Improving quality and shelf life

Challenges in the packaging of ready-to-cook meals with fresh ingredients

In most countries in Europe the demand for ready meals or dinners is increasing. Ready meals can be marketed as chilled, frozen, dried or canned, but there is a trend towards selling more chilled meals. Offering meals with a better appearance, taste and quality is a challenge for the food industry.

By Oddvin Sørheim and Nina Veflen Olsen

Most chilled ready meals in the market today are cooked by the producers before being sold, and then reheated by the consumers, in microwave ovens or by other techniques. The industrial heating is either by the sous-vide method by heating a prepackaged meal, or by hot filling of the meal in a package. The packages may contain one or several chambers for the different components of the meal. The microbiological shelf life of preheated ready meals can be 3 to 4 weeks or more. The meals may not be very appealing, because of flaws in colour, texture or general appearance. Sometimes, ready meals are covered with cardboards or non-transparent films. Photos of the finished meals are printed on the packages.

A small segment of the European ready meal market is called ready-to-cook or ready-to-steam meals. These meals consist of raw meat or fish, raw cut vegetables, precooked or semicooked staple foods like rice, pasta or potatoes, and a precooked sauce. Since these meals are heated only once by the consumers, preferably by microwaves, they are likely to taste better than preheated meals. Ready-to-cook meals are sold in countries like the Netherlands and the UK, but sales are limited by a short microbiological shelf life, normally only 5 to 6 days. A consequence of the rapid spoilage is that up to 20% of the meals are discarded as waste or sold at a reduced price. A high degree of food waste is not desirable from ethical and environmental points of view. For the meal producers and retailers it is difficult to make a profit with such a short shelf life.

Research and development

The EU funded project Double Fresh has addressed the issue of improving the quality and image of ready meals. The aim of the project was to produce meals that are tasty, safe and healthy, combined with viable business concepts based on extended shelf life of the meals. The project has been joined by more than 20 scientific and industrial partners over the period 2006 to 2009. The development work has been shared between preheated and ready-to-cook meals. Examples of two newly developed Norwegian ready-to-cook meals containing chicken and salmon will be presented in this article. In the technological development work, key success factors include selection of fresh raw materials of high quality, pretreatment of certain perishable ingredients and modified atmosphere packaging. The view of consumers on the quality of the two meals and different types of packaging will be described.

Ingredients of the two new meals

The chicken meal is consisting of a raw chicken breast, broccoli, cauliflower, carrots, precooked rice and a bell pepper sauce. The other meal is including a pre-rigor filleted salmon piece, green beans, cauliflower, carrots, precooked pasta and a mushroom and cream sauce. Both meals are weighing 475 g. A photo of the two meals is shown in Figure 1.

The meat and fish were used 1 to 2 days after slaughter with total bacterial counts of about 3.5 and 2 log, respectively. The chicken meat was marinated in an unsweetened juice of lingonberries (*Vaccinium vitis-idaea*) for 10 minutes for the purpose of lowering growth of bacteria that inevitably are present on the surface of the meat. The juice penetrated only 1 to 2 mm in into the meat, and the weight increase was less than 1%. Lingonberries, found in Scandinavia, northern Eurasia and North America, have a slightly bitter taste and contain various acids like benzoic acid, flavonoids and other antimicrobiologial compounds. The lingonberry juice has a pH below 3. The concentration of the juice and contact time in the marinade must be balanced against effects on taste, colour and drip loss. Lingonberry juice marination of salmon was abandoned, since it yielded an artificial reddish colour of the fish.

Fig. 1: Salmon and marinated chicken meals

The cut vegetables were washed in water twice and centrifuged to remove excess water. No further treatments or additives were used for the vegetables.

Package for extended storage and microwave heating

Respiring vegetables and non-respiring foods like meat and fish have different requirements for modified atmosphere packaging. During the project, a number of different gas mixtures combining oxygen, carbon dioxide and nitrogen were tested. The composition of the gas mixtures must be delicately balanced. In general, vegetables need access to oxygen (O_2) in levels of at least 2 to 3% and below 15 to 20% carbon dioxide (CO_2) during storage for maximizing shelf life and quality. O_2 levels below 2% will rapidly cause the vegetables to deteriorate. Vegetables differ greatly in their rate of O_2 respiration and need of O_2. The age and type of processing of the vegetables may also play a role in respiration rates. In this study, first single types followed by mixtures of raw cut vegetables were tested in micro-perforated bags for finding the most suitable and robust vegetables for these ready-to-cook meals.

In contrast, the shelf life and quality of meat and fish are best maintained under anaerobic storage and high concentrations of CO_2. In our ready-to-cook meal concept with a microwaveable package with one compartment for all ingredients, it is a challenge to find suitable packaging materials and gas compositions. At an early stage of the project, we decided to create modified atmospheres in the packages that were optimal for the vegetable fraction of the meal. That strategy left the meat and fish as the weak links for maintaining the shelf life of the meals. Therefore, high quality requirements were imposed for the raw materials of meat and fish, as well as a marination step for the chicken meat.

Fig. 2: Promens tray sealing machine

The ingredients were placed in transparent trays starting in the bottom with sauce, followed by rice/pasta, vegetables and meat/fish at the top. The packages were flushed with a gas mixture of 5% O_2/ 10% CO_2/ 85% N_2 on a Promens 511VG tray sealing machine (Promens, Kristiansand, Norway), as illustrated in Figure 2. The oval trays were of type polypropylene 1221-1G (Færch Plast, Holstebro, Denmark) containing 1,150 cm^3. The top film was a laser-perforated film of type 52LD (Amcor Flexibles, Brussels, Belgium). The specification for the perforations was adjusted to the chosen vegetable mixtures of the meals. By monitoring the O_2 levels of the meal packages during storage, it is possible to predict changes in the quality and microbiological status of the meals. The O_2 levels for salmon and marinated and non-marinated chicken meal packages are shown in Figure 3. Up to 9 of storage, the O_2 concentrations were at 5 to 7%, slightly above the target of 3 to 5%. The drop in O_2 values after 9 days storage indicates additional consumption of O_2 by bacteria, faster in non-marinated meat. As an alternative to gas flushing, the trays can be sealed with air inside. The 2 to 3 days that are needed with air to reach the desired gas equilibrium, will shorten the shelf life of the meal compared to starting with a near optimal premixture of gases.

The top film of the trays can be supplied with integrated steam valves (e.g. Amcor ProtectValve) that open automatically when the inside of the package heats up in the microwave oven. Steam valves facilitate a more rapid and uniform microwave heating. The dimension and thickness of the different ingredients must be regulated in order to make the heating as equal as possible. Other heating factors are the shape of the tray and the amount of steam that is generated. The salmon and chicken meals had heating times in microwave ovens at 700 W for about 7 and 8 minutes, respectively.

Consumer acceptance of the meals and packages

An at-home acceptance study was conducted among 120 frequent ready meal consumers in Norway. After preparing and consuming the meals at their own kitchen, consumers reported their liking. Norwegian consumers gave the two newly developed meals high acceptance scores. They liked the appearance, the odour, the taste and the user-friendliness of the package. Especially the salmon meal, but also the chicken meal was perceived to be a healthy and good alternative to other kinds of ready meals.

The following statement from one of the salmon meal testers illustrates how a large group of the consumers perceived this meal: "This dish was absolutely delicious. It's the best ready meal with everything included, that I have ever tasted."

The overall evaluation showed significant differences in consumer rating of the two meals. Although both meals were rated high, the salmon meal had on average the highest likelihood of buying, the highest score on total feeling, visual appearance, flavour, odour and texture. The mean for the consumers total feeling for the salmon meal was exceptionally high with a score of 5.7 on a 7 point scale. For the chicken meal the mean score was 5.0.

The texture and the amount of most ingredients included in the meals were perceived to be just about right. Most consumers highly appreciated the flavours of the ingredients of both meals. Some consumers evaluated the beans and the cauliflower as too moist and the chicken meat as too dry. The amount of sauce was regarded to be too small in both meals, while the total size of the meals tended to be too large.

The consumer acceptance for the tested one-compartment transparent tray was high, with an average liking score higher than 5. The package was perceived to be easy to handle in and out of oven, and easy to open. A few consumers stated negative comments related to the user-friendliness like "I burned my fingers while opening the top film", and "We need a tray that is easy to handle for consumers with reduced hand functionality". These statements indicate a need for further improvement of the package.

In addition, the consumers were presented pictures of 8 different packages of the salmon meal, where the trays varied according to colour (black, white and transparent), number of chambers (one or three) and placement of sauce (within the tray or in a separate bag), as illustrated in Figure 4. The transparent, one chamber tray with the sauce within received the highest acceptance score. However, consumers expressed variable individual preferences regarding these packaging issues.

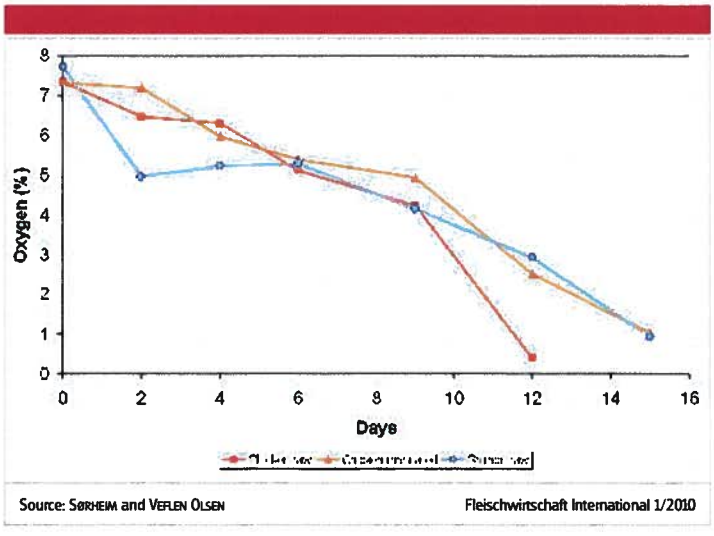

Fig. 3: Concentration of oxygen (O_2) in the headspace of packages of ready-to-cook meals stored at 4 °C for up to 15 days.

The main features of the meals

After conducting several upscale production tests of the two meals, we can conclude:

- The microbiological shelf life of the lingonberry-marinated chicken meal was 12 days at 4 °C.
- The shelf life was only 7 days for non-marinated chicken meals.
- Total bacterial counts on chicken were reduced by 1 log shortly after lingonberry juice marination, and by 2 to 3 log during modified atmosphere storage.
- The salmon meal with pre-rigor filleted fish also had a shelf life of 12 days.
- The colour of marinated chicken meat was more red and more stable during storage than of non-marinated meat.

Source: Sørheim and Veflen Olsen — Fleischwirtschaft International 1/2010

Fig. 4: Eight alternative packages for the salmon meal with different tray colour, number of chambers and placement of sauce

■ The drip loss of marinated meat was higher, probably due to protein denaturation at the meat surface.

Both meals, in particular the salmon meal, received high consumer liking scores. The consumer evaluation revealed specific suggestions for future improvements of the meals and the packages.

The substantial extension of the microbiological shelf life that was obtained for the two meals in this project compared to current commercial meals, makes it more interesting to produce and market ready-to-cook meals. With a shelf life of the meals approaching 12 days, a wider distribution range is possible, and losses at the retail level are likely to be reduced. Future improvements of the package, for example by introducing separate chambers for different ingredients, could further improve the quality and shelf life of the meals. Although these ready-to-cook meals are going to be expensive, we believe that the appearance, taste and nutritional value of the meals will make them tempting for many consumers. We also see an interesting market for ready-to-cook meals at a larger scale in the food catering and fast-food business.

Acknowledgements

The authors are grateful for financial support from the European Union in the project Double Fresh STREP FR6 PL 023182. The ready meal producers and project partners Fjordland and Nortura (both Oslo, Norway) have contributed to the development of the meals.

Authors' address

Dr. Oddvin Sørheim and Dr. Nina Veflen Olsen, Nofima Mat, Osloveien 1, NO-1430 Ås, Norway

Dr. Oddvin Sørheim is a food scientist at Nofima Mat, working mainly with packaging and colour of meat, as well as meat quality issues.

Dr. Nina Veflen Olsen is a research scientist at Nofima Mat. Her fields of interest include product development management and consumer behaviour.