Ice-cream wafers

Pleading for a New Quality Consciousness

Is the Development Finished, are we at the Climax? Compared to other areas of food industry, especially of the confectionery business there is - at least for Europe - the impression the development in ice-cream wafers is essentially completed.

Within the other bakery and the confectionery industry we see - besides of traditional top brands - a bunch of successful new products and product extensions, often combinations of Bakery item – Filling(s) – Nut/fruit/cereal pieces – Chocolate or coating.
By such kind of combinations traditional chocolate manufacturers as well as bakery and confectionery companies take potential advantages from

- a more sophisticated taste impression,
- the combination of different textures,
- the trend to smaller, bit-sized pieces and
- getting sweet & heavy "mono" products lighter by combining them with crunchy and tender wafers.

In contrary in ice-cream distribution changing the type of ice-cream, the packaging or other traditional marketing elements are considered to be fully sufficient. Wafers are rarely used as a vehicle to be different or to develop the market. Is it impossible for ice-cream products to have top quality defined by the look, the taste and the functional aspects of their wafer part?

A second point is: In shops selling frozen yoghurt or ice-cream there is often paid little attention to some basic rules of handling crunchy wafers. And additional opportunities from offering more of the variability in wafer types - as available today - are not fully taken.

WAFERS TYPES FOR ICE-CREAM

Crunchy wafers, either for consumption with fresh ice-cream or as edible containers for frozen industrial ice-cream are manufactured in several types. They differ in the manufacturing process, in the type of equipment as well as in their composition. Starting with cake cones, so-called "moulded" wafer cones or cups, being very bland and not even sweet in taste there are several types of wafers (table 1). The percentage of sugar, being one of the value-determining ingredients may differ significantly.

Table 1: Wafers for Ice-cream

Wafer Type	Sugar Content, %
Flat wafer for wafer biscuits	0
Moulded wafer cones & cups	0 to 5
Moulded sugar wafer cones & cups	15
Rolled sugar cones	30
Deep-drawn wafer bowls	35
Wafer sticks (crisp wafer tubes)	45

Considering wafer manufacturing equipment, older machines are more and more replaced by the economically more advantageous new ones, producing between a few thousand and 13 000 cones per hour. For highest output an optimization both of the ingredients (flour quality) and the recipes is essential for a trouble-free operation.
All the elements: ingredients, recipe, proper processing, and high-quality equipment may not be sufficient for delivering the best final quality of ice-cream wafers. We have to point out clearly that packaging and intermediate storage can be critical for sustaining the quality originally produced. Crunchy wafers pick up moisture easily from the humidity of the air. As a consequence they are getting tough or even soft within a short period of time whilst taking up just a few percent of moisture. That effect is seen quite frequently in ice-cream shops.
Moreover wafers might easily absorb smells, e. g. "cardboard" or "printing ink" flavours. In frozen ice-cream cone distribution the biggest thread to quality is any interruption of the low-temperature freezing chain. Because any higher, even still freezing temperatures over-proportionally promote moisture migration from the ice-cream towards the wafer cone.

THE MAIN QUALITY FEATURES OF WAFERS – CRUNCHY, STABLE AND ...

Asking for the main quality features in wafers their texture (crunchiness) and mechanical stability are dominating. The look – evenly brown-coloured – and a fresh, typical taste are further aspects being important in practice. But at the height of the ice-cream season sometimes every cone available has to be used.
Because of its very importance I want to discuss the aspect of crunchiness (crispness) here in some more detail. Crunchy wafers are sensitive items in a way that f.i. ice-cream-filled wafers quite rapidly may reach a moisture content where texture changes occur from crunchy into slightly tough, later on leathery and finally soft. Table 2 has some data on it.

"Water activity", as shown additionally in table 2 is an interesting physical parameter, reflecting the "state of energy" of the moisture being present within a material. Therefore water activity is more suitable to follow-up moisture migration tendencies in combined food materials than looking just for the absolute moisture content.

Table 2: Wafer Texture, Moisture Content & Water Activity

Condition of the Wafer	Texture	Moisture, %	Water Activity, appr.
Freshly baked	Very tender, crispy	below 2	below 0,1
Stored, conditioned	Crunchy, harder	4,5	0,3
Wafer gets tough	Crunchy-hard to tough	6 and more	0,5 / 0,55
Wafer is soft	Soft, flexible	12 and more	0,7
Structural collapse	Very soft, shrinks	over 20	0,85

The extent of moisture pick-up by wafers from the surrounding air should never be underestimated. The water activity of air calculates from the "relative humidity" figure in %, divided by 100.
First Example: A wafer in an ice-cream shop – the relative humidity is (only) 50 % (= water activity 0,5). Within a short period of time the wafer accumulates up to approx. 6 % moisture, in case of slightly higher humidity in the air it will get even tough and lose its crispness. Recommendations: Protect by a (transparent) cover, store just quantities used-up almost immediately in open air.
Second Example: Ice-cream-filled wafer cone, frozen. During storage moisture will migrate from ice-cream to wafer until the water activity has equilibrated finally. That, by comparing the water activity data in tables 2 and 3, would result in a totally mushy wafer.

HOW TO KEEP AN ICE-CREAM-FILLED FROZEN WAFER CRUNCHY?

Knowing the two main sources of moisture migration into a wafer,

1. Moisture pick-up from air humidity between baking and filling with ice-cream.
2. 2/3 of an ice-cream is water and has at 0 °C an water activity close to 1.
   At minus 20 °C water activity is still about 0,8 (Table 3).

one can design counter strategies. By various precautions we try to retard moisture migration and to hinder the system from attaining the equilibrium in water activity between wafer and ice-cream. These precautions must be sufficient to guarantee the consumer finally will enjoy a crunchy ice-cream wafer.

- Packaging of the wafer cones after baking.
- For frozen ice-cream: Inside-coating of the cones with a chocolate compound before filling. These coatings are in no way a permanent protection against moisture migration (Cocoa powder f.i. is hygroscopic).
- Isolating the top of the filled cone with chocolate towards the packaging sleeve in order to avoid any moisture migration from the surface of the ice-cream to the non-glazed outside of the wafer cone.
- Sufficiently low freezing temperatures to greatly reduce any moisture migration and keeping those low temperatures all over the distribution chain.

Table 3: Water Activity of Frozen Ice-cream (Fennema, 1996)

Temperature, °C	Water Activity Over Ice Phase
0	*
-5	0,95
-10	0,91
-15	0,86
-20	0,82
-25	0,78
-30	0,75
-40	0,69
-50	0,61

* No ice phase, water activity of unfrozen cream slightly below 1,00.

Deep freezing is an extremely efficient way to reduce moisture diffusion. Special physical measurements of the so-called "glass temperature" of ice-cream determined a range of minus 31 °C to minus 33 °C (Levine & Slade, 1990). Within the glassy state all diffusion is strongly reduced. But if the actual storage temperature is up by 20 °C to 25 °C above that glass transition temperature, the diffusion coefficients again increase by several decades. That corresponds to the common experience of long time storability of frozen ice-cream cones at industrial freezing conditions, approx. –40 °C, and even within well-operated freezers in stores or households at –18 °C.
The main issue is in any interruptions of that deep-freezing in distribution - during transports over long distances in hot summertime, in open supermarket freezers or all the way from the store back to the home freezer. Here the actual temperature might increase to a few °C below 0 °C and moisture migration will increase dramatically. The wafer cone might get soggy.

RECIPE CHANGES FOR KEEPING CRUNCHINESS?

The situation of losing crunchiness due to moisture absorption - in contrary to widespread opinions and "secret hints" cannot be greatly improved by recipe changes. Even an increase in the percentage of hydrophobic ingredients as fat or oil leaves the wafer with still 90% of hydrophilic carbohydrates and proteins. Much higher fat percentage is impossible, both from manufacturing technology as well as from texture - no one likes a crumbling "something" instead of a crunchy wafer.

If we compare wafer cones with increasing sugar content - from cake cones to moulded sugar cones and finally to rolled sugar cones (cf. table 1) - more sugar helps in retarding moisture migration. During the cool-down of the wafers after baking the recrystallizing sugar is forming hard, glassy structures which slow down moisture permeation compared to no-sugar wafer matrices. But within each of the wafer categories in table 1 there is a limit in the sugar percentage possible.
1. from the ingredient cost side,
2. from in-creasing de-moulding problems and 3. the baking time increases with high sugar ratios, therefore the output would be reduced.

Similar arguments apply to a trivial way of improvement, the increase in cone weight. Higher weight proportionally increases the quantity of moisture needed to get from the crunchy into the tough texture range.
Moreover even today there are very few other, at least no cost-effective ingredients available for further improvement from the recipe side. The well-known rule applies here again: quality has its cost.

PACKAGING & STORING WAFERS BEFORE FILLING

Packaging the freshly manufactured wafer cones avoids non-controllable moisture pick-up during storage in medium or high moisture environments. Moreover there is protection against any off-flavours and the access of air (oxygen) is reduced which retards the development of "old" or "rancid" flavour notes.
Unfortunately the weight ratios are in no way favourable for our wafers. An example: a rolled sugar cone for standard frozen ice-cream wafers: The cone has 12 gram and approx. 1,5 % residual moisture after baking. By absorbing some 5% moisture (= just 0,6 g) it comes close to the limit of crunchiness. These 0,6 g easily can be absorbed during storage, if inadequately packed and stored at normal or higher relative humidity. If later the cone will be filled with f.i. 50 g ice-cream,

containing 33 g of moisture there is plenty of moisture for migration - if the precautions to retard as discussed before are not done sufficiently and properly.
That might happen even faster to cake cones, having usually just half the weight of rolled sugar cones and being far more sensitive due to the lacking sugar. Now as little as 0,2 to 0,3 g of additional moisture are sufficient to move into the toughness and later on softness range. Considering the handling of wafer biscuits, wafer cones and wafer sticks in some of the ice-cream outlets these facts seem to be almost unknown.

TRENDS WITHIN THE DIFFERENT WAFER TYPES FOR ICE-CREAM

The wafer types outlined in table 1 can be used in different ways for fresh or frozen ice-cream distribution and consumption. Here we see a couple of trends and some potential for further developments:

• Moulded Wafer Cones and Wafer Cups
Starting from the Far East, during the past few years ice-cream cones & cups having a non-flat top entered the market. Nowadays baking moulds with fancy non-linear edges are possible to manufacture without any problems. So f.i. with blossom or leaf-type structures.

We see more and more attractive wafer cups and cones being really different from the standard ones - showing side walls with pronounced relief-type figures or non-symmetrical engravings.
Bigger-sized wafer bowls or cups as edible or biodegradable containers for food uses are just available in a few markets. For some of these products in my opinion still an increase in stability by modifying the ingredient list and the recipe might be necessary. But that is possible and will widen the range of application.

• Rolled Wafer Cones, Deep-drawn Wafer Bowls, Convenience Food Containers
With ice-cream-filled wafers the trend into miniaturizing food snacking items as in other areas (biscuits, confectionery) has not yet happened. Nowadays bit-sized cones or wafer sticks are manufacturable easily.
Or there are recipes for premium quality wafer cones not yet realized, maybe because of higher costs. An example: a rolled "chocolate sugar cone", tasting like chocolate.
Rolled sugar cones, being products of higher quality and price in the distribution of frozen yoghurts and fresh ice-cream are only partially offered as an alternative to standard moulded cake cones. There are many shapes, sizes, and even colours of rolled sugar cones possible, both "heart-shaped" or with flat tops.

A new development - non-sweet rolled cones and non-sweet deep-drawn bowls - has widened the application range of wafer containers. A potential use is in very stable "tortilla chip-like" cones & bowls from maize flour for a more convenient consumption of e. g. salads or ethno-food.

• Wafer Sticks (Wafer Tubes)
In that area newly developed tools for manufacturing one-side closed and inside-coated wafer tubes may open some chances for small, frozen ice-cream snacks.
Moreover we expect the much more homogeneous texture of wafer sticks, manufactured on newly available, non-gas but inductively heated baking equipment will be even better suitable for ice-cream filling.

• Cookie Cones, Pretzel Cones
Novelties as "American chocolate chip cookies" formed in a cone shape or other cones, formed from biscuit-type doughs fit well into a general trend, especially in USA, for stronger, harder-textured products.
Cookie cones or Cones from Pretzel dough are initially marketed in the US and could lead into an new generation of cones and cups - despite there are still some open technological questions as well as some need for a professional development of the idea.

REFERENCES

O.R. Fennema (1996): Water and Ice, in Food chemistry, 3rd Ed., p. 17-94, Marcel Dekker.
H. Levine, L. Slade (1990): Cryostabilization Technology, in V.R. Harwalkar, C.-Y. Ma (Eds:) Thermal Analysis of Foods, p. 221-305, Elsevier Applied Science.
K. Tiefenbacher (1998): Technology of rolled sugar cones, Haas customer information.

ABSTRACT

The review concentrates on the various types of wafers for ice cream. A special chapter deals with the question: How wafer cones stay crunchy? Here newer scientific approaches to water activity and moisture migration are presented. Moreover trends and development potential for wafer cones and cups in both areas, distribution of fresh and frozen ice cream are discussed.

Author: Dr. Karl Tiefenbacher,
Director of Research & Development,
Franz Haas Waffelmaschinen Industrie AG,
A-2100 Leobendorf,
Phone 0043 - 2262 - 600 260,
Fax 0043 - 2262 - 664 55,
E-Mail: kt@haaswaffel.at

Keywords
Wafer cones –
Wafer cups –
Crunchyness –
Frozen ice cream –
Fresh ice cream –
Trends