

MATERIALS IN PROGRESS

Innovations for Designers and Architects

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FOREWORD

Innovations in the materials we use have influenced the development of mankind since time immemorial. New materials are constantly triggering major changes in society, the environment and technology. Today, 70 % of all product innovations are attributed to new findings in materials science and a new generation of products is emerging that exploits new functionality made possible by materials research. At the same time, researchers are constantly extending the boundaries of what is feasible and creating materials that will have an important impact on our everyday lives. We are currently on the verge of major new technological advances that will have a disruptive effect on many sectors, whether mobility, consumption or energy supply. As such, material developments point the way forward in many different respects.

In industry, materials are needed that require far fewer resources than was the case 20 years ago, that can fulfil multiple functions, are lighter, thinner, denser and mechanically stronger and also support the potential of a digitalised world. Designers and architects, in turn, frequently deal with questions of sustainability and the impending scarcity of resources and are developing their own material solutions that are founded on bio-based recyclables or waste from other industries and can be fed back into material cycles when a product's life cycle comes to an end. In the process, approaches previously of limited applicability for industrial mass production are being rediscovered and revived through new processing techniques such as additive production. The artisanal know-how of old crafts techniques or knowledge of locally available plants or useful waste material that was previously passed down from generation to generation are experiencing a renaissance.

In recent years, designers have increasingly turned to developing their own material innovations to realise product ideas and production and disposal goals that they were not able to achieve using what was available on the market. This renewed focus on materials has given rise to a new field of activity for designers that in turn has spawned numerous new developments. In many cases, their work is several years ahead of application scenarios in industry and one can expect to see industry adopt some of the methods in the coming years. Achieving greater functionality with fewer means, lower CO₂ emissions in production and disposal, less waste and disposable plastics and more effective material cycles are goals that can help foster and positively influence important social trends and developments such as the transition to new modes of energy production and mobility, the digitalisation of our various living environments and the increasing urbanisation of society.

Finally, with this book we hope to provide you, the reader, with much inspiration and stimulation for new ideas of your own!

Diana Drewes and Sascha Peters

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THE NEW MINDFUL- NESS AND CONSCIOUS CONSUMPTION

For many people in the Western world, shopping is one of the most popular leisure activities. On average, every European owns some 10,000 belongings, and that number continues to rise. For economists, rising consumption is a positive trend: it strengthens the economy, creates jobs and increases social security contributions to the public purse. Ecologists, however, view this much more critically, especially in the context of the growing global population. After all, our planet is not growing with it. Natural resources such as water, soil, air and forests are finite, but these resources are part of every single product consumed. In addition, considerable energy is required for their production, use and ultimately for their disposal, too.

Concepts that help us grasp the complexity of these interrelationships such as the ecological footprint or the ecological rucksack, which express the consumption of resources in relation to the end product in kilograms, show us what has been a fact for more than 40 years: we consume more resources than the earth provides and emit more CO₂ than nature is able to decompose. The ecological footprint – the biologically productive area necessary to sustain our lifestyle – grows exponentially with population growth. Biological capacity, on the other hand, has improved only slightly despite technical advances. The consequences are well-known and omnipresent: soil and water pollution, drought, water scarcity and a loss of biodiversity. In Germany alone, every citizen consumes on average twice as many resources as he or she would be entitled to. This is a huge problem, for which solutions must be found.



Festival site with recyclable cardboard tents in England

Source: Papertent



In vitro bred balls of minced meat

Source: Memphis Meats

In Europe, a trend towards “meaningful consumption” is emerging, especially among younger generations with families. People are beginning to call into question status symbols such as a car of one’s own, or whether one needs a new car or a wardrobe well-stocked with the latest fashion. New concepts for sustainable ways of living instead focus on finding the right balance.

As with all new and innovative approaches towards living sustainably and responsibly, it entails that we reassess what we do for the sake of convenience. But it also requires overcoming bureaucratic hurdles, which in Europe are not insignificant. The various new initiatives that are emerging – the use of biodegradable packaging, the advent of burgers made of insects, a ban on plastic bags and disposable plastic articles, the rise in car-sharing or the use of individual reuseable cups – are also the product of the reform of food and hygiene regulations and innovations in parking space management regulations which local authorities, and in some cases the European Parliament, have implemented to pave the way towards a more sustainable way of life in Europe.



Animal proteins – breeding mealworms in 18 days
Source: LivinFarms

ALTERNATIVE NUTRITION CONCEPTS



Street food market in New York City
Source: Haute Innovation

In the last five decades, global meat production has quadrupled. Europeans now consume an annual average of 64 kg of meat per person each year. Researchers expect that rising prosperity in the densely populated emerging economies combined with the trend towards a “Western diet” will lead to a further increase in per capita meat consumption. Food technologists have been developing sustainable meat substitutes for several years, predominantly based on vegetable protein sources such as sweet lupins or algae, but also on more unusual animal protein sources such as insects or jellyfish. The objective is to avoid a one-sided diet that is low in nutrients. As technical advances are made and our understanding of the complex interrelationships of a variety of materials improves, disruptive methods (i.e. methods that may disrupt traditional production processes) such as meat cultivated in vitro (Latin: in glass) are offering increasingly viable solutions to the need for animal proteins. The laboratory cultivation of meat requires far fewer resources, reducing the need for agricultural land and water and, in the case of farmed beef in particular, potentially achieving a hundredfold reduction in climate-damaging methane emissions.



In vitro bred balls of minced meat

Source: Memphis Meats

IN VITRO MEAT

In early 2016, the US start-up Memphis Meats presented to the press a ball of minced meat costing almost 985 euros. What made it special was that it was not made of meat from a slaughtered animal but had been grown in a laboratory. Based on muscle cells from a living cow, it was cultivated on a collagen culture enriched with nutrients such as sugar, amino acids, minerals and vitamins with the addition of a growth serum from the blood of living bovine embryos. This biotechnological process is called tissue engineering and has already proven valuable in the breeding of skin transplants for burn victims in medicine. In contrast to plant cells, animal cells are much more difficult to cultivate. In addition to a sophisticated composition of nutrients and minerals, muscle cells also require weak but regular electrical stimulation to grow and form a thin layer. The membranes can then be minced and dyed with beetroot juice or saffron and enriched with fat. Critics point to the high cost of production and the ethically questionable nature of laboratory meat production: the extraction of the growth serum from the beating heart of an embryo often costs it its life. A new, more cost-effective and ethically justifiable alternative is the use of growth serums made from algae.

Insect burger by
Bugfoundation
Source: Bugfoundation GmbH



BUXBURGER

For more than two billion people around the world, insects are a normal part of their diet. Locusts, worms and crickets are particularly popular in Asia and Africa due to their high protein content and cost-effective production. In Germany, the last known entomophagic recipe, Maikäfersuppe (cockchafer soup), has all but disappeared despite being very popular until the middle of the 20th century. But insects are increasingly making their way back into the European cuisine as a source of protein. The numerous start-ups that are emerging, for example the Bugfoundation or SWARM Protein in Germany or Fazer in Finland, do not, in contrast to other cultures, use recognisable insects for their food creations but instead prefer to use the pulverised product. Insect flour can be used in many ways, for example for baked goods, pasta dough, energy bars or burger patties. As early as 2013, the UN Food and Agriculture Organisation (FAO) drew attention to the advantages of insect-based nutrition. In contrast to livestock such as cows, pigs or chickens, insect production consumes only a fraction of water, land and feed. The rapid growth and uncomplicated raising of cold-blooded animals or ectotherms likewise result in lower greenhouse gas emissions. Ectotherms, unlike poikilotherms, do not need to ingest so much food to acquire energy. A further advantage is the higher percentage of edible insect mass – about 80 % – compared with that of cows, where the proportion is only around 40 %. Insects are also a healthier alternative to conventional meat from a nutritional point of view. Crickets, for example, are considered to be particularly high in protein and rich in healthy fatty acids and minerals. Nutritionists note, however, that people with crustacean allergies should also be careful with insect consumption.



Crawling protein bomb –
insects are the superfood of
the future

Source: LivinFarms



Mealworm breeding box for
the home kitchen

Source: LivinFarms

The Austrian industrial designer Katharina Unger has launched the first miniature breeding farm for food insects. Her product “The Hive” provides the optimal conditions to breed mealworms within 18 days in one’s own kitchen without requiring a lot of space or energy. The latest model is not only attractive and space-saving in its design, but also provides accompanying information for the new mealworm breeder. It explains the advantages of the nutritional concept and provides a step-by-step guide to feeding the insects with organic waste such as vegetable skins and fruit peel, introducing younger consumers to the superfood of the future in a playful manner.



Jellyfish chips – a fishy snack from the sea

Source: Mie Thorborg Pedersen/
University of Southern Denmark

JELLYFISH CHIPS

Danish gastrophysicist Mie Thorborg Pedersen has discovered a potential food source for the future in the form of the jellyfish that live around the Danish coast. The particular species of jellyfish is non-toxic and very easy to catch, but rather than landing on a plate, as they might in China, the slithery jellyfish are processed into crunchy crisps. To extract the water from this unusual seafood, the scientist developed a customised dehydration process. To break down the water-storing collagen that gives the jellyfish its form, it is soaked in alcohol for approximately 48 hours. The alcoholic bath gives the jellyfish a more solid, rubbery consistency and causes its transparent colour to become milky. To achieve a satisfying crunchiness, the alcohol is then evaporated in a commercial drying oven. According to the young researcher, jellyfish crisps melt almost instantaneously in the mouth leaving behind a slightly salty aftertaste.

SWEET LUPINS

Scientists at the Fraunhofer Institute in Freising have been working for several years on future plant-based alternatives to traditional dairy products. Back in 2014, they were able to successfully produce yoghurt from the protein-rich seeds of domestic sweet lupins, once they had succeeded in developing a method to extract the unpleasantly bitter and grassy taste from the plant mass. Lupins are comparatively under-manding plants that will grow on nutrient-poor soils and are considered the European counterpart to soy plants. The scientists were also able to develop ice cream using a concentrate derived from the protein-rich plant. Andrea Hickisch, one of the scientists at the laboratory kitchen in Freising, has gone a step further and is currently endeavouring to make matured lupin products such as cheese, which is no easy task: in contrast to fresh produce such as yoghurt or cream cheese, mature cheese production requires the appropriate microorganisms to initiate a successful fermentation process and create the right structure.

Noodles made of cellulose
and konjac root

Source: Haute Innovation



Camembert made of almond
milk

Source: Haute Innovation

CAMEMBERT MADE OF NUTS

In addition to working with sweet lupins, Andrea Hickisch from the Fraunhofer Institute in Freising also sees great potential for developing food using nuts such as almonds, pistachios or cashew kernels to create dairy products from plant-based materials. Initial attempts to produce Camembert cheese from almonds appear promising. Ground almonds were first boiled in water at 90°C and after the nut-water mixture had cooled, the milky liquid was inoculated with edible moulds and acidifying agents to cultivate a taste that approaches that of an aromatic Camembert. Although not all testers were convinced by the initial round of taste tests, a first step has been made.

CELLULOSE NOODLES

A few years ago, the Japanese textile company Omikenshi Co. from Osaka surprised the market by expanding into the food industry. Now, in addition to their textiles, they sell extremely low-fat, cellulose-based noodles made of the same raw material they use for their textiles. To transform the cellulose material into an edible flour, the company developed its own production process that combines the cellulose with konjac root, which is similar to a sweet potato. The low-carbohydrate noodles are aimed not only at health-conscious Japanese consumers but also, for example, at the Chinese market, where increasing prosperity has brought with it an accompanying rise in obesity.



Baker's Butchery – from industrial bread overproduction to mealworm protein
Source: Lukas Keller

CONCEPTS FOR REDUCING FOOD WASTE

According to the Federal Ministry of Food and Agriculture, every German discarded an average of 55 kg of food in 2017. Of that a good 34 % was made up of fruit and vegetables, followed by cooked food leftovers with a share of 16 % and bread and bakery products amounting to 14 %. In recent years, more and more developers have found creative ways of addressing the problem and have developed strategies of their own to tackle the problem of food waste.

MEALWORM CHIPS



Baker's Butchery – chips made of stale bread and mealworms

Source: Lukas Keller

As part of the “reuse” semester project at Burg Giebichenstein in Halle, the designer Lukas Keller has developed an exciting concept for reusing stale bread from industrial bakeries. Entitled “Baker’s Butchery”, his concept combines the up-and-coming theme of insects as the protein source of the future with stale bread from large bakeries, which is often thrown away due to overproduction. Although insect breeding is far less demanding than cattle breeding, requiring less space and much less feed, it is important to keep the temperature at approximately 30 °C for efficient breeding. An obvious solution is to direct unused waste heat from the bakery to a nearby breeding house to provide the optimum growth conditions. The combination of crushed stale bread and mealworms is also a sensible idea: the chitin contained in the exoskeleton of the mealworms has a gelling and binding effect and lends the new chips the necessary stability. The first product by the designer is mealworm chips, which he coloured with beetroot juice.

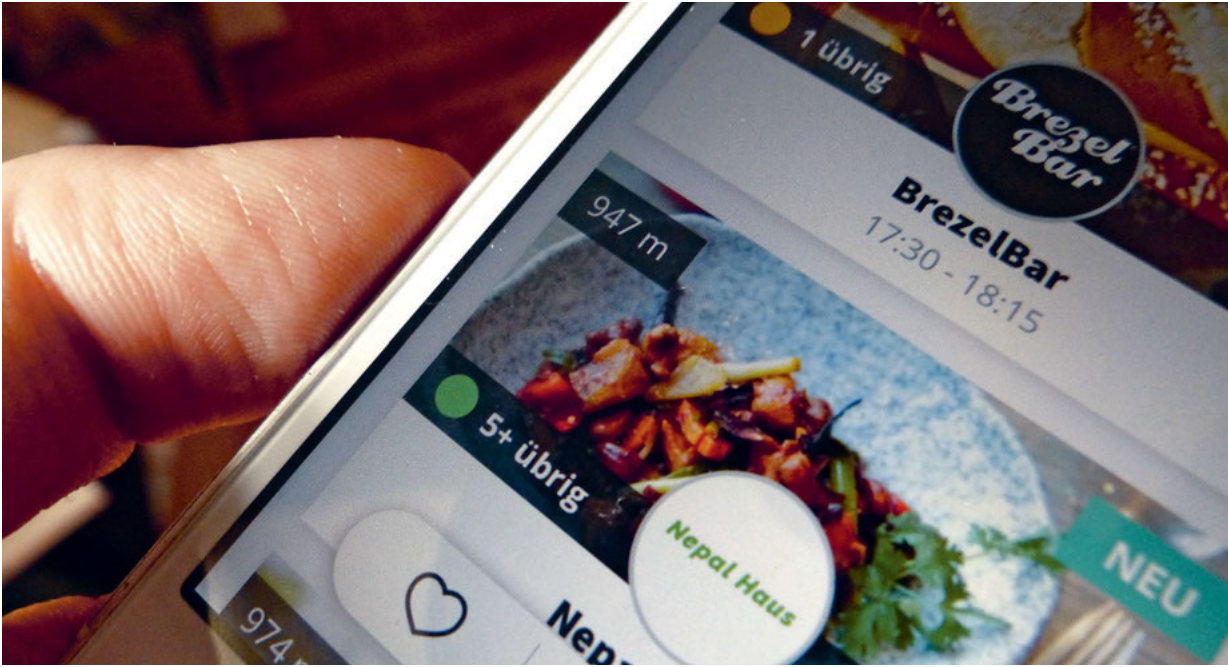


The fruit rescuers of Berlin –
a healthy snack made from
unsaleable fruit
Source: Dörrwerk



DÖRRWERK BERLIN

With his concept of the “Dörrwerk” factory, Zubin Farahani from Berlin has come up with a solution for the large amounts of food that many supermarkets and wholesalers in Germany throw away. Every day, huge amounts of apples, pineapples, mangos and other fruit are discarded because they either have small flaws or are overripe. In particular, tropical fruit that ripens faster is often disposed of, according to the young entrepreneur. But as brown stains or small dents have no influence on the taste of the sweet suppliers of vitamins, the fruit can still be processed. Farahani’s concept uses the traditional technique of drying to not only create a sustainable and healthy snack, but also save enormous amounts of fruit from disposal or the biogas plant. The dried, wafer-thin crisps made of fruit are sold online and in selected supermarkets under the name “Fruchtpapier”. The basis for each type of fruit paper is apple purée, which makes the fruit paper soft and tasty, to which a few drops of lemon juice and various types of fruit are added, depending on the desired flavour, before being spread in thin layers for the drying process.



App to avoid food waste

Source: Haute Innovation

“TOO GOOD TO GO” APP

The “Too Good to Go” app offers restaurants and cafés a digital platform through which to sell their remaining prepared food shortly before closing time. The idea recalls the sales tactics of market traders who sell off their remaining goods at dumping prices shortly before shutting in order to avoid the logistics and cost of disposing of them. Both retailers and consumers benefit. As it is usually impossible to say exactly how much will be left over, the quantities are given in so-called food boxes or portions and offered online at a greatly reduced fixed price. Using the app, customers can conveniently peruse nearby restaurants and their offers and buy portions online before arriving at the store to pick them up in a fixed time frame shortly before closing time. The only drawback with the service is the uncertainty: if the goods are indeed sold contrary to expectations, the journey was in vain and the money is refunded online. But for those who are flexible and open to surprises, it can be a ticket to very reasonably priced sushi, sandwiches or fresh salads and smoothies, and at the same time saves food from being thrown away.



Single-use tableware at a night market in Beijing

Source: Haute Innovation

REUSABLE RATHER THAN DISPOSABLE

After free plastic bags were successfully banned from supermarkets in numerous countries, the coffee-to-go cup has since become the symbol of the throwaway society in the Western world and is a common sight on the street. More and more end consumers are, however, beginning to change their ways and have started to use returnable or reusable cups in an effort to protect the environment, and sellers are increasingly rewarding them accordingly by reducing the price of takeaway hot drinks.



WEDUCER

The Berlin-based designer Julian Lechner has come up with several surprising creations. Using dried coffee grounds and a lignin-based binding agent, he not only makes espresso and cappuccino cups, but also a returnable cup with a screw-top lid: a positive example of how readily available urban waste material can be used to produce a waste-reducing product. All variants are available from his online shop.

Weducer Cup – a takeaway coffee cup made of coffee grounds

Source: Kaffeeform/Julian Lechner



Tavolina – a porcelain drinking bottle

Source: Peter Eichler/Saale-Land

TAVOLINA – A PORCELAIN DRINKING BOTTLE

The trend towards reusable receptacles is also making inroads into the market for water bottles. Designs for reusable bottles are just as varied as the materials they are made of, which include glass, stainless steel or plastic. Melamine bottles are particularly popular in Asia because they are unbreakable, light and inexpensive. However, even at temperatures as low as 70 °C, they can release melamine and formaldehyde into the beverage. The product designer Claudia Bischoff at Eschenbach Porzellan has presented an alternative drinking bottle that is pollutant-free, food-safe and above all robust. The bottle called TAVOLINA Aqua is made of hard porcelain and is dish-washer- and microwave-safe. The lid is made of thermoplastic elastomers (TPE) and polypropylene (PP) and is free of harmful bisphenol A (BPA).

WATER REFILLING STATIONS

Those who want to refill their water bottles free of charge can download a mobile phone app by the non-profit organisation Refill Deutschland. It shows a virtual map with all participating water refill points in the vicinity, which can be restaurants, cafés and drinking water fountains.



Compostable water bottle
made of algae gelatine
Source: Ari Jónsson

BIODEGRADABLE PACKAGING

Assuming that in future animal-based food will be produced outside cities and plant-based food on roofs or vertical gardens in urban conurbations, product groups such as packaging will play an increasingly important role in closing biological material cycles in cities. It is important in this context to clarify what biodegradability means: the industrial processing of organic waste is often mistakenly equated with decomposition via conventional composting.

ASPIC BOTTLES

The Icelandic product designer Ari Jónsson has developed a water bottle that rots within a few days of use. A mixture of agar-agar and water is brought to the boil to initiate the gelling process and then, once it has acquired a jelly-like consistency, the viscous material is poured into a mould. After cooling, a transparent shiny film forms on its surface. In physics, this phenomenon is known as syneresis: water is released from the surface of the gelled structure but does not weaken it. When the bottle is refilled with water, the film inside the bottle is retained, ensuring its continued stability. The outside, on the other hand, dries out after a while, and the material becomes brittle.



Compostable packaging
made of plant waste

Source: BIO-LUTIONS International AG

Compostable packaging
made from locally available
agricultural waste material

Source: Screenshot from the
YouTube-Video /BIO-LUTIONS -
Agricultural Waste to Biodegradable
Cartons & Tableware



COMPOSTABLE PACKAGING MADE FROM BANANA AND SUGAR CANE LEAVES

The Hamburg-based start-up Bio-Lutions shows how sustainable packaging can be. Its 100 % compostable packaging is made directly at the place of production in India from banana and sugar cane leaves, a waste product of the food-producing industry. Until now, the unused, dried leaves of sugar cane grass and harvested banana palms were simply burnt. The German company now purchases the former waste by-product from the farmers at fair prices and uses it to produce biodegradable cardboard packaging for fruit and vegetables in a local factory. Since the required binder is already present in the plant residues, all that is needed is the addition of water to produce stable packaging cardboard.



Biodegradable and pollutant-free packaging made of wood and a natural binder from Finland

Source: Sulapac

PACKED IN WOOD

The Finnish company Sulapac has launched an environmentally friendly alternative to conventional plastic packaging for cosmetics and other wood-based hygiene products using material from sustainably managed Nordic forests, which is readily available and free of harmful substances. The raw material is first shredded into wood chips and heated together with a binding agent. While the company has not revealed which binder is used, it is known that it protects the wood from burning. After heating, the mass can be shaped using conventional methods such as injection moulding. Its significantly lower CO₂ footprint and low price make it a serious contender for use in place of its petrochemical predecessors. The only disadvantage is its limited stability of approximately twelve months.



Edible takeaway tableware
at a market in Samarkand/
Uzbekistan

Source: Haute Innovation

EDIBLE PACKAGING

According to the latest statistics, Europeans produce on average about 31 kg of plastic packaging waste every year, a figure so alarming that the European Parliament has since passed a law banning disposable plastic tableware from 2020 onwards. In the Anthropocene age, in which man shapes his environment, this represents a significant attempt at living more responsibly for the benefit of future generations. Ideas for edible packaging as a potential replacement of conventional packaging have so far ranged from the good old ice-cream waffle cones to edible straws made of sugar. The newest developments go a step further and only use raw materials that do not compete directly with the traditional food-producing industry.



Water-soluble food-pack-
aging material based on
algae

Source: EVOWARE

ALGAE PACKAGING

According to EVOWARE, the packaging of the future is floating in the sea. The Indonesian company has developed compostable and edible packaging based on algae for dry products such as pasta, spices and even burgers. The packaging has no flavour, is free of preservatives and can last up to two years in a cool and dry environment. It can easily be dissolved in warm water and can even be eaten.



Edible mouthful of water to avoid waste at big events

Source: Ohoo



OHOO

In late 2015, one of the most unusual water bottles in the world was launched, causing a small sensation in the media. Looking much like a soap bubble filled with water, it is soft and completely edible. The media are already heralding it as the bottle of the future. Although countries like Germany have long attempted to minimise everyday plastic waste by introducing a bottle deposit, 46% of all beverage bottles are still disposable bottles. Irrespective of whether the bottle is truly practical for everyday use, the edible packaging made of water, alginate and calcium could massively reduce the waste problem at large events such as concerts, festivals and sporting events. The chemical structure of alginate is similar to that of plant starch and is also used as a thickening agent in the food industry. It is classed as a long-chain molecule or polymer, which, in conjunction with calcium ions, cross-links to form a three-dimensional sponge network that can absorb water. The natural reaction of both components has been known for years in the field of molecular cuisine as “spherification” and is used to encapsulate liquids. Liquids enriched with sodium alginate are dripped into a salt solution and, due to the calcium ions they contain, form an edible gel shell within a few minutes that is similar to the skin of a grape. The edible water drops can be stored in clear water until ready to be consumed.

Spoontainable – a sustainable, edible ice-cream spoon
Source: Spoontainable



VEGAN ICE-CREAM SPOON WITHOUT SUGAR

A group of young students from near Stuttgart have found inspiration in the waste bins of the food-processing industry. Using discarded fruit peel, they have developed an edible ice-cream spoon, which they are already selling under the name of “Spoontainable” and is even available in various flavours such as chocolate, vanilla or strawberry. The primary component of the edible spoon is dried plant fibres from fruit peel, ground into a flour and then pressed into shape using a process much like baking biscuits. Their creation has met with great interest and the first contracts with local ice-cream shops are due to be signed in early 2019.