Stevia lingers in its sweetness, sometimes in its licorice off taste, proteins linger in bitterness and fats, once off, in rancidity. From these observations, lingering seems to have a negative effect on food quality. Creaminess, koku(mi) and sweetness bulkiness are highly appreciated sensations and rely on lingering taste and texture effects as well. This whitepaper explains how to implement the desired and prevent the undesired effects of lingering.

**Summary**

The quality of food products relies on the sensory performance of a product. This concerns the effect of the packaging materials, its convenience during preparing the food but largely also on the sensations that consumers experience during the eating. taste, aroma, texture, trigeminal (pain), astringency, cooling effects, all these factors determine the sensory properties of foods and thereby affect the final quality judgement of the consumer. In many cases, all sensory attributes need be in harmony to prove to the consumer that a product has a high quality. well appreciated sensory attributes, such as for example creaminess, require a congruent multisensory experience; the texture of a product should match its flavour (aroma and taste) performance in every way, and needs to be in line with the consumers' expectations of the product.
Every sensory aspect has three major parameters;
1. The intensity of the effect
2. The balance of the effect, e.g. in combination with other sensations
3. The duration of the effect.

This Whitepaper addresses each of these three parameters separately and shows how products can be optimised to fulfil the consumers’ expectations.

Most sensory aspects are well known, such as smell, aroma, colour and texture. Some are less common such as trigeminal sensations, astringency and the effect of lingering. A trigeminal sensation is related to pain. Compounds such as capsaicin in pepper produce a sensation of burning. In fact there is a large family of compounds (capsaicinoids) which are secondary metabolites in for instance chili peppers, probably as deterrents against grazing. These compounds do not provoke pain due physical damage of the tissue but as a result of the chemical compound interacts with the receptor that under normal circumstances registers physically damaging actions. This is similar to the cooling aspect of mint; the temperature is not changed but the compounds have been found to chemically interact with the receptors, simulating cold.

Astringency is a mouthfeel related effect as a dry sensation such as is known in, for instance, wine. It has been shown that the effect is the result of food compounds reacting with proteins in the saliva. In case they form aggregates (which are too small to be tasted as particles that would make it calky) our sensory system interprets this phenomenon as astringent.

Lingering is related to the persistence of flavour. It relates to long-lasting sensations in taste. It has been shown that the time that people experience flavour has important sensory consequences; it is crucial for creaminess and has an effect on how people decide that they had enough to eat. While lingering is found positive, too long persistent flavours are negative. Typical examples are the lingering bitterness of many vegetable proteins, the persistent rancidity of old oils and the log-lasting sweetness of stevia compounds.

It goes without saying that intensity of any sensory effect is crucial. Too strong or too weak; in both cases a product will not perform well. In many cases the intensity can easily be changed by adopting concentrations of certain ingredient. E.g. stronger aroma can be generated by adding more of an aroma or prolong the fermentation process in case the flavour is from a microbial source, e.g. as in cheese, wine etc. Stronger sweet taste can be accomplished by adding larger amounts of sugar or sweeteners while a more salty taste can easily be enhanced by adding extra salt or salt replacer systems. Texture attributes such as thickness can be changed by adding thickeners, fattiness by increasing the amounts of low-melting fats, and roughness, if desired, by introducing particles in the formulations. Fat is important to lubricate the oral cavity. This is crucial for creaminess, hence fat needs to become available in sufficient quantities. In some cases, however, only a small amount of the sensory active ingredients are actually tasted. We have seen cases in which 80% of the salt was not perceived during the eating because the speed of release was insufficient to allow the full load of salt to be actually perceived. In such a case, salt reduction can easily be accomplished by changing the texture of a product to enable efficient release of the taste compound [ref. 1]. In addition it is worthwhile to mention that intensity can also be enhanced by generating contrast in foods. Spatial contrast or pulsed sensation (temporal contrast) have both shown to enhance taste intensity [ref.2, ref.3]. Designing enhanced release and increasing contrast are therefore interesting concepts in salt, sugar and fat reduction strategies; they all make these compounds more effective and thereby offer the opportunity to reduce their concentrations without effecting the desired taste intensities.

Balance
Any sensory aspects need to be well balanced. A good product can be converted into a lower-quality food just by adding or removing one aspect generating a misbalance in the product. Creamy products will be perceived much less creamy when they are too sour. A bit of rancidity is required in virtually all foods but too much will make the product off. Similarly, all products require a certain viscosity (even soft drinks!) while too viscous products will be rejected. The balance between all these sensory attributes can only be modified in relatively small ranges from their optimal values without a quality drop. The balance is only partially the effect of the aroma and taste compound composition. Also here, the product composition is extremely important. Compounds like acetic acid and butyric acid are converted to ions at high pH losing their aroma characteristics. As a result, lowering the pH will be accompanied by decreasing concentrations of these compounds. pH has an effect on perceived sourness, but pH is surely not the only factor; the buffer capacity of the food matrix plays a key role as well.

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The effect described for fat is also applicable, albeit less pronounced, for developing products based on starches and proteins.

Once all these intensity factors have been re-designed to produce optimal food products, the last parameter to take care of is the time-related perception.

Temporal sensory effects
Although sensory intensity and balance have been generally accepted as crucial aspects determining food quality, the duration of sensory stimuli is less well-known. Already 10 years ago, NIZO showed that the duration of aroma perception determines the level of sensory satiation consumers experience [ref.5]. In a second set of experiments it was shown that people actually eat less when the flavour sensation was artificially prolonged using an olfactometer. Once the aroma formulation was adapted to provide a low fat dairy product the intensity perception of a well-balanced full-fat product experience, the low fat product gave away its low quality by not being able to deliver the flavour system long enough. These examples show that duration of sensory sensation is an important driver for consumer appreciation. Similarly, texture perception is a dynamic sensation. Fat containing products should lubricate the oral cavity, reducing the friction forces between the tongue and the palate. Mechanoreceptors detect this and deliver these sensory cues to the brain for interpretation. Creamy foods, although they need to be stable during shelf-life, will need to destabilise during mastication in order to release fat for lubrication [ref.6]. This programmed destabilisation has shown to be of critical importance to generation creamy sensations. Obviously, stagnant fat in the oral cavity is not easily removed and, as many flavours are very fat soluble, aroma and taste perception will remain to be present longer than in case the emulsion is stable and washed away relatively easily. Prolonged flavour sensations and enhanced lubrication in combination induce creaminess. Recently Japanese literature reports [ref.7] of a sensory aspect called koku(mi). This quality is highly appreciated in the Japanese kitchen and depends, similarly to creaminess, on the temporal perception of the flavour and texture combination.

Too long?
Although prolonged release is a requirement for food quality, too persistent sensations are often cueing for negative aspects. The bitterness of proteins and protein hydrolysates, the lingering sweetness of steviosides and the rancidity of fats are all off-flavour aspects that linger. Too viscous products are judged thick while persistent fat coating leads to waxiness. They linger well beyond the profile of well-liked sensory percepts such as creaminess. Astringency has been shown to be caused by compounds interacting with mucus proteins in the saliva, generating aggregates that are sensually translated into astringency perception [ref.8]. Steviosides provoke trigeminal sensations (pain) consequently being rated as having a lower quality that one would expect from its sweetness. Based on these observations, NIZO concluded that there is a delicate balance in the lingering of sensory aspects as well; too short cues for the absence of key ingredients (fat, sugar) while too long perception triggers negative consumer reactions.

Balancing lingering
To be able to balance lingering, it is crucial to be able to measure these effects, both from the sensory perspective as well as from their physical nature. NIZO has developed and implemented a series of methods to do that;

Temporal Dominance of Sensations sensory methods that, next to Time-Intensity measurements measures the time dependant sensory performance of a products. This method is complementary to QDA;

Tribology measurement characterising the lubrication properties of products under dynamic shear conditions;

Tools to assess the effect of saliva; This ranges from using saliva (human saliva or various saliva analogues) in analytical texture measurements to analys saliva on texture, taste and/or aroma compounds for determining the persistence of ingredients that affect these sensory properties;

CLSM-OTC; Confocal Laser Scanning Microscopy allows simultaneously investigating the microstructure of a product while obtaining compositional information. A tribology setup (OTC; Optical Tribology Cell) can be mounted in order to apply shear during visual inspection of the sample. This allows determining time-related, structure breakdown of foods;

PTR-MS; a mass spectrometry method that allows determining the release profiles of aroma compounds. This can be used to measure aroma concentrations in the nose space while a person is eating a food but it can also be applied to monitor aromas released during food preparations;

PTR-MS-OTC; This allows monitoring aroma release as a result of shear-induced emulsion breakdown of food product;

Olfactometer/gustometer combinations; The olfactometer allows providing a computer-programmed aroma profile to a subject with exactly defined composition, intensity and its temporal profile. Similarly, the gustometer can deliver well-controlled taste stimuli. Together they can offer flavour (taste and aroma) to the person who is eating a food. This allows virtually checking the required taste profiles for optimal perception. This includes tailoring the amount of lingering to match the requirements of a product;

Olfactoscan; a method to systematically screen for aroma-induced flavour enhancing and masking effects. This method is being applied, for instance, to design temporal effects of taste compounds, e.g. masking of bitterness, stevia off-taste as well as designing sweet and salt temporal sensations to best match the taste sensations of sugar and salt respectively.

References
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