What About Risks in Low Water Activity Foods?

Markus Bernasconi, Novasina, email: markus.bernasconi@novasina.ch

Until now, there has been a common belief that food with water activity below 0.6aw is safe, can be easily processed and comes with a very long shelf life. Recent studies have clearly shown that this assumption is not correct. Moreover, most companies are missing optimisation opportunities in the manufacturing process and thereby produce at higher costs than necessary. To understand what possibilities exist, it is required to understand the risks and behaviour of components in the products and processes which are applied to manufacture the product.

A false sense of security is very dangerous and definitely not beneficial for food manufacturers but it happens day by day in food manufacturing plants producing low water foods. As there is a sharp water activity limit for microbiological growth at 0.60aw, most users expect not having any problems below this value. But what about spores or germs which are still in the product but remain not active? What is about other sensory changing processes as oxidation or ingredient degradation? Let's have a closer look to those issues.

Residual Pathogens in the Product

Drying or heating in general are used to preserve a product and extend its shelf-life but keep in mind that pathogens cannot be eliminated completely by drying. Spores and vegetative cells can survive in low water activity environments for months even if they do not grow as aw conditions are not met. Studies have shown that E.Coli, Salmonella and Listeria monocytogenes populations just drop little in environments with aw of 0.3-0.4aw. Just believing that below 0.6aw everything is safe is careless.

Additionally, once a dry product is mixed with water at consumer side or in case of an intermediate to produce the final product, growth conditions are suddenly present and evolution of dangerous pathogens goes its way.

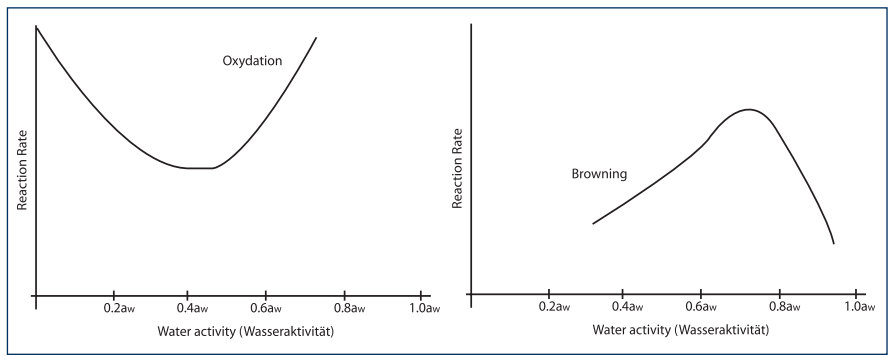
Secondarily, dry products are mostly hygroscopic. If the storage box or package has been opened and content has been exposed to environmental conditions, most probably humidity from air is absorbed and changes the aw-value in the product remarkably. This can happen within seconds and surprisingly, one can find perfect growth conditions for pathogens which no one has expected.

Oxidation and Browning

There are a few chemical and physical processes taking place at low water activity levels and thereby need to be understood while manufacturing low water activity food.

Oxidation is one of the major causes of food spoilage and it is initiated by metal ions.

The reaction rate falls with a lower aw-value and increases again.



The minimum is at 0.3 aw. Free water acts here not as reactant, but as the solvent for metal ion and the oxygen from outside. Once both are transported to the area of action, means where the oxidisable ingredient is present, reaction takes place. How can this be solved? First step is bringing the aw in the area where reaction rate is low. Second opportunity is adding an easy oxidisable ingredient or an oxygen absorber bag. Third, an optimisation of the packaging (sealing and material which do not allow oxygen passing through) can provide good protection.

In some processes it is requested but normally, non-enzymatic reaction like protein denaturation or browning is an enemy for producing safe and high quality low water activity foods. Like in oxidation processes, free water acts as a solvent to transport the reactants to the place of action. High risk ingredients are carbohydrates plus proteins as they react and form a brownish product if enough energy (heat) is available. This is called Maillard-reaction. And how is a low water activity product created? Yes, by drying which means heat. See the problem? Every milk powder or dry beef producer knows what this is about. The problem with the non-enzymatic reaction is that it changes the product in two ways:

- Optical: Discoloration occurs
- Sensory-wise: Some products are getting a bitter taste

Careful adjustments of water activity levels in the product minimise the risk of inter-product reactions. An additional advantage of conducting aw measurement is that drying process can be optimised in terms of temperature, airflow, speed (inlet pressure etc) which is beneficial for the production costs

Physical Properties

As water activity is frequently used for microbial risk assessment, it is mostly forgotten that free water influences the physical properties of a product. The following points have to be considered:

- Two ingredients may have the same moisture content, but totally different aw-values. Means, just determine the water content or moisture of a product can hurt
- Free water migrates from regions of high aw to regions of low aw, and not between areas of unequal moisture contents!
- Free water migrates between different layers of a multi-component food causing un-desirable textural changes.

Rate of Migration Depends on Structure/Diffusion Properties

Now let's combine this information with low water activity foods. They will be dried by various means like sun drying, roller-, drum or spray-drying. The basic principle to use heat to evaporate and by then remove the water in the product is the same for all. Economic reasons lead to enhance the process in speed but extra problems are caught by that. Ever wondered that a spray-dried milk powder has to be removed by jack-hammer from the tank even if it was 'completely' dried?

The reason for caking and clumping lies in unfavorable drying conditions. If a liquid is dried, accumulations of small particles are created. Less in spray-drying than in drum- or roller-drying. If the drying happens too fast, free water molecules will be enclosed in these aggregations. Even if the water draws into the first layers, it sticks there as the outer layer of the particles is hard and dense due to the drying process, respectively the heat treatment. If water activity is measured after drying, everything looks fine as the enclosed free water is not detectable right now. The dried product is transferred into a tank and there the nightmare starts. Free water starts migrating slowly from areas with high water activity to low ones forming bigger accumulations as the products dissolve and re-precipitate. And finally, there is one big clump and cannot be used anymore.

Adjusting drying conditions to product properties and a though monitoring of water activity paired with long time studies of aw vs. time will help to control this issue.

Summary

Global competition, higher costs for raw materials and labour, all those factors are daily points on food manufacturers agenda. Negotiation for better prices and more automation in the plant is the result of it but what about optimising the production process in a reliable and safe way having less waste? No doubt, there are activities but experience has shown, that it is not easy to find good ideas, how to optimise and if found, there is no clue about the measurement technology nor the interpretation of the results. Especially in low water activity / low water food manufacturing becomes critical and the pressure for being economical leads to wrong process parameters which punish finally the operator by receiving a non-conformal product. Water Activity is not the holy glory solution but it is an important piece in the product quality jigsaw which was neglected so far. The potential which it offers is tremendous and understanding water activity or in general the behaviour of water in a product helps to make it better, more stable and extends its shelf-life.