to extend the shelf life of raw fish (Torrieri *et al.*, 2011).

MAP also used in pre-rigor fillet farmed Atlantic cod (*Gadus morhua*) stored at 0°C and the quality was determined through sensory evaluation of raw odour as well as chemical, physical, and microbiological analysis. Cod was packaged under gas to product ratio of 2:1 and CO₂, O₂ and N₂ were analysed after 7, 10 and 14 days of storage. The result shows that the weighted optimum gas mixture for MA packaging of farmed cod was determined to be 63 ml/100 ml O₂ and 37 ml/100 ml CO₂, aerobic and psychrotrophic plate count decreased, and H₂S-producing bacteria were not present or not able to grow under the different gas mixtures (Sivertsvik, 2006).

This article will discuss about MAP and its application for fisheries product since MAP is widely known as one of the methods which potential to extend fisheries product shelf life.

FISHERIES PRODUCT CHARACTERISTICS

Fish quality deteriorates rapidly and the shelf life is reduced if they are not handled and stored properly. It was reported that the rate of spoilage doubles every 5.5°C rise in temperature.

Spoilage of fish and shellfish resulted from the changes is caused by 3 major mechanisms, i.e:

1. The breakdown of tissue by the fish's own enzymes (cell autolysis). Cell autolysis is the degradation of nucleotides (ATP-related compounds) which is caused by autolytic enzymes. The autolytic changes are contributing to spoilage mainly by making catabolites available for bacterial growth (Huss, 1995 in Gram & Huss, 1996).
2. The growth of microorganism. Microorganism that usually grow in aerobically stored fish is Gram-negative psychrotrophic non-fermenting rods. Thus, under aerobic iced storage, the flora is composed almost exclusively of *Pseudomonas* sp. and *S.putrefaciens* (Gram & Huss, 1996).
3. Oxidative reactions. Lipid oxidation produces off flavours that smell strongly during peeling and may be tasted even in the peeled product (Bak *et al.*, 1999). Packaging in modified atmospheres depleted of oxygen may improve colour stability and prevent lipid oxidation in chill-stored shrimps (Sivertsvik, 1995).

MAP can be used to suppress the spoilage microorganism and oxidative reactions but doesn't have direct effect to autolysis (Mulan & McDowell in Coles *et al.*, 2003). MAP must be combined with other preservation technique, like refrigeration, to overcome cell autolysis mechanism. There are several important specific intrinsic factors in fish which greatly influence the spoilage of fish, i.e :

1. The poikilotherm nature of the fish and its aquatic environment. The poikilotherm nature of fish allows bacteria with a broad temperature range to grow. For example, the microflora of temperate water fish is dominated by psychrotrophic Gram-negative, rod-shaped bacteria like *Pseudomonas*, *Moraxella*, *Acinetobacter*, *Shewanella*, *Flavobacterium*, *Vibrionaceae* and *Aeromonadaceae*, but Gram-positive organisms such as *Bacillus*, *Micrococcus*, *Clostridium*, *Lactobacillus* and *Corynebacterium* can also be found in varying proportions (Liston, 1980 in Gram & Huss, 1996).

2. A high post mortem pH in the flesh (usually > 6.0). This factor has important consequences for the microbiology of fish amongs other factors because it allows the pH sensitive spoilage bacteria *Shewanella putrefaciens* to grow.
3. The presence of large amounts of Non-protein-nitrogen (NPN).
4. The presence of trimethylamine oxide (TMAO) as part of the NPN fraction (Gram & Huss, 1996)

Generally, the major spoilage bacteria found on processed fish are anaerobs including *Pseudomonas*, *Moraxella*, *Acinetobacter*, *Flavobacterium*, and *Cytophaga* species. There are several microorganisms that are of particular importance when dealing with MAP fish products, including *C. botulinum* (Mulan & McDowell in Coles *et al.*, 2003).

As mentioned earlier, spoilage on fish mainly caused by microorganisms, so the control of microorganisms growth is one of the success

parameter of active packaging technology. Microorganisms can be found at the outer surface (skin and gill) and in colon of live fish (Sivertsvik, 2003).

Meanwhile, the microbes that exists inside the body of fresh shrimp are aerobic spoilage bacteria including *Pseudomonas*, *Achromobacter*, *Flavobacterium* and *Micrococcus* (Lu, 2009); and the spoilage bacteria that exists in captured shrimp are *Shewanella putrefaciens* and *Pseudomonas spp.* (Chinivasagam *et al.*, 1996; Matches, 1982 in Lu, 2009). The action of autolysis by inner proteases together with melanosis results in inferior quality in shrimp at the early period of storage while bacterial spoilage makes the shrimp deteriorate during time-term storage (Martinez-A´lvarez *et al.*, 2005 in Lu, 2009). Therefore, we need to add preservative that is combined with MAP.

The concern about the use of MAP on fishery products has to do with the fact that non proteolytic

Table 1. Fisheries product and their suitable packaging form/material



Source: Gopal, 2011.



Figure 1. Shrimp in plastic bag and being frozen in Individually Quick Frozen (IQF) (Saudi Fisheries Company, 2005).

botulism strains are found in waters and they can grow at temperatures $<4^{\circ}\text{C}$ (Jay, 2011). Fisheries product and their suitable packaging form / material is shown in Table 1. The example of MAP fisheries product packaging is shown in Figure 1.

MODIFIED ATMOSPHERE PACKAGING (MAP)

The objective of MAP design is to define conditions that will create the atmosphere best suited for the extended storage of a given product while minimising the time required to achieve this atmosphere condition (Mahajan *et al.*, 2007). The atmosphere gas consists of 78.08% N_2 , 20.96% O_2 , and 0.03% CO_2 . Many food products are rapidly damaged when stored in open air, this is due to reaction with oxygen and the growth of aerobic microorganism like bacteria (Mulan & McDowell *in Coles et al.*, 2003).

Storage under MAP will extend the shelf life and delaying the rate of spoilage. The success of MAP in extending seafood shelf life depends on many factors, including good initial product quality, good hygiene during slaughter, correct packing material selection, packing equipment, appropriate gas mixture and gas-to-product volume (g/p) ratio for the product, and maintenance of the process temperatures (Sivertsvik, 2007 *in Fernandez et al.*, 2009). In addition, the amount of CO_2 dissolved into the product and the storage temperature are the most critical factors (Rotabakk *et al.*, 2008 *in Fernandez et al.*, 2009).

Gases Used in MAP

There are few gases that involved in MAP, which are Nitrogen (N_2), Oxygen (O_2), Carbondioxide (CO_2), Carbon monoxide (CO), and Argon (Ar). Nitrogen and

Argon are gases that used to create anaerobic/ microaerophilic condition (if the oxygen is removed) (Regenstein, 2006 *in Otwell et al.*, 2006). Nitrogen does not support the growth of aerobic microbes but doesn't prevent the growth of anaerobic microbes. Besides that, N_2 is used to maintain the balance of gas pressure in the packaging (Mulan and McDowell *in Coles et al.*, 2003). Bono and Badalucco (2012) reported that striped red mullet treated with ozonated water (0.3 mg L^{-1}) and packaged under MAP (50% N_2 and 50% O_2) can significantly delayed the bacterial growth and the growth levels remained relatively low until day 10 ($<6 \text{ log CFU g}^{-1}$).

Oxygen promotes several types of deteriorative reactions in foods including fat oxidation, browning reactions, and pigment oxidation. Therefore, to increase the shelf life of foods, the package atmosphere should contain a low concentration of O_2 . In some foods, low concentration of O_2 resulting in quality and safety problems, so this must be taken into account when selecting the gaseous composition for packaged food (Mulan & McDowell *in Coles et al.*, 2003). One way to reduce the O_2 composition in packaging is by using O_2 absorber. Oxygen absorber will actively reduce the O_2 concentration in packaging head space until 0.01%, therefore it can prevent oxidation and microorganism growth (Hurme *et al.*, 2002).

Carbondioxide has negative effect to some microbes if used in sufficient quantities, and it is soluble in water to form mild acid, like HCO_3 or carbonic acid. This means that CO_2 can migrate to fish and has positive impact, as antimicrobial agent (Regenstein, 2006 *in Otwell et al.*, 2006). Carbondioxide is mostly present in the greatest



Figure 2. Rigid tray packaging for sandwich (Anon.^a, 2012).

quantity in MAP. Guldager *et al.* (1998) reported that Pacific whiting fillet packed in 100% CO₂ and kept at 4°C has shelf life up to 15 days. Meanwhile, combination of MAP with super-chilling can extend the shelf life, i.e of Atlantic salmon (*Salmo salar*) fillets. The samples with the highest CO₂ concentration (90%) and gas-to-product ratio (g/p ratio) of 2.5 showed the highest shelf life : 22 days vs. 11 days (control sample) based on microbial analysis (Fernandez *et al.*, 2009).

Carbon monoxide has a low solubility in water but relatively soluble in some organic solvents. The use of carbon monoxide in MAP (CO-MAP) was approved by the US FDA (2002, 2004) for master bags and retail packages. The carbon monoxide is usually used in meat packed with MAP because it binds to the pigment myoglobin, forming carboxymyoglobin. This form of myoglobin exhibits a cherry red color similar to that of oxymyoglobin, the reduced form of myoglobin with bound oxygen (Jeong & Claus, 2011).

Selection of Packaging Materials for MAP

Selection of Packaging Materials for MAP is aimed to maintain the quality and safety of packed product. Flexible and semi-rigid laminated plastics are the common materials used for MAP. Laminated plastic is made from *polyethylene* (PE), *polypropylene* (PP), *polyamide* (nilon), *polyethylene terephthalate* (PET), *polyvinyl chloride* (PVC), *polyvinylidene chloride* (PVdC), and *ethylene vinyl alcohol* (EVOH). Meanwhile rigid and semi rigid plastic is made from PP, PET, *unplasticized PVC*, and *expanded polystyrene*. MAP can be achieved by use of polymeric films where gas transmission rate through the film, product respiration, carbon dioxide and oxygen levels within the package are related by a simple material balance (Henig & Gilbert, 1975 in Christie *et al.*, 1995).

The example of MAP packaging materials used for sandwich, is shown in Figure 2. The cover is made from aluminium foil while the body is made from rigid tray.

Storage temperature is never constant in the distribution chain of fresh produce. Due to the temperature dependence of the respiration rate (R) and of the gas permeability of a packaging film, fluctuating temperatures result in changes of the internal O₂ and CO₂ concentrations (yO₂ and yCO₂) (Jacxsens *et al.*, 2000).

The Equipment Used for MAP Application

The Equipment used for MAP Application are :

a. Chamber machine

Preformed high-barrier bags are manually placed within the chamber before evacuation, back-flushing with the desired gas mixture, and heat sealing (Anon b, 2012). This machine (Fig. 4) is widely used in Indonesia because it is labor intensive, cheap, can be used for big packs but it relatively needs more time to operate.

The product to be packaged is put into a film pouch and placed in the vacuum chamber. When the lid has been closed, the desired level of vacuum is produced in both the vacuum chamber and the pouch. The pouch is then sealed in a vacuum (vacuum package) or the chamber (and thus the pouch as well) is filled with a MAP gas before the sealing operation. The example of chamber machine and digital control panel of chamber machines are shown in Fig. 5.

b. Snorkel machine

Snorkel machine operates without chamber and using pouch. Bag-in-box bulk products and retail packs inside big packs can be produced using this machine (Mulan & McDowell in Coles *et al.*, 2003)

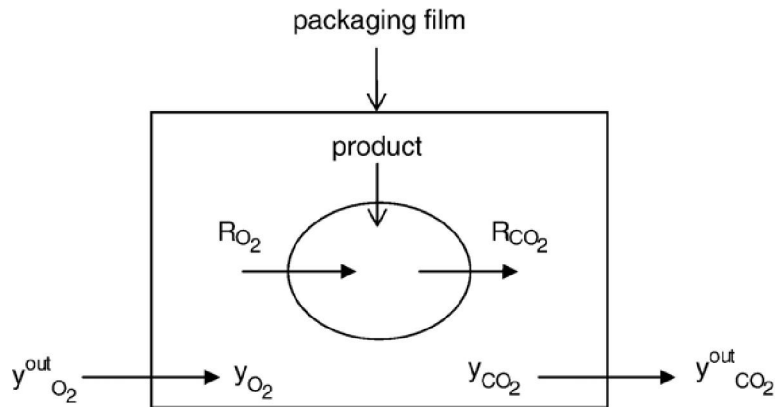


Figure 3. Gas exchange in a modified atmosphere package containing fresh product (Mahajan *et al.*, 2007).

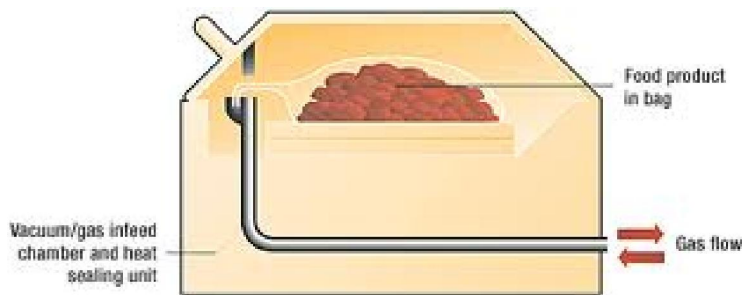


Figure 4. Chamber Machines (Anon., 2012c)

In this machines, preformed plastic bags are positioned on a heat seal mandrel, then the air is removed using retractable snorkels forming a vacuum condition. The vacuum plastic bags are then back-flushed with a desired gas mixture and sealed. Snorkel machines is shown in Fig. 6.

c. Form-fill-seal tray machines

Form fill seal (FFS) machine forms pouch from continued roll stock layer. FFS machine consists of 3 types, which are Horizontal Form Fill Seal (HFFS), Vertical Form Fill Seal (VFFS), and Thermoform Form Fill Seal (TFFS).

HFFS machines can overwrap a pre-filled tray of product. The air from the package is removed by a pulse of gas or continuous gas flushing, however gas mixtures containing levels > 21% O₂ cannot be used due to the use of hot sealing jaws at the end of the machine.

VFFS machine forms a tube, it is then filled with product (in most cases dropped from an overhead multi-weigher), purged with gas and then sealed. At the same time film is transported vertically downwards.

Meanwhile in the TFFS machine, packaging material is heated in the forming die and formed into pockets/trays. The formed pockets are then loaded



(a)



(b)

Figure 5. (a) Digital control panel of chamber machines, (b) Chamber machines (Anon., 2012b).

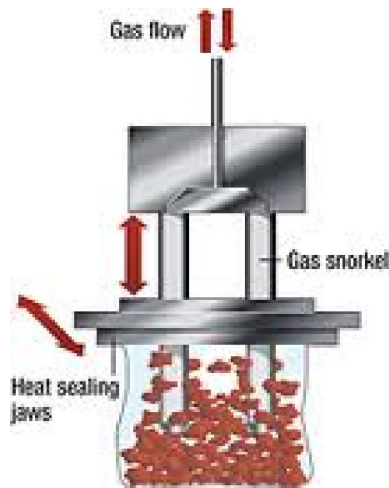


Figure 6. Snorkel Machines (Anon., 2012c).

manually or automatically. The top web of packaging material (lid film) covers the filled pockets/trays. The air is evacuated from the sealing die and protective gas is added. Then the pack is sealed by the application of heat and pressure. Thermoform Form Fill Seal (TFFS) is shown in Fig. 7.

d. Sealing

Film factor (thickness and treatment to its surface) and plastic composition (resin type, molecular weight distribution, and additional substances) will determine the setting of sealing machine (Mulan & McDowell *in* Coles *et al.*, 2003).

FDA compliant hygienic sealing materials range from grades of ethylene propylene rubber (EPDM), acrylonitrile butadiene rubber (NBR), silicone rubber (VMQ), fluoroelastomer (FKM), Hydrogenated Nitrile Rubber (HNBR) and perfluoroelastomer (FFKM) (Warren, 2008). Sealing materials and their suitability to use in different foodstuffs is shown in Table 2.

These packaging materials also have different endurance to sealing temperature, for example the

endurance to sealing temperature of FFKM is 310°C and VQM is 60°C (Warren, 2008).

e. Cutting

The last packaging stage is to separate the whole packages into individual packages. This can be done using three ways, which are die cutting, longitudinal and transverse cutting (Mulan & McDowell *in* Coles *et al.*, 2003).

MAP APPLICATION IN FRESH FISH

Packaging process for fish, especially fresh fish, highly depends on the temperature. The common packaging temperature is about 0°C (32°F) or lower. The lower the temperature, the slower is the deterioration reaction.

MAP application for fisheries product preservation has been widely known. It can be used alone or combined with other preservation technique like freeze-chilling which is able to extend the shelf life of pacific whiting, mackerel and salmon fillet (Fagan *et*

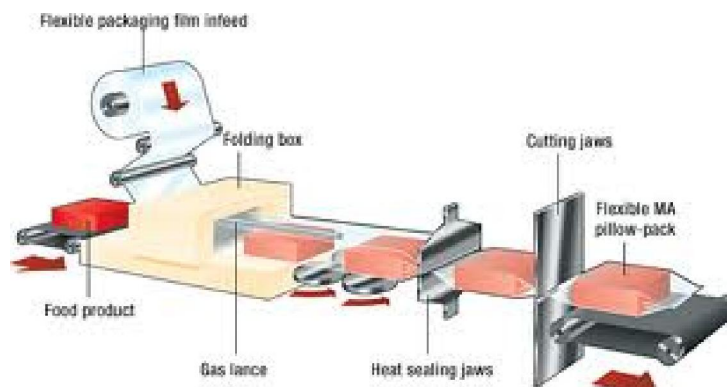



Figure 7. Thermoform Form Fill Seal (TFFS) (Anon., 2012c).

Table 2. Sealing materials and their suitability to use in different foodstuffs



Note: Generally suitable, *Could be suitable, dependent on grade (Source:Warren, 2008).

al., 2004). Another example of MAP application in fisheries product has been reported Pacific whiting fillet packed in 100% CO₂ and kept at 4°C has shelf life up to 15 days (Guldager *et al.*, 1998).

The combination of MAP with refrigeration also shows positive effect to cod fillet quality, especially to fresh-raw cod. Short term frozen storage of cod for 6 weeks at -20°C or -30°C substantially reduced the number of *P. phosphoreum*. This specific spoilage organism was not detected during chill storage of cod fillets previously frozen and stored at -20°C (Boknaes *et al.*, 2000 in Torrieri *et al.*, 2011).

The combination of MAP with super-chilling can extend the shelf life of Atlantic salmon (*Salmo salar*) fillets. The samples with the highest CO₂ concentration (90%) and gas-to-product ratio (g/p ratio) of 2.5 showed the highest shelf life which is 22 days while control sample remains only 11 days based on microbial analysis (Fernandez *et al.*, 2009). Superchilling is another technique used to inhibit most autolytic and microbial reactions (Huss, 1995). Several types of cooling systems (-4°C to 0°C) have been used for superchilling of seafood products including the use of flake ice or slurry ice (Losada *et al.*, 2006; Zeng *et al.*, 2005) and subzero temperatures during storage (-2°C) (Sivertsvik *et al.*, 2003).

Quality Analysis of MAP Product

Some physical and chemical tests have been performed to analyze MAP product, such as color,

trimethylamine, water content, total viable count, peroxide value, odor, etc. Torrieri *et al.* (2011) measured pH using pH meter, color with colorimeter, and Thiobarbituric Acid Reactive Substances (TBARS) using extraction procedure from Lemon (1975) and Kilic & Richards (2003).

Torrieri *et al.* (2011) reported that the pH of fresh bluefin tuna fillets was constant throughout storage with no differences among samples. The TBARS values of samples packed with 100% N₂ were lower than those of control samples, thus 100% N₂ was chosen as the optimal atmosphere to pack the product. Samples packed in MAP 100% N₂ showed no change in colour during storage ($p > 0.05$), thus indicating a protective effect of this atmosphere on colour change; so 100% N₂ atmosphere was the optimal atmosphere in which to pack the product. Moreover, the final report showed that the combined use of MAP and active film resulted in a less oxidized product after 18 days of storage at 3°C.

Meanwhile, some physical tests have to be performed to ensure the quality of MAP packaging, such as :

1. Heat integrity of packaging seal. Heat integrity of packaging seal is measured using destructive (based on immersing packs in water and checking for escaping gas bubbles around the seal) and non destructive test (based on measuring changes in pressure generated by packs under vacuum in sealed chambers) (Mulan & McDowell *in* Coles *et al.*, 2003).

2. Transmission rate and permeability of packaging film. Transmission rate and permeability of packaging film is measured using isostatic method (both sides of the test film are maintained by passing test gas continuously on one side of the film while inert carrier gas continuously removes permeant from the other side of the film) (Mulan & McDowell in Coles *et al.*, 2003).
3. Composition of pack headspace. The analysis for composition of pack headspace is performed using O₂ and CO₂ headspace analyzer for MAP (Fig. 8).

APPLICATION OF MAP IN INDONESIA

Indonesia has a high temperature and humidity, therefore MAP application can be very interesting and become a compromising opportunity for food industries to develop MAP using local components and based on environmental characteristic or consumer demand.

MAP in Indonesia is mainly used for fresh fruits, because fresh fruits are highly perishable. Fresh fruits still undergo respiration process after being harvested. This respiration produced simple molecules that reduce fresh fruits' quality. Temperature is one of the important factor to determine respiration rate. The higher the temperature, the faster is the respiration rate. Therefore MAP is needed to modify the atmosphere inside the fresh fruits' packages in order to maintain fresh fruits' quality (Hadisumarto, 1997).

An example of MAP in fruit has been done by Hidayat (2005), MAP combined with low temperature storage was used to maintain the quality of rambutan (*Nephelium lappaceum*, Linn). The results shows that minimally-processed rambutan packed with stretch films (initial concentration: 2-4 O₂, 14-17% CO₂) and stored at 10°C has shelf life up to 8 days.

However the application of MAP to fresh fish products in Indonesia is rarely used, but it has potency to be developed in the future because it has many advantages especially to extend shelf life of fresh fish products.

The Future of MAP

Trends in the evolution of food packaging has been changing since decades, started from convenience and marketing orientation in the 1960s; weight, sustainable resources, and energy savings in the 1970s; safety and quality in the 1980s; environmental impact in the 1990s; and safety and security in the 2000s (Han, 2005 in McMilin, 2008). The key to successful packaging is selection of materials and designs, which meet the needs of

product characteristics, marketing considerations including distribution and consumer needs, environmental and waste management issues, and cost (Marsh & Bugusu, 2007).

Consumers demands for more environmentally friendly packaging and more natural products will also create increased demand for packaging from biodegradable and renewable resources (Cutter, 2006). Organic-based materials may be anaerobically degraded while biodegradable polymers from replenishable agricultural feedstocks, animal sources, marine food processing industry wastes, or microbial sources are being developed (Marsh & Bugusu, 2007).

Nowadays, the equipment widely used in Indonesia is chamber-type machines, because it has the same principle as vacuum packaging machine. The difference is that chamber-type machines can fill or replace the gas inside the pack. In the future it is expected that another MAP machines (chamber machines, snorkel machines, form-fill-seal tray machines, sealing, and cutting machines) and other packaging material (such as polymer films) can be used in Indonesia .

CONCLUSION

Modified Atmosphere Packaging (MAP) is an active packaging technology that can be used to extend fresh fish's shelf life. MAP can be used alone or combined with other preservation technique, like freeze chilling, refrigeration, and also combined with antioxidant, bactericides, and ozone. In MAP application, gas composition or gas mixture should be well defined, since every gases have different characteristics.

The packaging materials used for MAP in Indonesia usually are flexible and semi-rigid laminated plastic. There are several MAP machines usually used in food industries, but in Indonesia chamber-type machines are usually used. In the future it is expected that other MAP machines (chamber machines, snorkel machines, form-fill-seal tray machines, sealing, and cutting machines) and other packaging material (such as polymer films) can be used in Indonesia.

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