White paper

Whole soya beverages

A new commercial production method

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www.tetrapak.com

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INTRODUCTION

Who is this white paper for?

This white paper is primarily aimed at current soya beverage producers, other producers or co-packers of plant-based beverages, and integrators serving the beverage industry. In general, this industry is thirsty for innovation and new products that meet growing consumer demands for nutritious plant-based products, at the same time meeting ambitious sustainability goals that cut waste.

It will also be of interest to dairy producers who are interested in developing a portfolio of soya-based products, or start-ups looking for new possibilities and product segments.

The intended audience includes marketing specialists, product owners, product research & development, production managers, heads of technical operations, procurement managers and CEOs.

What's the opportunity?

This white paper describes an emerging new opportunity in soya beverages – whole soya – a full-fibre product that is healthy, nutritious and has a delightful new taste. At the same time, it is likely to contribute to your sustainability targets because it can use 100% of the bean, and thus doesn't generate waste or by-products. In other words, a new product with global appeal. And it might fit your business.

SOYA OPPORTUNITIES

Plant-based beverages on the rise – and soya is a big part of it

Plant-based beverages are booming in American and European markets, with a positioning as an alternative to dairy products. In some markets – where permitted – they even use product names like coconut milk or soya milk. This is not advised, however, as the word "milk" is often legally restricted to bovine milk or dairy milk. We will refer to them as "drinks" or "beverages" here. Consumers are pursuing balanced diets, and plant-based beverages are replacing white dairy milk within a wide product range. This includes derivative products of dairy milk, such as yoghurt, and exploration of new ingredients and supplements. This is coupled to a change in consumer attitude – plant-based beverages are perceived as trendy and eco-friendly.

The Asia-Pacific region is quite simply different, due to its longer history with plant-based drinks. In fact, they are a traditional category in that region and are not perceived as a substitution for dairy. And while traditional plant-based products may be facing challenges, new plant-based products are emerging strongly. There are multiple factors driving the growth of plant-based beverages in this region:

- Lactose intolerance: it is estimated that over 80% of Asians have an impaired ability to digest lactose.
- Rising proportion of elderly population
- Younger generation's growing preference for trendy Westernized products
- Rising trend of healthier lifestyles and adoption of veganism
- Food safety is among the top three environmental concerns in Asia

The whole soya advantage

There is a global interest in "full-fibre" products for health benefits and digestive health, and this has carried over to soya drink production, as full-fibre soya beverages can use 100% of the protein and other nutrients present (see Table 1). Its profile of high fibre, high protein and low calories meets a growing consumer trend.

As it utilizes a maximum of the food raw material, this also adds to its sustainability profile. Not generating waste or by-products is in the interest of the producers everywhere.

Table 1 *Nutritional comparison of whole bean soya, extracted soya, and white dairy milk*

Nutrients	100% whole bean	Extracted bean	White milk
Protein %	3.0	3.0	3.0
Fat %	1.8	1.8	3.5
Carbohydrates %	0.7	0.7	4.7
Fibre %	1.2	0.26	0
Kcal/100g)	134	134	263
Protein/Kcal %	2.2	2.2	1.1
Fibre/Kcal %	0.9	0.2	0

Using the whole bean in beverage processing brings with it a number of advantages:

- The most significant attribute is the high dietary fibre content in the bean itself (11.5g/100g). These fibres aid the workings of the intestinal tract, helping to relieve constipation and clear residual matter, which can in turn assist in the prevention of intestinal cancer.
- Okara retains a high proportion of the calcium in soya beans and about 40% of soya bean protein.
- Soya bean carbohydrate also contributes greatly to intestinal health. The abundant oligosaccharides contained in soya bean carbohydrates nourish the friendly bacteria in the gut.
- The greatest appeal of okara is its low cost and low calorie count.

Against this background, it's easy to see why a whole soya formulation could be appreciated, particularly where soya is already extensively used, in Asia. There is no fibre removed. There are no added ingredients or stabilizers, so it is a clean-label product. If produced correctly, it has a pleasant taste and a creamy, smooth texture to the product. It also means there is less waste and more healthy nutrition in the product. It will reduce the cost of raw material and waste treatment.

A variety of soya beverages

In a highly differentiated marketplace with large regional differences, there are many types of soya beverages. In the following table, the top two sections represent high-value products that often command a premium price. The second section, high-fibre soya beverages is the focus of this white paper.

Table 2 *The soya beverage spectrum*

Type	Description
High solids or rich soya beverages	Made by water extraction from whole soyabeans, using a bean-to-water ratio of 1:5 (approx. 4% protein)
High-fibre soya beverage (whole beverage)	**A formulation where most or all dietary fibres from the soya bean are still present in the final beverage**
Dairy-like soya extract	The composition is similar to that of dairy products. The bean to water ratio is approximately 1:7 (protein content 3.5%). It is slightly sweetened, and oil and salt are added to similar properties to that of dairy milk
Barista soya beverages	Formulation includes specific stabilizer / emulsifier to ensure stability, good foam, pH of 7+, with low beany base, can be mildly flavoured with vanilla / milk / cream aroma
Lower solids soya beverages	Sweetened and flavoured drinks (approx. 1% protein) with a bean to water ratio of 1:20
Soya extract-based fruit juices or milk-like beverages	Mixtures of soya extract with fruit juice, other plant extracts or dairy milk

Whole soya is also a beverage or a base for other plant-based products like “-gurts” (non-dairy yoghurt-inspired foods), spreads, and ice cream. It utilizes the whole bean, no fibres are separated, hence the entire bean is digested, and no okara is present as a side product and made into cattle feed, biogas or waste.

In our perspective, a full-fibre soya beverage is a traditional product made by re-thinking the established production line concept, utilizing regular equipment in a new way. This yields a clean label advantage, and super shelf life stability without stabilizers or emulsifiers.

A BEAN FULL OF CHALLENGES

The soya bean was discovered about 5,000 years ago, and is believed to have been cultivated as a food crop in the New Stone Age in China. From there it spread by land and sea to other parts of Asia, and eventually in modern times to Europe.

But there is no single standard soya bean. There are currently many varieties grown under very different conditions around the globe, with varying rainfall, maturing at different times, and thus having different protein content and varying levels of critical enzymes. All of these variables may require a different approach to processing into beverages, depending on food processing traditions and consumer preferences.

Timing is critical for harvesting, which usually takes place in autumn when the seed has reached maturity, with 13-14% moisture content. Seeds with a moisture content over 13.5% must be dried to control microbial growth and prevent germination.

Because there are so many soya bean varieties, as well as quality variations, grading has economic significance, and also affects the final use of the seed. Most countries therefore have established systems for grading and trading to promote fairness in how markets use this commodity. As an example, **Table 3** shows the US standards.

Table 3. *US Standards for soya bean grading*

Colour	Light coloured cotyledon Light golden-yellow or clean white hull White hilium (the eye)
Protein Solubility	Nitrogen Solubility Index (NSI) of the bean must be above 85%
Protein Content	Soluble protein content is important, but not the total protein content
Moisture Content	10-12% is desired, but should not exeed 13% In excess of 14%, there is risk of enzyme activity leading to the oxidation of the fats
Season of Maturity	Fully ripened beans. Unripe beans may give a raw and bitter flavour Uniform sized beans
Age	Should not exceed 12 months. Prolonged storage may cause discolouring, lowered NSI, high viscosity and poor flavour

Besides quality variations, genotype differences can also result in agronomic characteristics (how well they grow under which conditions) and chemical composition (differences in oil and protein content, fatty acid composition, etc.).

There are two major types of soya beans, those that are food-grade and those primarily used to produce oil.

Of all legumes the soyabean has the highest protein content, about 40% of its dry matter. In addition, its oil (fat or lipid) content at about 20% is second only to that of the peanut (about 48%).

Table 4. *Comparison of nutritional components of plants, per 100g of product. Adapted from Queiroz Silva & Smetana, 2022 (Note: figures have been rounded off for easier comparison. The wide range of values is based on the varying quality of the raw materials, which may not all be commercial grade.)*

Plant source	Carbohydrates (g)	Fibres (g)	Fats (g)	Proteins (g)
Almond	2 – 27	8 – 14	42 – 67	14 – 29
Cashew	18 – 3	3 – 4	44 – 50	18 – 23
Coconut	10 – 20	2 – 4	28 – 62	3 – 8
Hazelnut	5 – 22	10 – 22	48 – 69	7 – 25
Hemp	9 – 38	4 – 38	25 – 49	20 – 32
Oat	60 – 72	2 – 18	5 – 8	8 – 17
Peanut	8 – 22	8 – 10	47 – 50	24 – 26
Quinoa	60 – 75	2 – 12	6 – 9	12 – 17
Rice	50 – 80	1 – 23	1 – 21	6 – 19
Sesame	11 – 24	6 – 12	50 – 61	18 – 20
Soya	**8 – 30**	**8 – 22**	**20 – 25**	**36 – 43**
Tiger nut	16 – 69	6 – 21	9 – 45	3 – 12
Walnut	3 – 23	5 – 10	40 – 67	15 – 22

Beany flavour

Traditional soya beverages have a residual soya bean flavour and aroma, plus a characteristic aftertaste. Many new soya beverage drinkers find this objectionable and frequently describe it as “beany” or “green”. However, we have ways of controlling or modifying this beany taste, and the process is the same for whole or dehulled soyabeans.

This characteristic flavour is caused by the hydroperoxidation of polyunsaturated fatty acids catalysed by an enzyme known as ***lipoxygenase.*** Lipoxygenase catalyses the hydroperoxidation of linoleic acid and other polyunsaturated lipids, a reaction that occurs in the presence of oxygen, resulting in hydroperoxides. This reaction produces many volatile compounds such as ketones, aldehydes and alcohols, many of which create undesirable flavours.

In a general sense, the beany flavour can be eliminated in two ways. The first is to breed soyabeans with less offensive qualities, and research is underway to create varieties with low linolenic acid content, and varieties lacking in lipoxygenase (also known as LOX null soyabeans). Both methods improve flavour stability in oil.

The second approach to minimizing the beany flavour is to handle it with special processing techniques, which is of course our main focus here.

In general, there are three ways of eliminating lipoxygenase in whole-bean soya beverage processing:

- Grinding whole beans in hot water
- Heating whole beans followed by grinding
- Blanching whole beans followed by grinding

However, the heat used to inactivate the lipoxygenase may also cause side effects, such as making soya proteins insoluble, losing protein functionality, or adding a cooked or toasted flavour. Correct processing parameters can avoid these issues.

DEFINING QUALITY FOR SOYA PRODUCTS

The key quality parameters for a full-fibre soya beverage are:

- Flavour
- Mouthfeel
- Product viscosity
- Product stability
- Nutritional value

Many producers have tried to achieve a whole soya beverage with full-fibre content from the whole bean, but have not succeeded. Many of the resulting products have a taste marked by bitterness, or a gritty or itchy mouthfeel. This is common with poorly produced plant-based products. It is important to understand how some of these quality characteristics are defined, and how they interact.

The importance of mouthfeel

One of the most important quality measures for beverages is “mouthfeel”. This is a highly subjective and complex quality measure. Mouthfeel consists of several building blocks such as viscosity, particle size, elastic properties, friction and lubrication. The importance of the different building blocks for the overall mouthfeel differs between products.

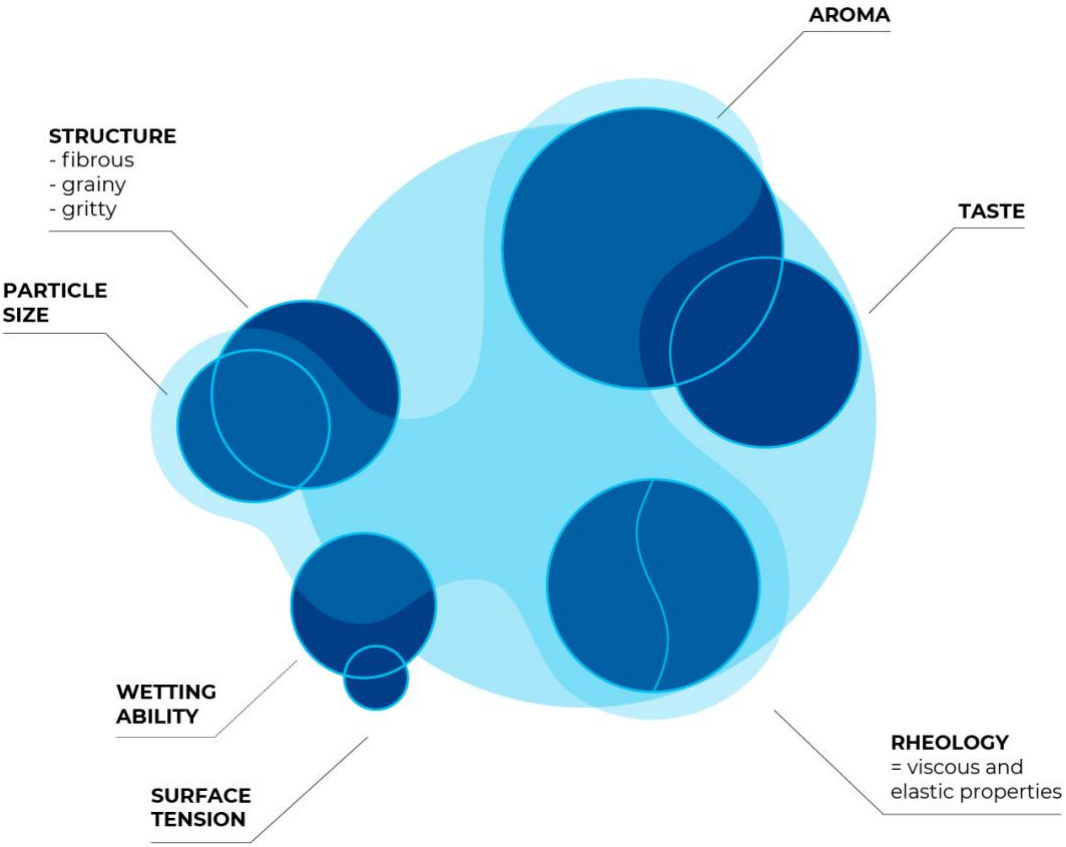

Figure 1. *Several building blocks that contribute to the mouthfeel perception*

Traditionally, and still most widely spread within the industry, is to evaluate mouthfeel in the human mouth, not with analytical instruments, but with a trained panel. Parts of the mouthfeel perception are fully possible to measure with an instrument, some are partly measurable and some are not possible to measure at all, as illustrated in **Figure 1.** The preference for a “good” product varies with age, cultural heritage and personal taste, but the mouthfeel can – with proper training of the panellists – be measured objectively, without mixing with personal preferences.

The taste and aroma sensations in the mouth are governed by principles quite different from those tactile sensations that govern texture perceptions. There are, however, interactions between taste, aroma and the mouthfeel building blocks that will disturb the sensory analysis.

It is known that the minimum particle size that the tongue can perceive depends upon the foodstuff. Changes in temperature will also affect mouthfeel. The particle size will be perceived differently in an ice cream (low temperature, ice particles) than a smoothie (room temperature, fibrous particles). Ice crystals in ice cream will be perceived by the tongue already at 20 µm, while starch granules will pass unnoticed at that size.

The human mouth can, under some conditions, detect particles down to 5 µm. The human mouth perceives a food with hard, irregularly shaped particles as gritty when the particles are only 10-20 µm, while products with soft, round particles are judged gritty at a larger particle diameter of 80 µm.

INNOVATION WITH CUSTOMERS AT OUR PRODUCT DEVELOPMENT CENTRES

Changing traditions in the East

Soya beverages, with or without the insoluble okara fibres present, have been consumed for over a thousand years in East and Southeast Asia, prepared in the home. These home-based techniques back in the day didn't remove the okara, but it eventually became more fashionable to remove the fibre by filtration.

On a commercial basis in modern times, it was judged to be better to remove okara in order to improve taste and mouthfeel, as we explained in the previous sections. Traditionally the extracted protein-rich okara was then used for animal feed, principally for the pork industry. But in recent years, as that industry in Asia has matured and become more nutritionally ambitious, they began rejecting okara as animal feed, because it was considered to be inefficient for their purposes.

This has left soya beverage producers with a problem, because if they can't sell off the extracted okara, they still have to use resources to handle it, and might have to pay to dispose of it. So the challenge then became:

> ***Can the industry produce a whole-fibre soya beverage that makes use of the high protein present in the okara, while improving taste and mouthfeel to appeal to a broad range of consumers?***

After all, this would fit in with ongoing global trends, where the high protein and fibre content of the okara are considered healthy. A whole soya beverage would be eagerly welcomed by both producers and consumers. And producers wouldn't have to lose money by throwing away 30% of the soya bean's protein content.

Repeated innovation

Given the widespread popularity of soya drinks in Asia, it is no mystery why Tetra Pak's Soya & Tea Centre (STC) has long been experimenting with soya formulations and processing techniques in the pilot plant in PDC Singapore, which has its own soya extraction system devoted to pilot studies and customer experiments.

As early as 2006, the STC ran experiments based on customer requests, using enzymes to break down fibres and reduce the particle size. At the time there were no mills or grinders available to further reduce particle size and produce an acceptable mouthfeel, and in the end, the customer decided not to proceed further.

When the STC received new customer requests in 2017 regarding whole-fibre soya, they reviewed their past trials and examined the technological development that had occurred with grinders over a ten-year period. They knew that significantly better particle size reduction was possible.

Over the course of two years, the STC ran trials in conjunction with Tetra Pak colleagues at the Shanghai PDC, as well as with the company's soya-savvy research and technology groups in Sweden, with access to the latest generation of mixing and homogenization technology.

In the first phase, they started with colloidal mills, or grinders, which used a special rotor-stator with double the usual cutting surface. Further experimentation added other milling (grinding) solutions that reduced particle size further, as well as a combination of grinding and homogenization. Further trials aimed at improving the taste of the products to understand the influence of processing on the mouth feel and taste, i.e. the beany taste – although acceptance of the beany profile differs from region to region.

The first customer was happy with the mouthfeel of whole soya produced this way, and accepted the line based on adding equipment components – grinders and homogenizers – supplemented by Tetra Pak's know-how regarding processing design and parameters.

Additional customers in Asia and beyond have been passionate about the new technology. They are now producing products that they can make healthy claims about, and promote a new creamy taste and texture. It's a premium product that commands higher prices in many markets.

Consumer reaction, as judged from market tests, has also been positive. It's perceived as a healthy drink, and many like the taste better than normal soya beverages.

There are currently several lines up and running around the world, including a number capable of producing beverages or product base without fibre separation. This includes one in China making "soygurt", a yoghurt-like product based on whole soya. Expressions of interest are coming in from every region on the globe.

In summary, we didn't invent a beverage – but we did invent a commercial production method that can be tuned and adjusted to many product requirements. In the rest of this white paper, we'll share some of the complexities of processing parameters and options that we have learned after hundreds of trials.

TRANSFORMING A BEVERAGE LINE FOR FULL-FIBRE SOYA BEVERAGES

In a traditional commercial soya beverage line, fibrous elements (the okara) are separated and removed during an early stage, after enzyme deactivation. In a whole soya beverage no fibre or other ingredients in the raw materials are removed. The focus instead is on reducing the particle size of the fibre, and carefully controlling the final texture and taste.

This means there is less waste and more healthy nutrition in the products. It will reduce the cost of raw material and waste treatment, and also bring a creamy and smooth texture to the product. It is a more sustainable way of making plant based beverage.

In this section we compare a traditional vs whole soya line, and outline the major steps involved in making the transition from one to the other. As shown in **Figure 2** one of the major differences begins by high-shear mixing – or grinding – along with further particle reduction provided by homogenization. But that's just part of the story, so let's look at it step by step.

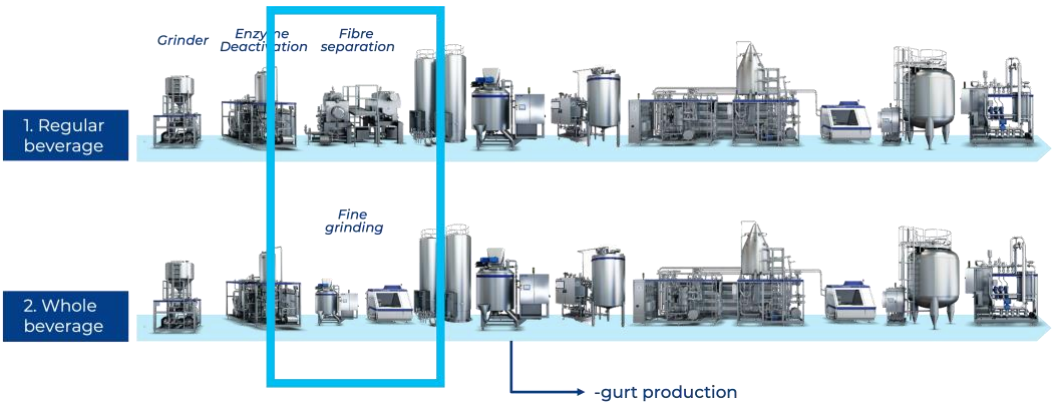

Figure 2. *Traditional vs whole soya beverage lines*

Soaking

Soyabeans are soaked by some producers to soften their cellular structure. The soyabeans are generally preheated at 40°C, dehulled, crushed into flakes and cooked in hot water starting at 50°C. After soaking, the soyabeans should weigh about 2.2 times their original weight. A wrinkled seed coat indicates oversoaking and possible fermenting and spoilage.

Tetra Pak does not recommend soaking as other equipment manufacturers do, because we have found that the protein yield and product quality are equally good without soaking, when using our equipment. This is why we do not show it in our process above.

Grinding

Even for regular soya products, it's important to have proper control over the grinding, so that you achieve an appropriately small particle size to facilitate the extraction of solids and nutrients to the clarified liquid soya extract. But, if the slurry is too coarse, the rate of extraction is reduced. Thus, smaller particles will increase yield, but will be more difficult to separate and can cause problems later in the process or even in the package.

Whole soya beverages – initial grinding is done with the same grinders as traditional beverages.

Trypsin inhibition/enzyme deactivation via heat treatment

Trypsin inhibitors are the substances that prevent trypsin enzymes in the human body from breaking down proteins and thus retard the absorption of proteins. To deactivate them, the clarified liquid soya extract is pumped into a steam injection system where it is heated to and maintained at a required temperature for deactivation. The temperature and time requirement are based on 85% deactivation of the trypsin inhibitors, which corresponds to the maximum protein efficiency ratio.

Heat treatment not only deactivates the trypsin inhibitors but also causes the formation of protein aggregates, which leads to an increased risk of precipitation and sedimentation. Increased pH due to deactivation also results in more aggregation, but these particles are looser and will break easily in the later homogenization stage.

Whole soya beverages – the process is the same.

Fibre separation

The liquid soya extract obtained from the grinding and extraction stage contains solids, which are collectively referred to as the sediment. Insoluble fibres – referred to as okara – are separated to avoid chalkiness and to achieve a good product stability. The okara contains all the cellulose but also much protein, and if it is separated or extracted, it is either considered waste or animal feed. Fibre separation can be made with a decanter or filter solution.

A rewash of okara can be applied to improve the protein recovery. The okara is mixed with water in a vessel from the first separation unit and the mix pumped to the second separation. The major advantage of this option is the possibility to increase the yield with an increase water-to-bean ratio and one often also gets a drier okara.

Whole soya beverages – a whole soya beverage does not need fibre separation. However, there may be a product quality benefit to first separate the fibres to okara, grind it and add it back, fully or partly, into the beverage. This additional grinding can be done in several ways, depending on customer preference and the desired level of quality:

- Using a high-shear mixer combined with a homogenizer
- The mixer could operate as a batch or inline process
- Using cavitation equipment.

Mixing/formulation of the product

The purpose of mixing is to disperse ingredients in the water so they:

- dissolve and hydrate raw materials
- form stable fat droplets/emulsions
- disperse small particles

Soya base is by nature a foamy product; precautions needs to be taken in the mixer to avoid foam. Vacuum in the mixer will do this and it will also decrease air content in the product. The lower air content will improve running times in UHT and reduce wear on the homogenizer. Less oxygen in the product will also increase shelf life.

Whole soya beverages – the mixing process is the same, but the ingredients may differ, for example, by requiring different stabilizers, or different amounts.

Heat treatment

After separation and final beverage blending, the product is heat treated in an ultra-high temperature (UHT) unit at a temperature of at least 137°C and minimum holding time of 4 seconds. Both steam injection and indirect heating are used in commercial production for soya beverages. The purpose of heat treatment is to make the food commercially sterile to secure food safety and shelf-life stability during ambient storage of the beverage. The microflora of soya is different from that of dairy milk, so the sterilization heat load for soya beverages is normally higher.

Whole soya beverages – the process is the same.

Deaeration

Deaeration is normally recommended to reduce oxygen level to get good quality product, reduce fouling and reduce foam in filling. Deaeration should take place before indirect heating; if direct heat is used instead, deaeration should take place after heat treatment.

Whole soya beverages – the process is the same, but depending on circumstances, there may be an increased need for deaeration, as larger fibres are prone to retain air.

Homogenization

Downstream homogenization is by far the most common arrangement to avoid “sandiness” in the product, which can come from aggregates that form during heat treatment. This means that the UHT should be configured such that the product is homogenized after the main heat treatment.

Whole soya beverages – homogenization pressure is normally higher than for traditional beverages, 400 – 600 bars, to break down particle size further. The main reason for this is to achieve a desirable mouthfeel.

Filling

After homogenization and final cooling, the product is sent to an aseptic tank for intermediate storage before it is packed. Shelf life is normally 6-12 months, depending on the type of packaging.

Whole soya beverages – the process is the same, with the same expected shelf life span of 6-12 months.

THE MAGIC IS IN PROCESS CONTROL

Whole soya drink is made with a new thinking of the established production line concept, utilizing existing equipment in a new way, and a careful choice of extra processing components.

As we have seen earlier, the key quality parameters for whole soya beverages are determined by a limited number of processing factors, which need to be carefully planned and controlled, as **Figure 3** shows:

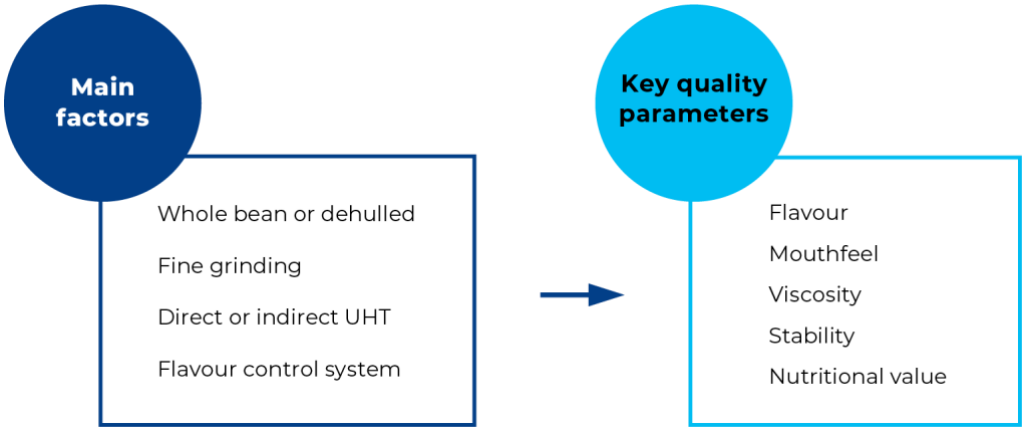

Figure 3. *Main processing factors determining quality of whole soya beverages*

It's easy to disconnect the decanter (or whatever fibre separation is used), but to x§grind the whole bean fibre content to the correct level for a good mouthfeel does not come easily.

We have run hundreds of experimental trials in our PDCs and other product centres in five countries, using a standard variety of soya beans sourced for trial comparison purposes from Canada. These trials allowed us to develop processing competence around controlling the final quality of the whole soya beverage, which we explain below with illustrative data showing the relationship between ingredient characteristics, processing parameters, and resulting quality.

Great taste with no waste from the soya ingredient

Both heat treatment and particle size reduction make huge differences in quality, but these steps need to be done in several carefully orchestrated steps, thorough grinding first and homogenization at the end, plus heating. For full-fibre soya beverage production, the particle size is the most important factor, as it affects all other quality parameters. This makes the settings of the fine grinders crucial for success. This demands a knowledge of both production processes and the perception of mouthfeel. And depending on the line configuration, there may be increases in energy consumption or machine parts wear and tear. (Since the soyabean seed coat is abrasive, it creates extra wear and tear on machine parts.)

We used modern grinding solutions to stay in control of the taste even when the full bean is utilized, creating no waste from the soya ingredient and still a great taste.

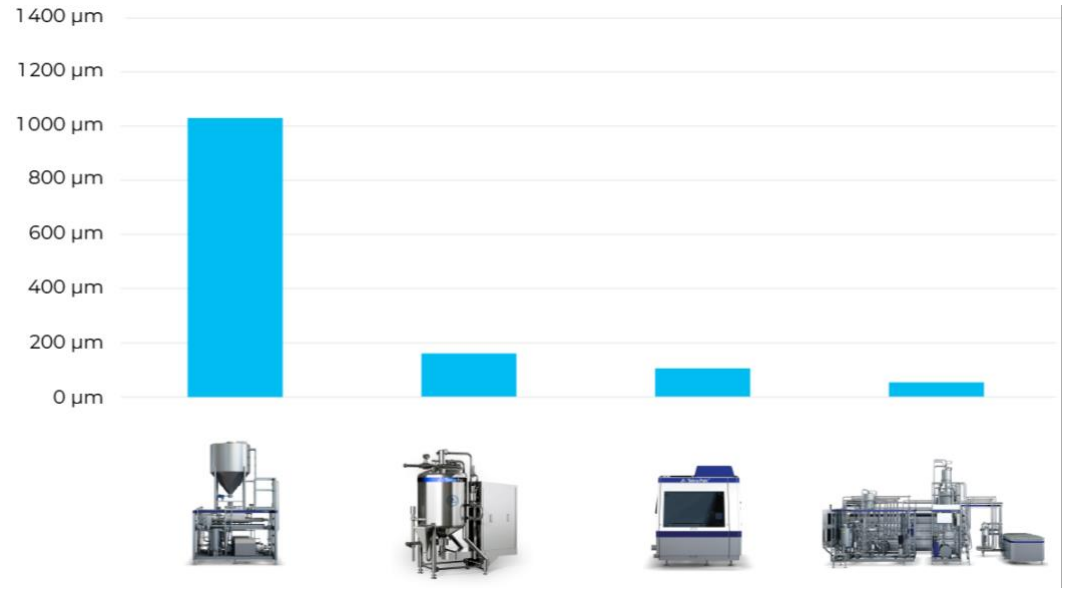

Figure 4. *Grinding combined with heat load to reduce particle size, step by step*

Figure 4 illustrates how particle size decreases with each unit operation in the line, moving from left to right. First the grinder, then the high-shear mixer, followed by the homogenizer, and then the final UHT heating unit (which includes the downstream homogenizer).

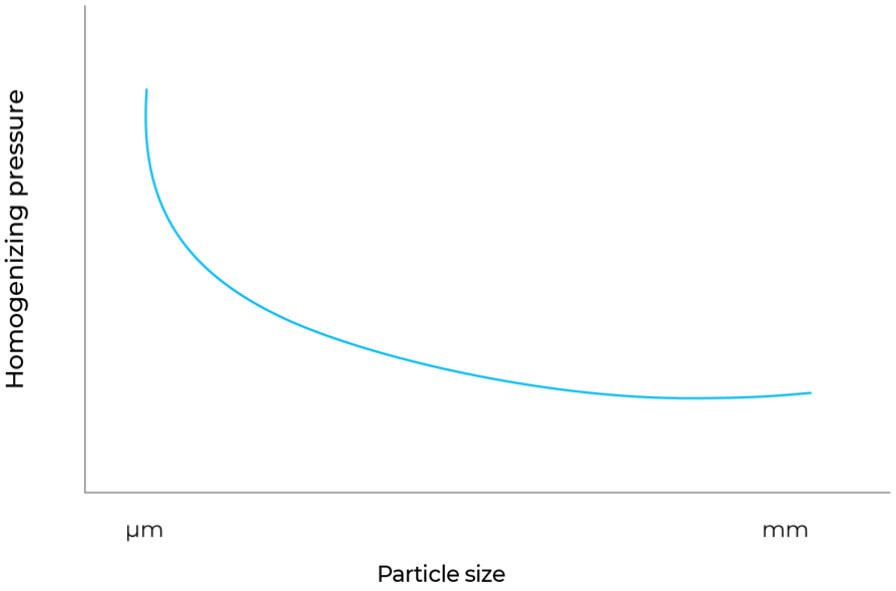

Figure 5. *Relationship of homogenizing pressure to particle size*

Figure 5 shows how homogenization pressure relates to particle size. As pressure increases, however, efficiency also decreases and the amount of particle reduction is reduced for the same pressure differential. In other words, as you increase the pressure, you get less payoff in terms of particle reduction. So finding that inflection point, where the graph turns upward, will provide the balance between particle breakdown efficiency and energy consumption. This inflection point will vary from one formulation to another.

Stability without stabilizers

Many of our trials were able to confirm that a stable product is achieved despite having 100% of the bean fibre present, and without any added stabilizers. We are currently investigating the limits of this stability.

How particle size affects quality characteristics

The following graphs show how particle size in the product affects certain perceived quality characteristics, based upon experimental trials in our laboratories.

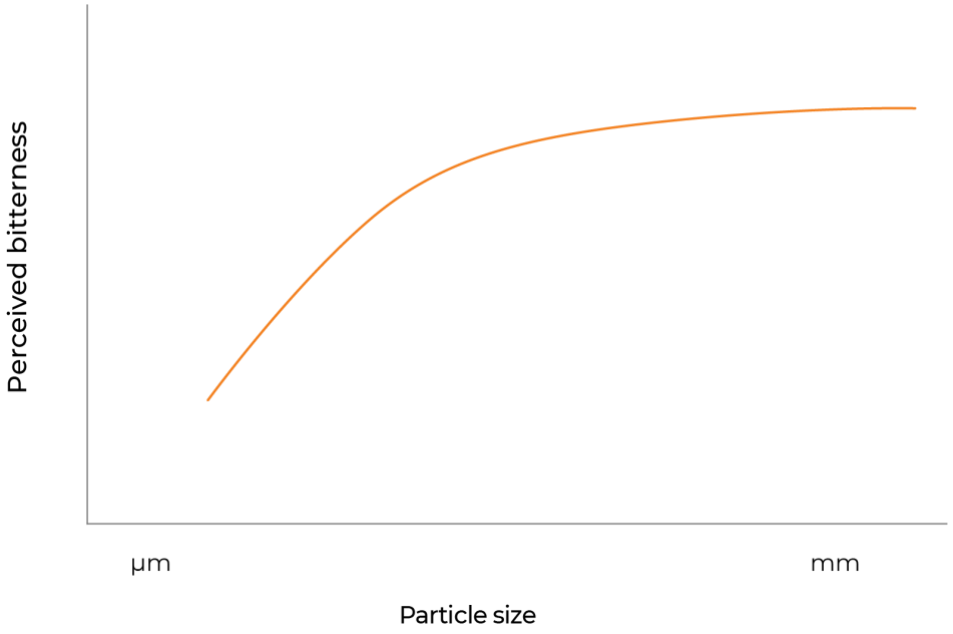

Figure 6. *Relationship of particle size to perception of bitterness*

Our trial runs have also revealed that smaller particle sizes contribute greatly to a reduction of bitterness in taste perception tests, as shown in **Figure 6**. Finding the inflection point that matches desirable product characteristics leads to more efficient design of the homogenization and grinding steps.

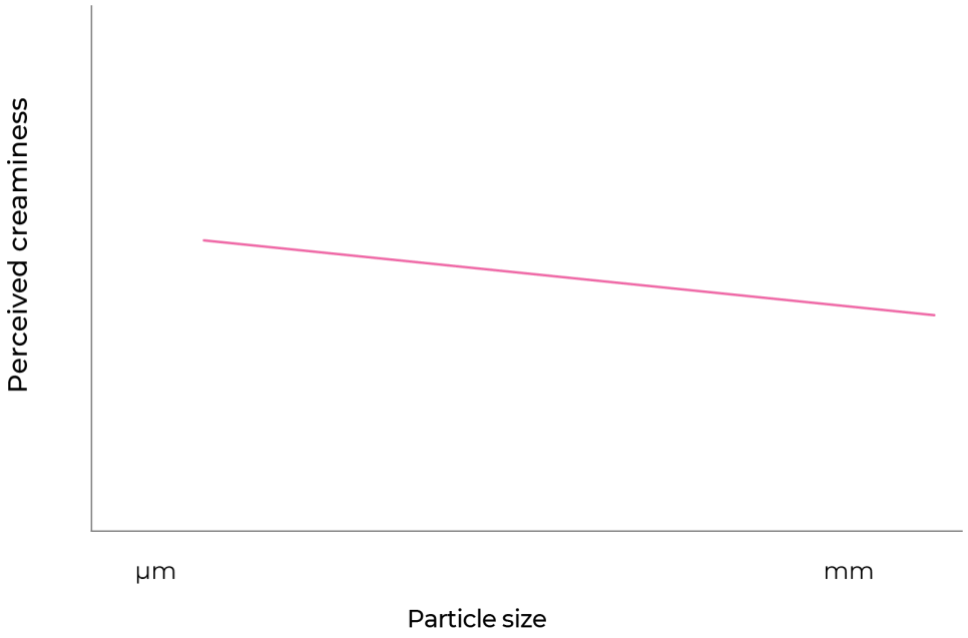

Figure 7. *Relationship of creaminess perception to particle size*

Perception of creaminess also increases as particle size decreases, but by smaller increments. And in this case it follows a linear relationship, as shown in **Figure 7**.

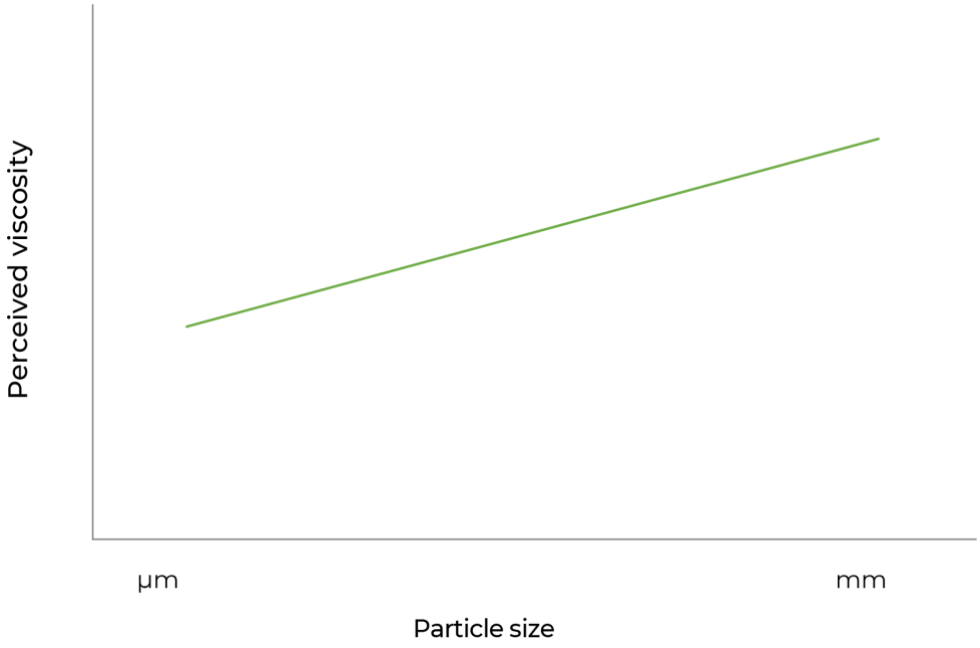

Figure 8. *Relationship of particle size to perceived viscosity*

With viscosity, the effect is even more pronounced than the linear relationship to creaminess, as **Figure 8** shows. As particle size decreases, the product is also *perceived by the palate* as thinner, or less viscous.

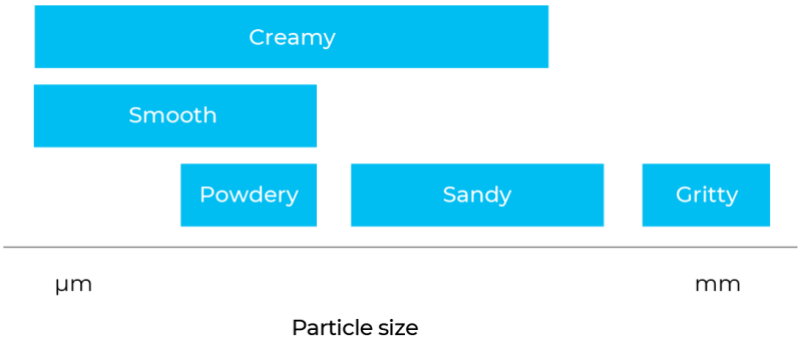

Figure 9. *How different characteristics relate to each other on the particle size scale*

Figure 9 is our way of showing how some of the perceptual impressions relate to each other on the particle size scale. Samples towards the large end of the scale (mm on the right) tend to be interpreted as gritty, and transition to sandy and powdery sensations as particle size decreases, moving to the left. Creaminess and smoothness are also located at the smaller end of the particle size scale.

Thus, depending on local or regional consumer preferences as a guide, producers can use findings like ours as the basis of running their own trials, and adjust processing parameters to balance different processing steps against energy consumption in reaching desired product characteristics.

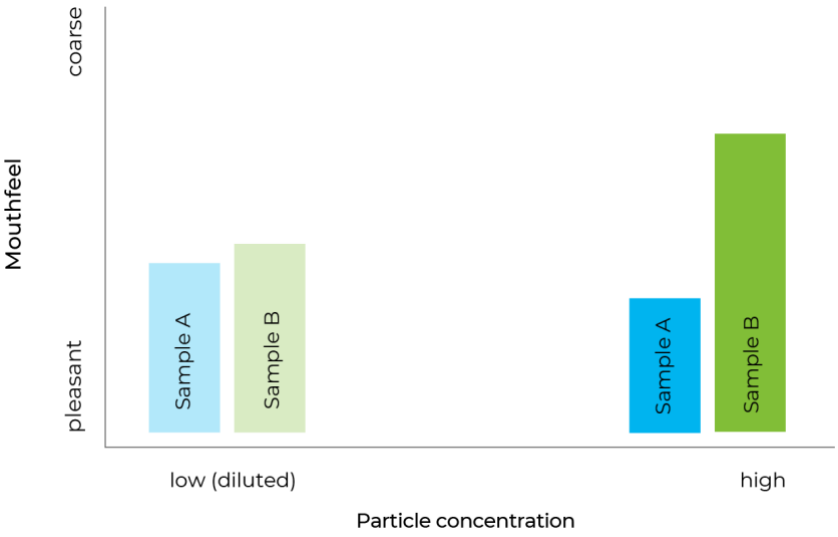

Figure 10. *Combined effects of particle concentration and particle size, on perceived mouthfeel*

In another series of tests, we compared the effects of particle density (concentration) as well as particle size, on mouthfeel (Figure 10). We started with two different samples: Sample A had smaller particles than sample B, and B was experienced as having a coarser mouthfeel than A at high particle concentrations (higher percentage of dry matter). But when the samples were diluted to a lower particle concentration, the differences in how samples A and B were experienced were much reduced.

BUILDING A WHOLE SOYA LINE

While we have shown process control issues can be complex, building a whole soya line is actually a bit more straightforward. An existing soy beverage production line can easily be converted or upgraded, with limited investments in new equipment. Moreover, the line will then be capable of producing both regular soy beverages and whole soy beverages.

The specific elements normally required to produce whole soya beverages are:

- Bypass piping and valves decanter, enabling setting up production of both whole and regular soya beverages
- A high-shear unit
- An additional homogenizer, specially designed to enable processing of products including fibres
- Bypass piping and valves high-shear treatment – to enable production of both whole and regular soya beverages
- CIP pressure line for cleaning any bypasses and high-shear units
- Potential upgrade of downstream homogenizer integrated with heat-treatment

There are different high shear units available and Tetra Pak can provide guidance and ensure an optimal solution based on specific customer requirements. The system can be designed to prepare blends of wholesome and regular beverages.

There are many design alternatives, which we at Tetra Pak have mapped out so that we can help you avoid common traps along the way. We have the equipment and the expertise for this solution, adaptable and customizable to meet your particular needs.

TETRA PAK – YOUR PARTNER FOR SOYA BEVERAGES

We have more than 40 years of experience delivering processing equipment for soya beverage lines around the world. Our customer and solution experience is based on deep understanding and extensive specialist knowledge, combining technology with successful application knowledge. When it comes to soya, we know the ins and outs of taste and mouthfeel, fibre mechanics and breakdown, heat treatment and stability, protein yield, sedimentation and enzyme deactivation. We are able to offer customized solutions targeting your requirements, and can help you design or upgrade lines based on your specific processing needs, with the lowest total cost of ownership.

Our experience with soya has also allowed us to deliver processing solutions and equipment over decades to customers expanding to other ingredients such as oats, rice, nuts, cereals, legumes and seeds.

At our Product Development Centres (PDCs) in Lund, Shanghai and Singapore, you can carry out beverage product trials together with our specialists with unique comprehensive expertise in food processing. You can experiment with recipes and use the latest processing equipment.

Thanks to our well established industrial and technology profile, we can support your innovation and production, helping you meet the changing tastes and demands of your marketplace. The right plant design and processing design can offer you unlimited new business opportunities – through new products, improved quality, and lower costs.

We offer:

- Extensive knowledge of processing technologies, as well as how to implement them
- PDCs and dedicated technology specialists
- Valuable knowledge and experience through partnerships with suppliers of technology, ingredients and supplies
- Processing modules and line concepts for a wide range of technologies for mixing, heating, filtration, separation, homogenization... and more.
- End-to-end offerings, handling everything from incoming raw ingredients to pallets of finished products on your loading dock.

As an innovator, we actively explore and develop the challenges of the food and beverage industry. We collaborate with customers, universities, and other business partners to develop new applications and find the best solutions for producing new products with flexibility.

For more information, visit our website:
https://www.tetrapak.com/en-th/campaigns/plantbasedexperts/plant-processing/soya

Or contact your local Tetra Pak office.

REFERENCES

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