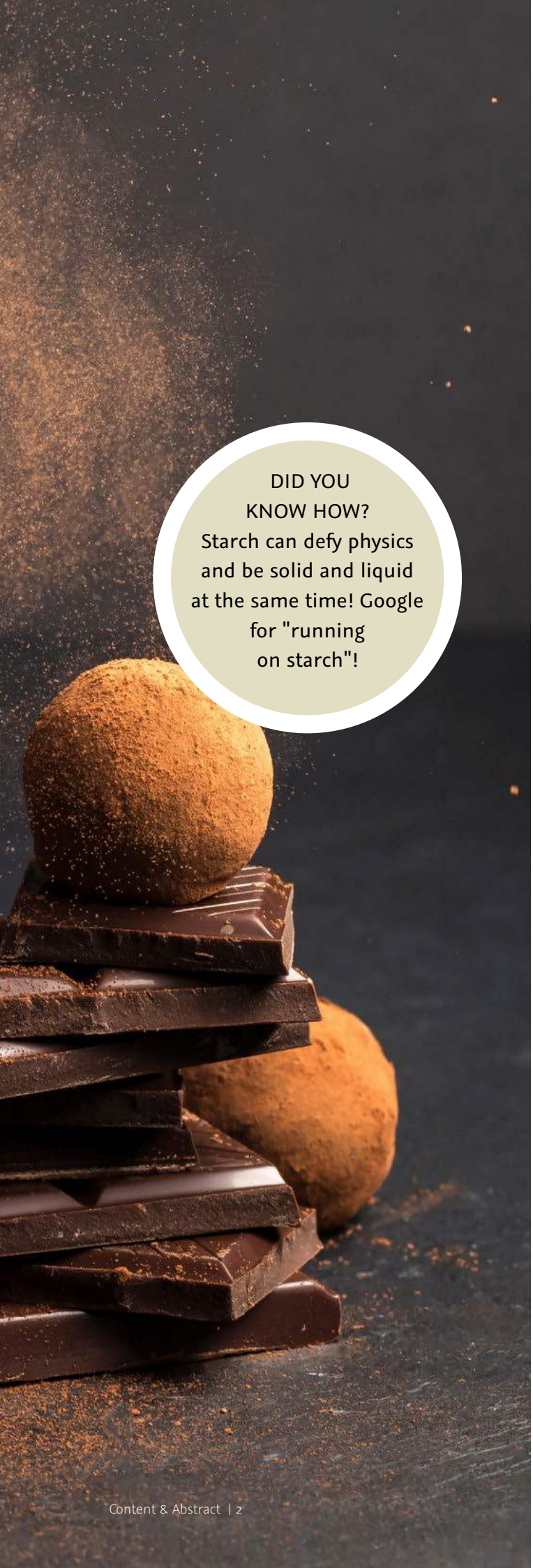
THE HIDDEN • **SUPER POWER**

WHY ORGANIC STARCHES ARE KEY TO INNOVATION.
YOUR CHECKLIST FOR SUCCESSFUL PRODUCT DEVELOPMENT.

MARROQUIN ORGANIC INTERNATIONAL
MEMBER OF THE AGRANA GROUP



CONTENT

AT A GLANCE

Consumers' expectations in food which they buy in the supermarket or enjoy out of home are constantly rising. Modern foods must meet a variety of requirements: for taste and nutritional value, for clean labeling that is consistent with healthy eating, sustainable lifestyles and cultural traditions. At the same time, the food must look appealing and appetizing, offering a holistic consumption experience. However, consumers value a short list of ingredients that identifies the product as natural and not highly processed, so called clean label products.

The hidden champion in this game is starch. As simple as this may sound, deploying starch in formulations and processes to achieve the perfect result can be complex. The more requirements need to be met, the more knowledge and experience in formulation and processing will be necessary.

In this paper, you will learn in detail about properties of different starches and thereby better assess how starch can support you in your next product innovation. You will find a checklist as well to help you prepare the right choice in starches to achieve the best result for the selected taste of your consumers.

1 WHY ORGANIC CLEAN LABEL STARCHES ARE YOUR KEY TO INNOVATION

You are a food manufacturer? If so, you are most likely continuously looking for innovative and new product formulations meeting the high demands of your consumers, supporting a healthy and sustainable lifestyle and remaining affordable for all. Did we guess right?

HIGH EXPECTATIONS IN TASTE AND TEXTURE

Consumers' expectations in food which they buy in the supermarket or enjoy out of home are constantly rising. We are increasingly trying to avoid artificial ingredients in foods and beverages, while at the same time expecting an appealing, appetizing texture. A survey of consumers in the USA by Mintel clearly shows that the overall eating experience plays an extremely important role. When asked which attributes play an important role when purchasing ice cream and frozen treats, 72 percent of the consumers surveyed in the U.S. said "taste," of course. However, the second most important factor is texture (eg creamy or crunchy), which 43 percent of respondents agreed to.

Texture is actually a powerful trigger for consumers: 34 percent of US consumers agree that new textures like crunchy or smooth would encourage them to try a new frozen treat product. Texture is probably a property that is still largely underestimated as a quality characteristic, because it makes a significant contribution to the taste sensation or also the flavor release in a food.

According to Mintel, textures, in addition to delivering desirable eating experiences, may have a role to play in delivering the public health agenda. It is becoming increasingly important for food producers to consider health, as well as sensory appeal, when developing food and drink products.

Health and dietary claims are expected to continue to be of high demand in the short term, states Euromonitor in its analysis on clean labels. Food safety and authenticity also come to the fore in this context: The perception of clean label is expected to expand to also include upstream production processes as well as transparency of food sources. According to Euromonitor, consumers are not only satisfied with labels that claim to be absent of certain ingredients, but seek to gain insight into and approve the entire supply chain process before they accept claims of “natural” to be authentic.

ROOM FOR PLANT-BASED INNOVATION

A wide playing field for clean label and texture is the area of plant-based and meat alternatives. Native and modified starches play a major role in this area having a water-binding and flavoring effect and impart meat-like texture. According to an evaluation by Mintel GNPD, the use of native starches in new meat substitutes has increased from 28 to 35 percent in the past five years. High-quality potato starch in particular is increasingly in the focus of interest: 14 percent of new products contain native potato starch, and corn starch showing a similarly high prevalence. Wheat starch is comparatively stable and is used as an ingredient in eight percent of new products.

LETS TALK ABOUT STARCH

How can you meet these market demands and shorten the time-to-market of a new product? The hidden champion in this game is organic starch. As simple as this may sound, starch is an ingredient that has many qualities and gives the final product the desired properties. Intensive knowledge in starch and experience in its processing are required to achieve the desired results..

Certainly the best-known sources of starch are corn, potato and wheat. Starch is mainly used in the bakery, dairy, ice cream, fruit preparation and confectionery industries as well as meat, sausages, meat alternatives, infant nutrition, soups and sauces. In addition, modified starch is regarded as an important binding and carrier agent, which is used, for example, to thicken food and used for pasta, bread, baked goods or thickening agents. There is a huge field of applications where organic starches bring an added value and additionally align with health related and sustainable lifestyle goals of consumers.

To understand the behavior of starch in different food manufacturing processes, it is helpful to have a deeper look in starches and their molecular structure. Let the following pages guide you step by step into the microscopic world of starch granules and inspire you for your next product innovation.

2 NATIVE BEAUTIES - MAIZE, POTATO AND WHEAT STARCHES

Let's approach the subject step by step and take this opportunity to look through the electron microscope. Starch basically consists of individual molecules, which is nothing else than glucose. The individual molecules can be organized in different ways - either linear or branched. Linear, non-branched molecules strung in a spiral are called amylose. In the case of branched molecules, they are called amylopectin.

Any native starch from common raw materials like corn, potato and wheat consists of both types of molecules, but amylopectin is the larger building block. Depending on the starch source, amylose accounts for approximately only one-third of the molecules.

An exception is starches derived from so-called waxy varieties. Starches e.g. from waxy corn consist of more than 99 percent branched molecules, i.e. amylopectin.

Now imagine that these molecules join together like chains and form larger units, clusters. And many of these clusters, shown schematically on the far right in figure 2, in turn join together to form starch granules which is what you are able to see in the electron microscope.

The starch granule itself is between 1 and 100 micrometers (µm), or 0.001 millimeters, in size and is ring-shaped in cross-section (see figure 1). Each ring represents an amorphous growth ring containing the semicrystalline regions.

Why is this important? Because the functional properties of starch, which we will examine in more detail below, depend largely on its molecular structure.

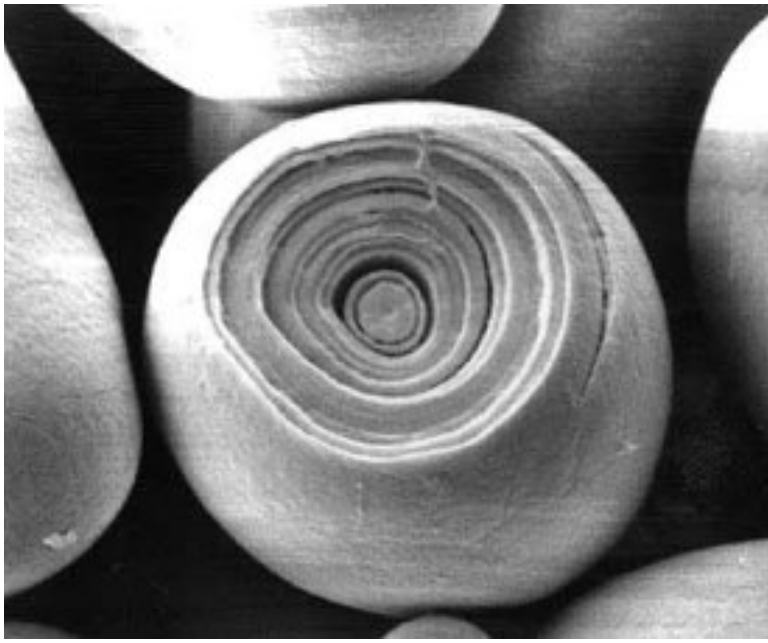


Figure 1: Starch granule with amorphous growth rings. Photo credit: Braukaiser

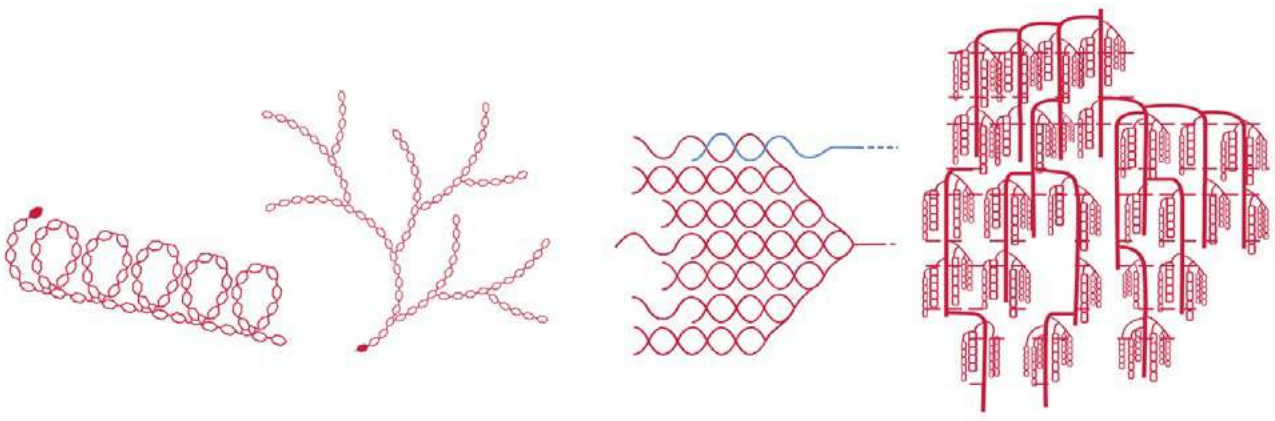


Figure 2: Molecular Structure of Starches. Source: AGRANA Research & Innovation Center

WHERE IS THE DIFFERENCE?

You may wonder if there are differences in how a starch granule looks like. Yes, there are indeed. The difference lies in which raw material the starch is derived from. In this paper, we look at starches from the three most widely used sources: maize, potato and wheat. In the Asian region, rice starch and tapioca starch are also widely used and processed.

The difference is clearly visible under the microscope. As you can easily see in figure 3, potato shows large, oval starch particles, while wheat shows roundish grains, but quite inhomogeneous in size: there is a mix of larger and smaller grains. Maize shows a very typical structure: it forms hexagonal granules.

If you may wonder if size matters: well, starch granule size is supposed to not have a strong effect on the properties of cooked starch. It is, however, believed to be a contributing factor in how rapidly a starch gelatinizes and its gelatinization temperature.

From our experience, we are convinced that larger granule size improve texture sensation for example in biscuits. This is the reason why, during wheat starch production, AGRANA isolates larger granules from smaller ones to achieve pure, best quality organic native starch.

Speaking of quality: Starch granules show the typical so called “polarization cross” under polarized light. You can clearly see the cross in figure 3 below. This is an unmistakable sign that grain is untreated and intact, neither overheated nor damaged, which is an important quality parameter.

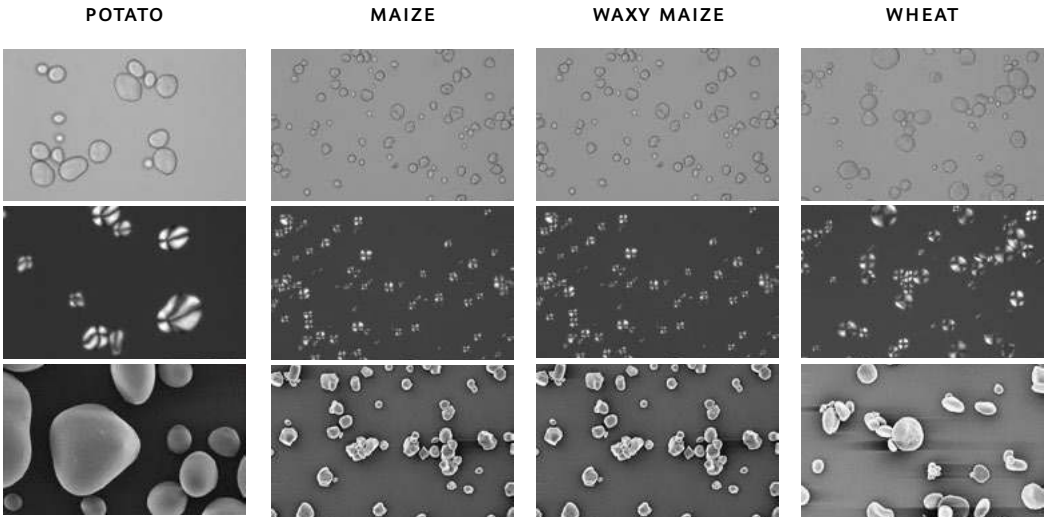
One more word about starches from raw materials other than those shown here. There are of course established raw materials such as pea or rice. These often do have extraordinary small starch granules and therefore an overall much larger surface area, or - in the case of pea - fine cracks onto the surface. Those properties make it more challenging to achieve expected purity.

However, with the conventional raw materials of maize, potato and wheat, we achieve good separation and thus a low protein content and, as a result, very white color and no off-note (neutral in taste and color).

A RISING STAR

Especially the potato starch stands out positively in this context: starch granules are relatively large and potato as a crop contains a very limited amount of fat (lipids). The separation of protein is a long and well established process. Therefore, potato starch is by far the purest starch and the rising star in the starch sky.

Before you read on, take a look at the "The world in a pudding" case study in the box. The experiment is simple and well-known, but it makes the behavior of native starch and the differences between native starches pictorial and understandable. If you like, pick up some pudding powder and stir away. In the following we compare native starches, their technical details can be found in the table under figure 3.



	POTATO	MAIZE	WAXY MAIZE	WHEAT
GRANULE SHAPE	elliptical	polyhedral	polyhedral	lens-shaped, polyhedral
GRAIN SIZE	15-100 µm	5-25 µm	5-25 µm	2-38 µm
AMYLOSE	23-27 %	26-31 %	< 1 %	27-31 %
GELATINISATION	58-65 °C	62-80 °C	63-72 °C	(52-) 85 °C
VISCOSITY	very high	medium high	low-medium	low
SWELLING CAPACITY	1150	24	64	21
PASTE TRANSPARENCY	clear	cloudy	little opaque	opaque
RETROGRADIATION	low-medium	high	very-low	high

Figure 3: Composition and properties of native starches. Source: AGRANA Research & Innovation Center

A little experiment

THE WORLD IN A PUDDING

Imagine you are mixing a pudding. Pudding is nothing more than corn starch with sugar and a flavoring component like vanilla or chocolate. You take cold milk, stir vigorously and observe that the starch powder disperses nicely and evenly in the milk.

Now if you leave this pudding milk like this, nothing will happen. The grains sink to the bottom, they do not dissolve and do not swell, the pudding does not become gelatinous. This is so-called native cooking starch, typically corn starch.

If you now stir and disperse the starch again and heat the milk, the starch grains absorb liquid above a certain temperature (see figure 6), viscosity sets in and the pudding magically becomes thick and creamy, just as we know and love it. Creation has a hand in this: Native starch naturally gelatinizes.

Now, when the mixture cools, the thick pudding becomes firmer in texture. When you turn it out of the mold, you have a gelatinous, perfectly formed pudding on your plate.

Now what happens if the pudding is not eaten? It will become firmer after approximately a week and it will lose some of the water. This is not a sign of poor quality and with home-cooked pudding no one will complain.

However, with pudding from the supermarket, this so-called syneresis is not desirable for aesthetic reasons. One would like to spoon an all-round homogeneous pudding after opening the package. And that is the moment when functional strengths come into play. But more on that later.

Pudding is made from granular, i.e. cook-up starches, which means it must be heated. There is a second classification of native starches, which dissolves in cold liquids. The are known as pre-gelatinized or instant starches. You know it from delicious dessert creams where the starch had been cooked up already upfront.

ORGANIC POTATO STARCH

Potato starch occupies a special position. As described above, it is by far the purest starch and has by far the highest viscosity. Therefore, potato starch performs more favorably in a cost-in-use. Furthermore, due to its neutral taste, high water absorption capacity, low fat content and absence of allergens, potato starch is a frequently requested starch product.

ORGANIC MAIZE STARCH

Maize starch is a so-called cook-up starch, such as any other starches. It must be brought to the boil so that its grains dissolve in the liquid and swell. This can be well illustrated using a pudding (see the info box "A little experiment"). Cooking starch by nature has the functionality of gelling – from creamy to gelatinous.

ORGANIC WAXY MAIZE STARCH

Waxy corn starch, however, looks the same on the outside as corn starch, but as described in the beginning it consists of pure amylopectin. When boiled, the difference between amylose and amylopectin becomes clearer: In a cold condition, waxy corn reacts in exactly the same way as corn starch: mixing easily but not swelling. When heated, however, the consistency of waxy corn does not become creamy, but rather long and a little slimy.

Unlike the standard maize starch the texture remains stable – due to its branched molecular structure it retains the shape which it takes after heating. Waxy corn is the most stable form and for this reason the ideal starting product for other functional starches. Deployed together in products and formulations they would perform better, which is especially critical for example in the ready-to-eat sector. Waxy corn is therefore rarely used on its own without beeing functionalized.

ORGANIC WHEAT STARCH

Wheat starch has the lowest viscosity in comparison. It is therefore primarily not used for stabilization in food, but focuses on providing structure. This is relevant in the area of bakery products, cookies and pasta.

3 THE UNIVERSE OF SUPER FUNCTIONAL STARCHES

Well, have you thought you have already read and understood a lot? Then we want to welcome you to the universe of functional starches! For your orientation, take a look at figure 4, where you can see a simple schematic overview of the classification of starches. To this point, we have covered only native starches. Now we will dive into functional starches. Depending on the degree of processing, starches are classified into:

- native starches and
- functional (native) starches

We have learned that native starches work properly in products, which are consumed directly after preparation or in special applications such as gluten-free bakery products. In simple words: products where no storage and process stability is needed (you can find the differences in figure 7). Within native starches you find two categories: Granular starches which have to be pre-cooked in order to develop their thickening properties. And pregelatinized instant starches are cold soluble and can work already by immersing into cold water.

However, the higher and more intensive the processing steps are up to a ready-to-eat product, the more complex the demands on the food product become. This is where functional starches come into play, helping to fulfill a wide range of functionalities. Typical functionalities of starches can be found in the info box.

For the sake of completeness, it must be said that you will find also chemically modified starches in the category of functional

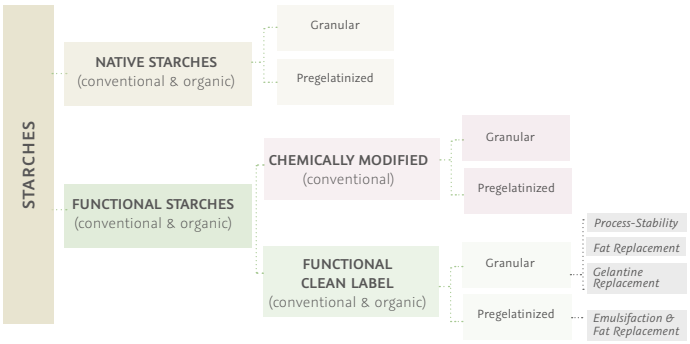


Figure 4: Classification of starches.

starches. Modified starches are conventional starches considered as food additive (E-number), due to their chemical modification process. They are highly functional starches, which are not available in organic quality and don't support clean label requirements.

Our organic clean label starches are alternatives to conventional functional and chemically modified starches. Due to pure physical not chemical treatment, clean label starches are able to perform similar to chemically modified starches (process stability, shelf life stability, texture profile) without applying any chemical process. Therefore, these kinds of functional star-

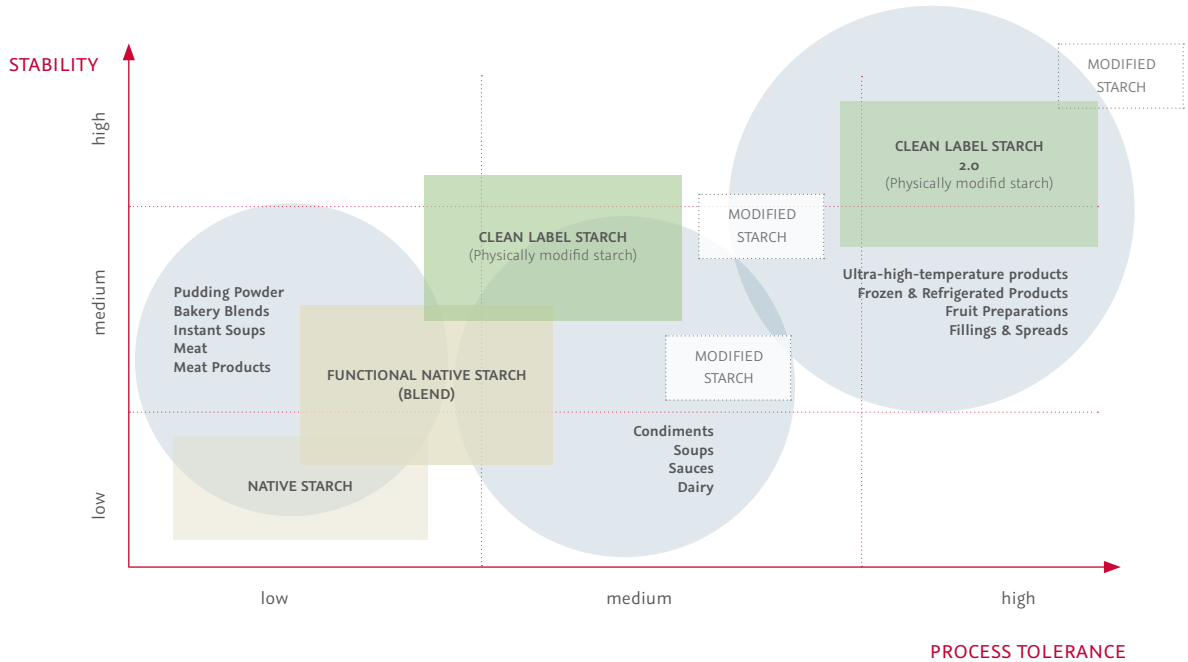
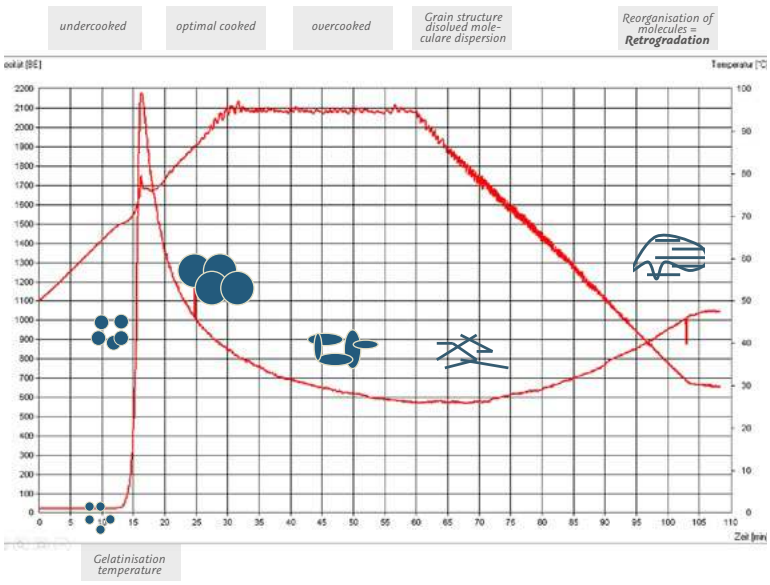
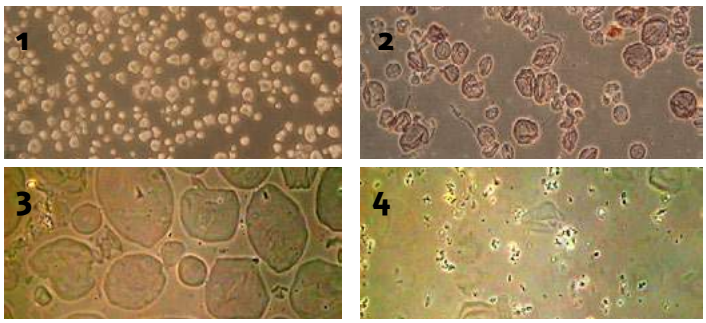


Figure 5: Functionality of starches.



Above: This is a schematic representation of the result when starch is not cooked optimally in the process. Only when the heating process is optimal can the desired properties be stably achieved. If starch is overcooked, syneresis occurs, i.e. it loses water. If it is undercooked, an additional sandy mouthfeel occurs.
Below: Native waxy maize starch through the electron microscope in (1) normal, (2) undercooked, (3) optimal cooked and (4) overcooked condition.



ches are being considered as food ingredients, not food additives (E-number) and are therefore perfect to meet the high expectations of consumers on clean label products.

The simplest way to induce functional tendencies is to logically combine native starches to take advantage of their benefits and balance the less desirable properties. Thus, the choice of starch depends on the necessary process tolerance and desired stability.

So how do I find the right starch for my next product innovation? At this point, expert knowledge is needed and a precise idea of the desired product properties and process conditions, e.g. acid, temperature and shear stress, osmotic properties, fat, sugar & water content, etc. Both process and formulation (recipe) are important, as starch – even in identical recipes – behaves differently when process conditions differ.

In the "Checklist" chapter, you will find guidance on the best questions to ask yourself in advance and how best to prepare for your exciting new formulation!

Figure 6: Principle of starch gelatinization.

	BENEFITS	APPLICATIONS	
NATIVE STARCHES	Natural & economical Creamy to long-lasting texture or gelling effect Universally applicable	Cooking pudding powder Tableting Dry blends / instant soups Bakery products	Instant preparation & consumption
CLEAN LABEL STARCHES	Process stability Shear stability Storage stability Texture from elastic to creamy and short No retrogradation No syneresis pH stable Temperature stable	Condiments & delicacies e.g. ketchup Fruit preparations Soups & sauces Puddings RTE Dressings Fillings & spreads Convenience Products Frozen & refrigerated products Dairy products	Process & Shelf life stability

Figure 7: Benefit matrix of native and clean label starches.

4 QUICK GUIDE TO SPECIALITIES

ORGANIC NATIVE STARCH:

POTATO STARCH **(STÄRKINA®)**	Bread & bakery products Meat & meat products Soups & sauces, gravy thickener Instant soups & dry mixes Grated cheese
MAIZE STARCH **(MAISITA®)**	Baking & pudding powder Molding starch
WAXY MAIZE STARCH **(MAISITA®)**	Convenience products Frozen food
WHEAT STARCH **(WEIZITA®)**	Bakery products Soups & sauces Candies & confectionaries Convenience products

ORGANIC PREGELATINIZED STARCH:

POTATO STARCH **(QUEMINA®)**	Gnocchi Convenience products
WHEAT STARCH **(QUEMINA®)**	Instant soups & sauces Sweet dessert creams Bakery blends
WAXY MAIZE STARCH **(QUEMINA®)**	Baby food Peanut coating

ORGANIC CLEAN LABEL STARCH:

MAIZE STARCH **(AGENAJEL®)**	Dairy products (esp. plant-based alternatives) Condiments & delicacies Soups & sauces Fillings & spreads
WAXY MAIZE STARCH **(AGENAJEL®)**	Condiments & delicacies Fruit preparations Soups & sauces Fillings & spreads Frozen & refrigerated products Dairy products
MAIZE STARCH **(QUEMLITE®)**	Convenience products Fat-reduced mayonnaise & dressings Baby food & adult nutrition

ORGANIC THIN-BOILING STARCH:

WAXY MAIZE STARCH **(AGENALITE®)**	Sweet spreads/nougat & coconut creams Savory spreads/processed cheese Meat & meat products, fish paste Ice cream
MAIZE STARCH **(AGENYDYN®)**	Jellies Spreadable cheese Cheese imitates Dairy products

5 SELECTED USE CASES

VEGAN CHOCOLATE CAKE

INGREDIENTS

Step 1

	[%]
PART A	
Drinking Water	9.88
Agenajel 21.357	3.60
PART B	
Soy Drink	28.56
Salt	1.28
Beet Sugar	3.21
PART C	
Organic Canola Oil	53.47

Step 2

	[%]
PART A	
Agenovum BIO 22.571	5.44
Wheat Flour W700	25.77
Baking Soda	1.15
Cocoa	4.55
PART B	
Beet Sugar	20.71
Vanilla Sugar	0.67
Vegan Mayonnaise	14.32
PART C	
Drinking Water	12.50
Soy Drink	14.89

PREPARATION

Step 1: Vegan Mayonnaise

Homogenize **PART A** and heat it to 176°F while stirring with 300 rpm. Stir for 10 min at 176°F, then cool down to 77°F. Add **PART B** and mix for 5 min with 1500 rpm. Then add **PART C** within 5 min while stirring. Continue stirring for 5 more minutes at 1500 rpm. Fill up the product under sterile conditions and store in a cold place (41°F).

Step 2: Vegan cake

Weigh out the ingredients of **PART A** and mix it. Then weigh out the ingredients of **PART B** (with the vegan mayonnaise prepared before) and homogenize well. Put **PART B** and **C** together and mix it well. Put **PART A** into the mixture and homogenize well. Fill it into a baking pan and bake it for 20-30 minutes at 356°F.

LIGHT RANCH DRESSING

INGREDIENTS

PART A	[%]
Olive Oil	14.96
QuemLite Bio	3.18
PART B	
Drinking Water	30.87
Organic Powdered Sugar	5.25
Table Salt	1.49
Egg Yolk	2.62
Vinegar (7,5% Acetic Acid)	2.80
Mustard	2.30

PART C	[%]
Yogurt	28.93
Lemon Juice	4.97
Dried Herbs	1.18
Garlic Powder	0.36
Onion Powder	0.81
Table Salt	0.09
Pepper	0.18

PREPARATION

Disperse the QuemLite Bio in the olive oil **(PART A)**. Weigh out the ingredients of **PART B** and homogenize this part. Weigh out the ingredients of **PART C** and homogenize it. Mix **PART A** into **PART B** (800 rpm) within 1 minute. Let the mixture swell for 1 minute. After swelling, mix the sauce at 800 rpm for 1 minute. Mix **Part C** into the sauce and stir at 1200 rpm for 1 minute. Stir the mixture under vacuum for 30 seconds and ladle off the product under sterile conditions. Store at 41°F.

PLANT-BASED QUESO DIP

INGREDIENTS

	[%]
Oat Milk	82.29
Coconut Oil	4.57
Organic Yeast Flakes	6.86
Agenajel 21.055	4.00
Table Salt	1.14
Onion Powder	0.68
Garlic Powder	0.18
Paprika Powder	0.05
Turmeric	0.23
Chili Powder	optional

PREPARATION

Weigh all ingredients into a pot and mix them well. Then, bring the mixture to boil while stirring gently. Keep stirring for 1 minute on medium heat until the dip thickens up.

6 CHECKLIST FOR YOUR NEXT PRODUCT DEVELOPMENT

We have learned that starches can perform a variety of functionalities and create many desirable product properties. Before you go into formulation or manufacturing process development, take a moment to be clear about the intended goals and desired properties which your new product or starch in your new product developement should fulfill.

From these findings, also derive the objectives that the ingredient list must meet. First read through the list of objectives below (without claiming to be complete) and then fill out the checklist. With this briefing in hand, a starch technologist can advise you perfectly on how best and most efficiently to develop the product!

INTENDED GOALS FOR USAGE OF STARCH

- **Stability**
- **Viscosity**
- **Water binding**
- **Oil binding**
- **Anti-caking**
- **Sugar reduction**
- **Bulking**
- **Carrier for flavors**
- **Tabletting Agent (to produce tablets in pharma)**
- **Increasing recipe efficiency**
- **Binding**
- **Fat reduction**
- **Nutritional source of carbs**
- **Film Forming & Coating**

Contact us for your product development:

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CHECKLIST

APPLICATION			
SUGAR CONTENT IN %			
SOLID CONTENT IN %			
PROCESS SEQUENCE			
MACHINERY USED			
PROCESS INTENSITY:			
PH VALUE	low	medium	high
SHEAR STRESS	low	medium	high
TEMPERATURE	low	medium	high
FORMULATION & INGREDIENTS			
INGREDIENTS ALREADY USED OR TRIED			
OPTIONS OF ADDING STARCH WITHIN THE PROCESS	disolve / disperse	dry blend	
	in watery phase	in oily phase	
	early in the process	late in the process	
LIMITATIONS & SPECIAL REQUIREMENTS	organic	non-GMO	lactose-free
	sugar-free	vegan	keto
	gluten-free	fructose-free	corn-free
	kosher	halal	others

PASSIONATE ABOUT
OUR INGREDIENTS

Starches
Fibers
Maltodextrins
Yeasts
Proteins
Glycerin
Oils
Dried Dairy

DRIVING ORGANIC INDUSTRY

Marroquin Organic International has the only organic potato fiber on the market worldwide and helps you innovate keto products easily. We are proud to have contributed to the dynamic evolution of the organic industry for nearly three decades. We provide our customers in the food, beverage, nutrac eutical, pet, and cosmetic industries with a reliable supply chain for the quality organic and non-GMO ingredients they need to innovate and grow.

As a part of the AGRANA group, a pio-neer in the production of organic and non-GMO starches and starch products, we are able to leverage our knowledge and support our customers even more on their organic journey. Let us show you how we can make a difference together.

INTERESTED IN ORGANIC? PLEASE CONTACT US!

In the US:
Marroquin Organic International
303 Potrero St., Suite 18
Santa Cruz, CA 95060 USA
info@marroquin-organics.com

Global Headquarters:
AGRANA Stärke GmbH
Conrathstr. 7
3950 Gmünd, AUSTRIA
starch.us@agrana.com

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