WHITE PAPER

Minimizing damage when processing particles, fibres and pulp

A summary of challenges and solutions

Published April 9, 2015

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Preventing particle, fibre and pulp damage via processing

Who is this white paper for?

This white paper is for beverage plant managers who want to minimize product damage when processing particles, fibres and pulp. It gives you practical information and guidance on how to do so.

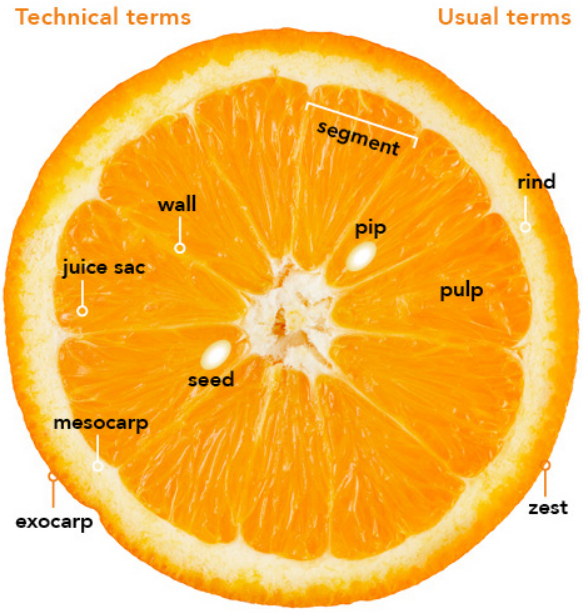
What elements are we dealing with?

Particles within beverage applications are typically 5-6 mm cubes, although there is a trend towards even larger sizes. Particles have a wide range of properties; for example, a Nata de coco particle – which is fermented coconut water cut into cubes – is quite rigid and strong while an Aloe Vera particle – from the core of the plant – is very fragile.

Fibres are the destroyed sacs (i.e. pulp emptied of its juice) or other parts inside the fruit. The mouth-feel of a product is dependent on the length of its fibres.

Pulp is the sacs, fruit cells or other parts inside a fruit that contains the fruit's juice (e.g., the pulp of a citrus fruit is the stringy content of the endocarp). When the juice-filled sacs burst in the mouth, they deliver the mouth-feel of freshly squeezed juice.

We sometimes refer to all three types as "**inclusions**".



Why does processing matter even more for beverages today?

There is a global trend toward more and bigger particles in both beverage and prepared food applications. The expanding market for beverages with particles, as well as fibres and pulp, is putting new demands on processors and the technologies they use to deliver high quality products. This is both because these constituents are often fragile and easily damaged during processing and because there is an endless array of combinations. Consequently, the lines between processing categories are being blurred. Is it a beverage or a food when we put coconut in juice or Aloe Vera in tea?

Beverage processors have traditionally worked with pulp and fibres, but particles have become more important ingredients in the last 5-10 years. Consumers are increasingly looking for enhanced, value-added, high-quality products with the trend accelerating towards keeping natural fruit fibres in the beverages – or mixing particles or pulp into them – to create products where consumers experience the feeling of drinking fruit in liquid form. In other words, consumers are looking for more than ‘just’ a beverage. This trend is emerging from the fruit and food industry where particles have been common for a very long time.

Beverage processing challenges and solutions

A number of considerations have to be taken into account when processing products with particles, fibres and pulp: How much damage to these inclusions is acceptable? How do we measure this? Where in the process is the damage most likely to occur and can something be done about it? How do variations, such as ripeness or sugar content in the raw material, affect the process and the product? How do the equipment factors – e.g. the pumps, valves, heat exchangers – influence the final product?

Products containing particles, fibres and pulp need both specialized and customized processing and packaging solutions. Each unique combination using these inclusions poses processing challenges, and considerable risks in terms of product quality, food safety and profitability.

Protecting particle integrity

To achieve good product quality, particle integrity needs to be protected. This can be challenging because all handling of raw material affects the product and because particles, fibres and pulp are sensitive to mechanical shearing or tearing. Important issues for pulp and particles are whether they come fresh, frozen or aseptic; their properties (e.g. size and quality); and the preparation or mixing. A normal acceptance level for reduction of particle content through processing within a certain specification is 10-20% (note that this does not mean that all particles or fibres are lost or destroyed; they are reduced to the next specification).

Particles

- Strength of a raw material may vary according to species, how it was ripened, where and when it was harvested
- Can be damaged via transport
- Behave different than liquids

Fibres

- Tend to be cut to pieces by centrifugal pumps

Pulp

- Very sensitive to warming and mechanical stress
- Difficult to deliver in a homogenous state so usually removed from fruit juice by filtering it out

To ensure integrity, all three types of inclusion need to be pumped with minimal mechanical treatment and without rapid pressure gradients. Special design and dimensions are the basis for minimum maceration. Sudden pressure drops in

control valves needs to be avoided, both from a maceration point of view but also from physical dimensions, avoiding flow blockage.

Positive pumps of sufficient size with low slippage and limited speed are a good bet for retaining product quality. **Heat exchangers** designed with fewer but larger tubes of sufficient diameter and smooth inlets are also beneficial since larger particles need larger tube diameters

Avoiding much maceration during processing also requires having control of raw material quality and the ripening or softening of particles. This can be done in a structured way and checked with instruments that measure particle characteristics such as texture and strength. Measuring particle damage can also occur at various processing stages so as to control the effects of the processing and filling procedures. This can be done via sieving and weighing, counting and measuring, and sophisticated **digital image analysis** that can measure the distribution of fibre lengths and that can characterize particle shapes to provide valuable information on particle distribution and size.

"Processing beverages and other products that are naturally fibrous, or which have fibres and particles added, inevitably damages them," explains Göran Stjernberg, Line Solution Manager. "Damage limitation is thus essential when designing new systems or optimizing existing plants. Reviewing the entire process to ensure particle integrity and fibre content is maintained can bring tangible rewards."

Product consistency

However, the main challenge with all three from a product quality standpoint is the floating or sedimentation tendency of the inclusions in the buffer tanks; if formulation and recipe are not optimized for the density difference between particles and carrier liquid, the particles will separate from the carrier liquid, resulting in an uneven distribution in the consumer package. This affects the consistency of the final product.

System design

To ensure product consistency, there needs to be proper internal design of the **heat exchangers** – such as the inlets of tube packages, tube sizes – as well as **tank and agitators**. Proper agitator optimization is of utmost importance to get an even end product; the design of the tank dimensions and the agitator must match. Gentle, low-shear agitation with slow, revolving paddle agitators gives a very good agitation that is able to keep the particles in an even distribution through the processing system without destroying the particles; good agitation doesn't necessarily mean high shear mixing.

Liquid over-processing

The liquid phase of a product should not be over-processed if high product quality is to be achieved. Particles, fibres and pulp require longer heating time than the liquid, which is sensitive to heat. This means that quality will be negatively impacted when holding times are too long because of the presence of particles, fibres and pulp.

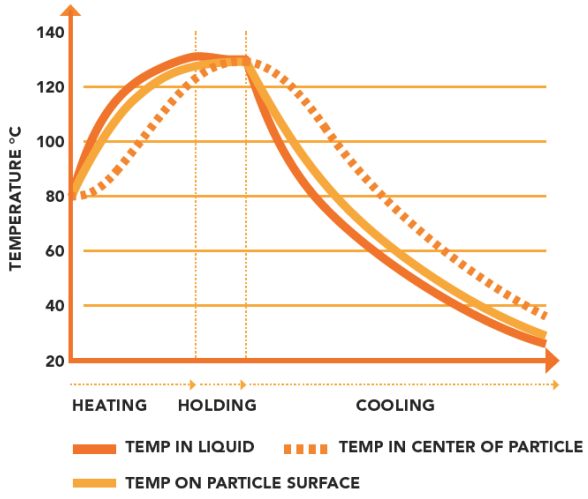
To ensure that the liquid phase is not over-processed, solutions like dual stream processing lines can be applied. **Single stream processing lines** can be used for most liquid products, but can only handle smaller particle sizes, require a longer holding time for the liquid phase, and make deaeration impossible. **Dual stream processing lines**, on the other hand, employ separate product flows. They allow the liquid to be processed in one line the conventional way – for example, in a plate heat exchanger or steam injection featuring standard pumps and processes – while the inclusions are processed according to their specific characteristics in another line. The line also includes an aseptic blending of the two streams, juice and inclusions. In addition to the prevention of liquid over-processing, the advantages of using these are minimized mechanical treatment and higher particle integrity, more efficient heating, and minimized thermal load on the end product. Splitting the streams also allows for the liquid to be homogenized and deaerated to reduce its free and dissolved air content, increase vitamin C retention, and minimize colour change, aroma loss, and foaming in filler, so as to improve its quality. Particles themselves can't be deaerated or homogenized.

An additional method is **in-line dosing**. This method adds the particles after the homogenizer or deaerator, but before the final heat treatment in a single-stream line. This way, the costly fruit content can be pasteurized gently and cost-efficiently. Using aseptic in-line dosing of particles in a single aseptic processing line, before aseptic filling, will yield better particle integrity. In addition, the liquid can be homogenized and deaerated, and the optimal holding time for the liquid can be used. This means a much smaller capital investment. However, particle size limitation narrows the possible product range.

Food safety

The key heat treatment challenge when producing particulate beverages is to achieve a safe product by ensuring that particles reach required temperature in the coldest spot while simultaneously avoiding overcooking the liquid and surface of the particle to preserve taste, colour, texture and nutrients. The other main challenge from a food safety perspective is controlling for the formation of lumps.

As shown in the graph, it takes time for the heat to penetrate into the centre of the particle – there is a temperature lag – and the process needs to allow time for this. The heating time depends on the size of the particles. Optimizing heat treatment requires selecting the right heat exchanger with an optimized heat exchanger design, whether it is a coil formed mono-tube for larger particles or a multi-tube for smaller particles; this requires an advanced multidimensional calculation that determines heat transfer from the liquid into the inclusions. Selecting the right heat exchanger gives you control of retention time to ensure optimal heat treatment with an optimized temperature curve. In a dual-stream process solution, heating is tailored even further to ensure the optimal quality of liquid and optimal food safety of particles.



Heating of the centre of the particle is clearly delayed and the centre does not reach sterilization temperature until it reaches the end of the holding tube.

It is also important to have an even distribution of particles throughout the system so that they are heated evenly in the holding section. To achieve this, proper mixing and agitation, and the density and viscosity of the liquid phase is important. Running a pulp slurry with high particle concentration can be helpful to obtain even distribution.

Profitability

Beverages are particularly price-sensitive. To save on investment costs, it is particularly important that the heat exchanger is properly dimensioned in order to minimize energy use.

Another dimension of cost savings is the cost of raw materials. Because the chunks and pieces are usually costly ingredients, minimizing damage to them and ensuring preservation of their shape, consistency and flavour throughout transportation and processing is very important.

But the overall cost driver for the line is product quality. Thus the process solutions have to be balanced and optimized for product quality demands in a given context of raw material cost. If raw materials can be obtained at lower cost, for example, then additional maceration or damage might be tolerated.

Summary

There is a growing trend towards the inclusion of particles, fibres and pulp in consumer products. Responding to this trend poses unique challenges for beverages and prepared food manufacturers given that particles, fibres or pulp behave differently according to their intrinsic properties and therefore require unique processing solutions.

To ensure integrity, all three types of inclusion require special design and dimensions of **control valves** and **pumps** – with low slippage and limited speed.

Heat exchangers designed with fewer but larger tubes of sufficient diameter and smooth inlets are beneficial since larger particles need larger tube diameters**.**

Proper **agitator optimization** is of utmost importance to get an even end product; the design of the tank dimensions and the agitator must match.

Measuring particle characteristics such as texture and strength can occur at various processing stages so as to control the effects of the processing and filling procedures, and checking that particle distribution meets recipe requirements.

The liquid phase of a product should not be over-processed, which may occur when particles, fibres and pulp require longer heating time than the liquid. Liquids with larger inclusions may require **dual stream processing lines**, which allow the liquid to be processed in one line the conventional way, while the inclusions are processed according to their specific characteristics in another line.

An additional method is **in-line dosing**, which adds particles after the homogenizer, but before the final heat treatment in a single-stream line, allowing costly fruit content to be pasteurized gently and cost-efficiently.

Careful calculations can lead to optimal processing, taking into account line design, safety requirements, raw material costs, recipes and quality specifications.

Tetra Pak – your processing partner

Tetra Pak's development engineers, process engineers, designers and field service engineers work with you to create solutions for beverages and prepared foods with particles, fibre and pulp.

At our **Product Development Centres** you can experiment with recipes and use the latest processing equipment for products that contain particles or inclusions. You will have the full support of our food technologists and scientists.

We use an advanced multidimensional calculation tool that takes **particle heating time lag** into consideration. This affects the choice and design of heat exchangers when particles or inclusions are part of the recipe.

We also have extensive experience **measuring product integrity using digital image analysis**, which shows how each processing step affects the character of particular particles. This can help take the guesswork out of system design.

Feel free to contact your Tetra Pak representative or connect with us via our website.

www.tetrapak.com/beverage-particles

For further details about processing inclusions, please contact: Goran.Stjernberg@tetrapak.com, Line Solution Manager, or your local Tetra Pak contact.