Processing and product design for natural food products

Dr.-Ing Ulrich Bobe, Dr. Martin Michel

Nestlé Research Center, Lausanne, Switzerland

(ulrich.bobe@rdls.nestle.com; martin.michel@rdls.nestle.com)

ABSTRACT

There is a strong consumer demand for natural food products that consist exclusively of natural ingredients. Many consumers value such products, as they consider them to be an integral part of their life quality. Offering safe natural products that are attractive to consumers requires significant innovation and renovation efforts. Simple recipes, the absence of chemically perceived or unknown additives and the use of ingredients familiar to consumers are crucial for the success of natural products.

Food processes play an important role for obtaining natural food products. The degree of processing depends on the desired outcome including taste, appearance and microbiological safety. Which processes help to create natural appeal depends on the general perception of a specific product category. One example is the loss of perceived ‘naturalness’ and freshness in powders. Whereas the drying of powders itself is not perceived as a non-natural process, consumers value pasty or even liquid product formats as more natural. However, for a given shelf life, the microbiological safety and colour stability is far more difficult to achieve in such high water activity products.

New technological approaches are needed in order to deliver the natural characteristics that are important to and recognizable by consumers. We will discuss current challenges and elaborate on the requirements for successful natural product development.

Keywords: Natural; Processing; Clean Label; Naturalness

BACKGROUND

Processing, besides careful sourcing of high quality raw materials and well executed logistics, is the key part of the value chain of transforming ingredients into high quality value added foods. One of the most important progresses in human history is the discovery of processes to preserve foods such as sterilization, drying, freezing, use of additives, etc. After humans learned empirically how to preserve their raw food materials, it was the French chef and confectioner Nicolas Appert in 1810 who first published his work on “The Art of Preserving all Kinds of Animal and Vegetable Substances for Several Years” already 100 years before Louis Pasteur proved that bacteria are killed by heat. These findings were the starting point for shelf-stable canned foods with usually perishable content inside like fruits, meat or vegetables. The impact was huge. Napoleon honoured this innovation because at that time supply of food (mainly for soldiers but also for the people) was very limited and storage during an extended period of time brought enormous strategic advantages [1].

Nicolas Appert also applied adding substances like sugar, vinegar or salt for further prevention of spoilage.

With time far more additives were found that could suppress microbiological growth. Those innovations contributed to higher quality of peoples’ life as the ability to store large amounts of food provided the basis for overcoming the frequently disastrous effects of food shortages.

Today, consumers and their needs have changed. Shortage and supply of food is not any more a real issue in the developed world and consumers have climbed the pyramid of needs. More and more consumers look for “whole health solutions” - products that promote health and wellbeing, prevent disease, help curing illnesses and protect the environment - and to a certain extend find them in “natural” products [2]. The need of consumers for safe supply of nutrition has transformed into the need for healthy (including safe) and trustworthy nutrition. If asked for the key drivers for buying a foodstuff, “natural” doesn’t always have to be the biggest motivation for the final choice. A study in Spain showed that sensory appeal, price and convenience are still more important for certain consumers and the importance of these factors can not be neglected [3]. But natural can be a strong point of differentiation, as consumers prefer a natural product over a non-natural alternative [4].

The safety remains of paramount importance which can be seen from the reactions of people and media if there is a food scandal or crisis. But especially those unknown and unfamiliar additives that assure safe and attractive foods are often associated by consumers with potential health risks. These concerns are reinforced...
by studies such as the Southampton-study about artificial colours publishing a potential correlation with hyperactivity in children [5]. Since, EFSA now requires a warning on food labels if one of these six colorants is used in processed foods.

The fundamental and non-negotiable task of delivering safe food to consumers is an on-going challenge for the food industry. Thermal processing is the classical preservation technique, but it can lead to losses of valuable components such as vitamins as well as changes in taste, colour, etc.

Technological solutions are in many cases not directly available to create natural products. There exist solutions for some single unit operations that could be perceived as more natural by the consumer (e.g. UHT vs. retort sterilisation or green solvents vs. organic solvents). But their integration into an existing process by a one-to-one replacement is usually not possible and the complete food production process has to be adapted to the new unit operation such as aseptic filling following the UHT-treatment.

In this paper we will discuss the current gaps and challenges for successful natural product development.

CHALLENGES

Definition of Natural

To date, regulatory authorities around the world have mostly refrained from defining “Natural” for food products. In the U.S. neither the Food and Drug Administration FDA nor the U.S. Department of Agriculture USDA has a general definition or guideline for natural. Local non-binding guidelines for claims and labelling related to “natural” exist e.g. in the UK [6], France [7] or Canada [8]. The guidelines have in common that they talk about 2 main criteria: The food must contain only ingredients directly produced by nature (natural ingredients) and the food must be treated with processes that do not significantly alter their original physical, chemical or biological state. More detailed examples for acceptable and non-acceptable processes are given in each guideline. The use of the term “natural flavouring” is regulated by and within the EU, stating that at least 95 % of the flavouring component should be obtained from the material referred to [9].

In the absence of general regulatory legislation for the term “natural” the underlying basic principle remains not to mislead consumers.

Reformulation and Processing

All the effects that are generated by food processing, ranging from pure edibility over microbiological safety, texture, taste and colour to functional effects etc., must be maintained throughout the shelf life. The length of the shelf life as well as the process itself determines the effort necessary for stabilisation and can be crucial for the perception of a “natural” product. The following factors are important for developing natural processed foods:

- **Clean label formulations** - removal of artificial additives, use of ingredients familiar to consumers
- **New Processing** - adaptation of processes to clean label formulations
- **New strategies and technologies** - closing the gap between safety and retention of natural properties

**Clean label formulations:**

A “Clean label” is an important criterion for consumers who are looking for natural products. To clean labels means to avoid additives (E-numbers) that generate a non-natural perception by using ingredients that are familiar to consumers. A successful example is given by SMARTIES®, that has been successfully renovated by moving from artificial colorants via non-artificial colorants to colouring foodstuffs (Table 1) [10].

Table 1: Evolution of colorants used for SMARTIES® since 2006

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E104 Quinoline Yellow</td>
<td>E160a Beta-Carotene</td>
<td>Lemon (yellow)</td>
</tr>
<tr>
<td>E110 Sunset Yellow</td>
<td>E141 Copper Chlorophyll</td>
<td>Radish (red)</td>
</tr>
<tr>
<td>E122 Carmoisine</td>
<td>E101 Riboflavin</td>
<td>Spirulina (blue)</td>
</tr>
<tr>
<td>E124 Ponceau 4R</td>
<td>E100 Curcumin</td>
<td>Safflower (yellow)</td>
</tr>
<tr>
<td>E133 Brilliant Blue</td>
<td>E120 Carmine</td>
<td>Black Carrot (purple)</td>
</tr>
<tr>
<td>E120 Carmine</td>
<td>No blue solution</td>
<td>Hibiscus (red)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Red Cabbage (red)</td>
</tr>
</tbody>
</table>
Similarly to colours the approach for finding natural alternatives is also applied to other additives like sweeteners, preservatives, emulsifiers or flavours. Rosemary and other spices are the most used examples of natural preservatives but there is a wide range of natural additives and even natural ingredients available from suppliers. Natural ingredients with emulsifying properties are so far limited to egg yolk and proteins (e.g. from milk). The most commonly used emulsifiers from a natural source are plant-derived lecithins, which are classified as additives (E 322).

New processing:
Generally speaking, to create simplicity on the label often means to increase complexity in processing. Finding solutions to valorise the different ingredients in a way that no additives are needed while maintaining the safety of the product is a huge challenge.
Natural ingredients, preservatives as well as natural emulsifiers or colorants, are often less effective than artificial additives and therefore have to be used in much bigger quantities. For natural blue colour from Spirulina the colouring intensity is approximately 1500 times less than the one of the artificial brilliant blue. The result for industrial scales is that tons of the colouring ingredient have to be used instead of kilograms, which affects the processing dramatically as well as the properties of the final product. Natural colours are also more sensitive to thermal treatment and often less stable during shelf life than synthetic colorants, as shown in Figure 1.

Figure 1: Degradation of a natural versus a synthetic blue colorant in high moisture environment due to pasteurisation (left), degradation of a natural versus a synthetic red colorant in high moisture environment due to shelf life at pH = 3, T = 23°C (right)

As a consequence, food processes often need to be adapted to the new formulations; however, in the case of heat-sterilisation compromises in reducing temperature and/or time are not possible due to safety reasons. New insight into fundamentals of food preservation, from pasteurisation to sterilisation, is necessary to achieve inactivation of spores and bacteria on lower temperature/time levels, preferably in a continuous way.

New strategies and technologies:
To create products with a more natural and fresh appeal to consumers it is essential that the product itself signals its naturality. A natural appearance is provided if consumers can figure out what has happened to the raw materials and when they can recognize them in the final product to a reasonable degree. This attribute can be lost or decreased by processing, e.g. due to drying of liquids to create instant food powders [11]. Even if the only difference is a unit operation of drying and even though this is rated as one of the most natural processes [12], it can decrease the degree of perceived naturalness of the final product.
Providing a more natural taste and texture requires retaining as many of the original raw material attributes valued by consumers as possible. The presence of recognizable pieces contributes to the natural perception but such pieces need higher heat loads in order to fulfil the microbiological safety requirements. A practical strategy is the separate processing of different streams of ingredients (Figure 2). This doesn’t necessarily require new innovative unit operations. Processing under separate streams allows the individual treatment of the ingredients under optimal processing conditions, thereby improving the final product quality.
Consumers are moving away from dried product formats and prefer liquid formats, as they consider them more natural. However, stabilisation of food at high water activity over an extended period of time is still a complex challenge and becomes even more difficult if additives should be avoided. The most natural ingredients to reduce water activity (without drying) are sugar and salt, as already applied by Mr. Appert over 200 years ago. Strong efforts are undertaken to reduce levels of exactly those well-known ingredients with preservative function because of their contribution to health problems (obesity, diabetes, high blood pressure, etc.) and therefore the challenge for preservation in a natural way becomes even more complex.

The strategy to overcome the antagonistic effects of making food safe and stable while keeping its appearance, taste and texture as natural as possible must go towards multi-hurdle approaches. They combine various preserving effects to obtain finally a safe product. This could be low-temperature pasteurisation plus acidification or reduction of the water activity. The packaging as a functional barrier builds another important hurdle. Oxygen scavengers as well as antimicrobial components inside the packaging material are options to maintain product quality and to keep a reduced microbiological load over shelf life.

As convenience and price are still key drivers for consumers’ choice many current technologies face limitations in terms of their applicability. Therefore new innovative technologies are necessary that help to increase the stability and the efficiency of ingredients while they enable providing an appealing sensory experience to the consumer via a natural product.

**CONCLUSIONS**

The needs and expectations of consumers are changing: besides just a safe supply for uptake of calories consumers look for healthy nutrition that matches their lifestyle and that gives them a higher quality of life in a convenient way.

Natural foods can offer this and consumers appreciate more and more the natural alternatives to what they are looking for. Despite the fact that consumers are usually not interested in how food is manufactured, processing is an integral part that determines the products’ appearance, stability, nutritional value and price.

The development of microbiologically safe and stable products that keep their natural attributes perceptible for the consumer is a big challenge. Some solutions for single improvements as well as more holistic strategies to deliver natural products exist. But new technologies and innovations are necessary to overcome the actual contradiction of delivering natural products that are also healthy, sensorial appealing, convenient and affordable. This requires further investment into focused research resulting in a huge business opportunity if new natural product formats can be realised.
REFERENCES


