

SOY JUICE BEVERAGES

**TAKING SOY PROTEIN
BEYOND MILK**

by Henk Hoogenkamp & Paul Evers

Soy juice beverages

Taking soy protein beyond milk

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Soy milk is not a new product; it has been consumed for hundreds of years in Asia. It is believed that soy milk was developed in China in 164BC and its manufacturing process based on water extraction of whole soybeans. For a great many centuries soy milk consumption was restricted to Asian countries such as China and Japan.

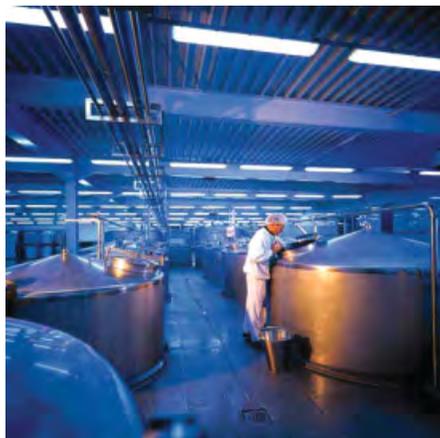
In Western countries, soy milk consumption for the general population is a much more recent development, with a real presence only by the beginning of the third millennium.

The demand for vegetable-based, low calorie foods by health conscious consumers has created the potential for significant growth in mainstream food and beverage market segments. Today, the popularity of soy milk and other soy-based beverages is rapidly increasing throughout the world. Especially areas with large population of affluent lifestyle consumers such as the west and east coast areas of the US, Australia, New Zealand and increasingly as well in western Europe, have positioned this product into both the main food and speciality categories.

Space increase

Soy and other grain-based beverages such as rice milk command increasing space in the grocery store. Initially mostly used as a welcome beacon for lactose-intolerant people, soy protein based beverages have now become the trailblazer for fun-drinks as well as a suitable nutritional dairy substitute category.

Soy milk and soy based beverages such as soy fruit juice, has benefited from rising consumer awareness that soy is a good source of protein, yet low in saturated fat and free of cholesterol and lactose. A wide variety of beverages can be produced based on specially processed soy protein isolate. These beverages are non-dairy and Europe's premier market is Germany, followed by the UK, France and Spain. In Germany



especially private label soy milk and soy beverages lead the growth while Yoplait was the first to launch a yoghurt brand Bioplait, combining soy and dairy protein.

To put soy milk into perspective: the estimated value of western Europe soy milk market in 2006 is approximately €450m or 2.25%, compared to the 'normal' milk market at €20bn. The soy beverage market in Europe is growing with 20 to 25 percent per year. Recent data from market intelligence research Freedonia indicates that in the US soy health claims will contribute to a 5.1 percent annual growth over the next 5 years. Over the same time frame – 2006 to 2010 – soy protein ingredients are expected to grow with 5.9 percent annually.

Different methods

Soy milk can be produced by two specific processes:

- An aqueous extraction of the soybean itself,
- A recombination process with water, fat and soy protein isolate,

It is also possible to combine the above mentioned manufacturing processes by using soy protein isolate to augment yield and texture of traditional soy milk processing methods. Soy milk normally is considered a perishable product. However the soy milk can be designed to make it shelf stable using

UHT sterilisation and aseptic packaging while maintaining good organoleptical properties, including delicate flavour profiles.

As mentioned, soy based beverages are formulated and processed in quite a few different ways. In principle, soy beverages consist of aqueous protein dispersion with protein content ranging from 1.0 to 5 percent. These products are made either from fresh or reconstituted soy milk, soy protein isolate, or a combination of traditional soy milk augmented with soy protein isolate technologies.

Traditionally soy milk is made by water extraction of the whole soybeans. Original processed soy milk has a typical bean-like soy taste which over centuries has become a favourite in some Asian regions. These typical soy 'beany' flavours are due to enzymatic reactions, which instantly occur when wet-grinding the soy beans. As a result specific compounds are found that deliver the typical soy notes. Additionally, soy beverages quite often show other organoleptical imperfections such as poor mouthfeel and/or lack of creaminess. Mouthfeel imperfections such as chalky, gritty, or sandy are due to the presence of large soy protein particles. Lack of creaminess is due to low fat content and/or insufficient 'microparticulation' caused by insufficient protein:fat interaction.

Emulsifying and stabilising

These variables nearly always can be corrected by selecting the right soy protein isolate in combination with the added benefits of specific stabilisers such as hydrocolloids like carrageenan, pectin and





also gellan gum, cellulose gum and monoglycerides. Increasingly integrated functional ingredient systems are used that are based on synergistic effects between emulsifiers and stabilisers which ultimately will decrease the sedimentation tendency and improve organoleptical quality of the soy beverage in general.

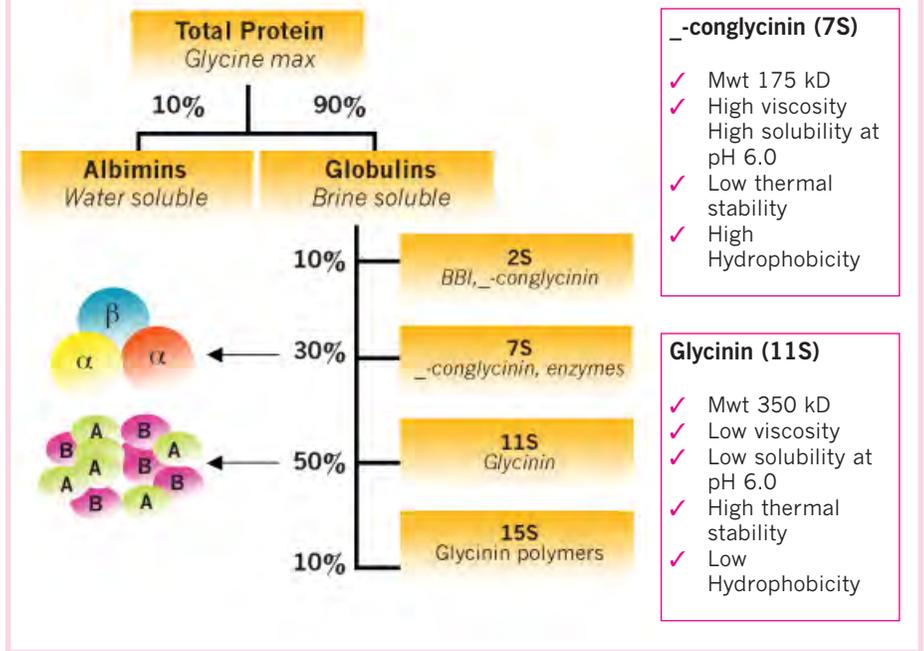
Of course of equal importance to perfect the soy beverage is the right method and sequence of ingredient addition together with the available processing equipment and expertise of its operators.

The typical soy protein structure is of determining importance to its ultimate performance. Soy protein isolate that are usually recommended for beverage application contain the globulin parts beta-conglycinin (7S) and/or glycinin (11S) (see figure 1). These specific properties are not only responsible for creating the needed protein-structure including fat stabilisation, but also influence time, temperature, shear/energy in relation to dispersibility, hydration and solubilisation in an aqueous solution containing other functional ingredients.

Major flavour innovation is on its way when by 2007 improved organoleptical quality soy protein isolate will become available.

Using plant-breeding technology, a specific Monsanto patented soybean variety will then provide high levels of beta-conglycinin, a naturally occurring texture and flavour improving compound. Beta-conglycinin is a highly soluble protein, especially suitable for beverage applications. Beta-conglycinin does not bind flavours so at higher levels it does not hold in the typical soybean taste, creating a more neutral taste profile, which subsequently will be carried over in the end product.

Figure 1: Soy protein isolate that are usually recommended for beverage application



Stabilising droplets

To prevent fat separation and creaming, it is essential to stabilise the fat droplets. A model network can be created by the addition of emulsifiers such as soy protein isolate which molecules possess both hydrophilic and lipophilic (=hydrophobic) properties that interface between the water and fat droplets. This allows the fat phase to be dispersed in the water phase. As a rule of thumb: the smaller the fat droplets, the higher the stability and mouthfeel, provided sufficient interfacial adsorption has taken place. The fine matrix of stabilised fat is also called microparticulation providing a smooth and creamy texture, improving overall mouthfeel.

Rancidity is a result of lipid-oxidation, which can be triggered by the exposure to heat, light, oxygen, enzyme activity or contact with metal ions in processing or packing. Of course, soy bean oil has a high content of unsaturated fat. Besides true emulsification of the fat or oil droplets, it is therefore important to add antioxidants such as potassium citrate and other chelators to delay or eliminate undesirable oxidation.

Acidified drinks

As a spin-off category, the fruit based soy beverages market segments are developing rather rapidly. Nearly always, fruit-based soy beverages are acidic, providing distinctly

different characteristics such as texture and mouthfeel in a pH range from 3.6 to 4.2. To obtain the desired pH range is accomplished by either direct acidification such as by food acids or fruit juice or fruit concentrate, or through fermentation with live bacteria cultures including probiotics.

Fermentation of soy milk and soy beverages is about the same as dairy, with the exception that it might be beneficial to fully understand the specific function of added sugars to improve fermentation.

Acidified soy beverages (see table 1) require additional stability and usually pectin is preferred because of its unique protein interaction properties. For direct acidified soy beverages the sugar-blended pectin should be added before the food acids or fruit



concentrates. However, when fermented beverages are made the sugar blended pectin should be added after the fermentation process has been completed.

Table 1: Typical nutrient analysis

Nutrient	Percent	Per 250ml serving
Protein	2.10	5g
Fat	1.50	4g
Carbohydrate	6.00	15g
Calcium	0.07	180mg
Phosphorus	0.05	120mg
Calories	-	120kcal

Nutritional information

As an eye-opener: soy and its specific health claims remain a highly controversial topic. According to the Associated Press (January 24, 2006) the American Heart Association panel of expertise has derided soy claims that soy protein can significantly lower cholesterol.

Soy industry sponsored research studies indicate that the soybean is more than a high-yielding source of premium protein. Soybeans also contain relatively high amounts of phytochemicals, such as genistein, daidzein and glycitein.

Epidemiological studies have suggested an association with lowered risks for prostate, breast and colon cancers, reduction of cholesterol, improved bone health, a delay in the onset of osteoporosis, reduced blood pressure, protection against heart disease, and an easing of menstrual and menopausal symptoms. Soy protein is also a significant source of essential fatty acids, minerals, and calories. Given below is the important nutritional information for soy milk produced with a low-flavour profile type of soy protein isolate.

■ **Heart disease:** it has long been recognised that Asian countries have a much lower incidence of cardiovascular disease than their Western counterparts. Traditionally the Asian diets contain a larger proportion of vegetable protein from soy and other plant sources, while Western diets contain more animal proteins such as meat, eggs and dairy. The plant proteins are rich in bioactive compounds such as phytoestrogens in soy and lignans in linseed that play a major role

in promoting a beneficial blood lipid profile. ■ **Cancer:** Studies conducted by the US National Cancer Institute suggest that Western consumers could significantly reduce the chance of developing breast and prostate cancer, by increasing the intake of soy proteins.

■ **Menopause:** The Japanese don't even have a word for menopause. The menopause is a natural transition for women and is certainly not a disease, but still can have some unpleasant side effects. A daily consumption of soy milk is reported to have a significant reduction in hot flushes.

■ **Osteoporosis:** Bone is a living tissue that is constantly being replaced. It develops and matures in the aging process reaching peak bone mass at around 30 years of age. During childhood and adolescence both bone size and density increase rapidly and calcium intake at this time is critical. Osteoporosis is the gradual thinning and weakening of bones, ultimately resulting in the possibility of fractures. This can be especially a problem for women, due to lower calcium intake and physical exercise.

■ **Cholesterol:** Consuming soy-rich foods has been proven to actually lower the LDL (bad) cholesterol levels. In 1999 the Food & Drug Administration allowed to make a product claim "The inclusion of at least 25g of soy protein per day as part of a diet low in saturated fat can help reduce blood cholesterol". In the UK, in 2002 the Joint Health Claims Initiative, the Government department responsible for food claims, approved a similar claim.

■ **Allergy:** no doubt that allergy and intolerances are on the increase and it is estimated that over 30% of the population are affected. Soy is free from the three most common intolerances, wheat, gluten and dairy, though in all fairness it should be stated that soy allergy levels are also on the rise. Allergic reactions have prompted the US and EC authorities to submit food legislative proposals to add allergy-warning on food labels for added protein ingredients. Theoretically, all protein-containing food can cause allergy. Many people are without clinical symptoms, but still could be sensitised by offending protein exposure triggering an IgE antibody response. Every

subsequent re-exposure will increase the level of sensitivity until a full-blown allergy can be medically diagnosed.



Bioactive soy drinks

Basically, functional drinks are defined as a concept that provides a health benefit beyond the basic nutritional content by virtue of their physiologically active added components. Yakult Japan is not only the pioneer of the probiotic functional drinks but also still the world leader of the distinctive 'one-shot size' drink format. It has taken a while, but in recent years a wave of me-too products has been introduced by giants like Yoplait, Danone and Nestle. Especially lifestyle consumers are increasingly aware of the need to address specific health and nutritional needs. These lifestyle consumers can be segmented in health categories providing benefits such as increased mental alertness, improved sport performance, lower cholesterol, and improved cardiovascular fitness, skin complexion as well as relief from a host of specific ailments and general sense of feeling good.

Soy protein, possibly in tandem with premium performing bioactive whey protein fragments, are uniquely able to serve as a beverage base model from which functional drinks can be made (see figure 2). The same is true to team up soy beverages with probiotic bacteria such as lactobacillus, not only do they help fight viruses but they may also protect against autoimmune diseases like diabetes by increasing white blood cells.

Logical platform

A soy-based beverage is a very logical platform from which to launch specific health segmented spin-off products. It is outside the scope of this article, but there are for

example hundreds of well-researched and approved micro-components based on vegetables, fruits, herbs or botanicals. Just to mention but a few: lycopene, cacao polyphenols, seaweed extracts, phytoosterols, soy isoflavones and prebiotic inulin.

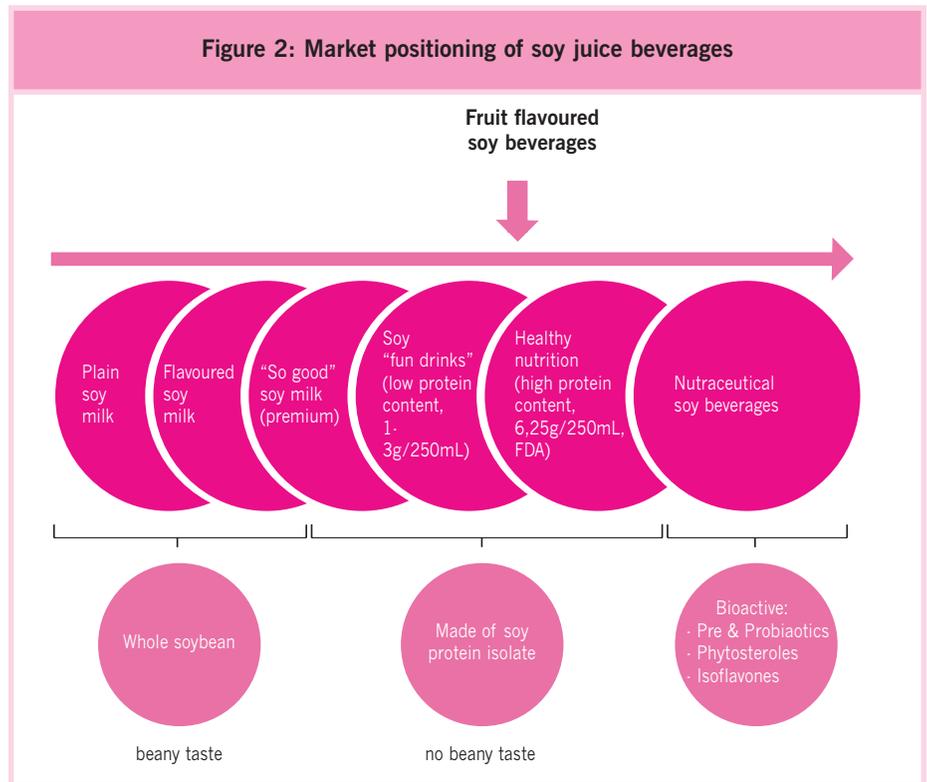
Increasingly, due to sky-rocketing health care costs – ironically caused by the ageing population – governments are actively encouraging self-managed or pro-active health initiatives. Functional foods and beverages, including the environmentally friendly soy protein will become a logical pathway to address these changing paradigms. Especially the cost efficiency of soy protein compared to the rather elusive price ranges of milk proteins, will be important to develop sustainable foods for the masses at affordable prices.

It is rather obvious that not all of the world's continents can be viewed singularly. For example, Asian Pacific regions have for centuries embraced a holistic approach to treating physiological problems and have been looking to nutrition for answers. And as such there is a deep-rooted awareness between diet, health and well-being. In this sense, nutraceutical drinks are not really new for the Asian Pacific population. The concept is centuries old, but the understanding only now starts to unravel, yet scientists still have more questions than answers.

Spin-offs

Within the category of nutraceutical beverages there are relatively recent spin-off segments such as esoteric drinks promoting for example bowel health or relieving insomnia or to make life easier for Crohn's disease patients. Not to mention yet another phenomenal growth area for cosmeceutical drinks, which are designed to improve physical beauty & appearance such as skin complexion or reduction of blemishes. Large world companies such as Nestle, L'Oreal, Coca Cola and Shiseido have cosmeceutical concepts nearing market introduction. Beauty from within suddenly has become a statement taken literally.

It seems as if the many tropical fruit juices have run their course in terms of product innovation. What is 'hot' right now are the green tea and chocolate health connections, backed up with other bioactive compounds such as polyphenol containing micro-extracts. All these new consumer preferences are packed in tasteful connotations of beverages



based from soy, juice or tea. Of course, there are innovative drinks that incorporate all of above in a delicious tasting convenience product that provides the required minimum intake of protein for heart health together with other active components to improve quality of life.

An example is pomegranate juice. The American Journal of Cardiology, (Sept.16, 2005) reported that pomegranate juice may improve blood flow to the heart without negatively affecting parameters such as blood pressure and blood glucose. Coronary heart disease is the leading cause of death in the Western world and pomegranate juice, rich in polyphenols and other naturally occurring antioxidants can serve as yet another health source to reduce the toll of this degenerative disease. Even better yet, these fruits packed with nutraceuticals can be ingeniously blended with soy milk and combined may demonstrate high capability in scavenging free radicals and inhibiting low-density lipoprotein in vitro and in vivo.

Another example is the recently uncovered compounds in cranberries. It has been known for a while that cranberry juice acted favorably to prevent urinary tract infections. However much attention now is given to proanthocyanidins, a cranberry chemical structure, inhibiting tumor growth and spread of in particular lung cancer, colon cancer and

leukemia cancer cells.

Satiety worker

Soy protein is also considered a 'satiety-protein'. And as such, DSM's new 'Fabulesse'-satiety ingredient could be an ideal fit to co-introduce in a personal weight management drink. Looking into the crystal ball, DSM also has near market introduction a milk beverage, yet without all the classical attributes such as taste or appearance of milk.

Further down the horizon soy based nutraceutical beverages appear which are based on nutrigenomics, and these technologies will set the stage for personalised nutrition beyond 2012. After all, there is increasing evidence of links between small DNA changes and the development of chronic disease, which ultimately will prove that there is a direct relation between genetic changes, lifestyle and food. Following this pathway, it even can be hypothesised that some food companies of today even might transform towards food diagnostics as their main creation of shareholder value.

Sales benefits

Research has shown consumers are prepared to pay a premium for beverages with added nutritional and medical benefits. These added benefits need to have the desired effects while maintaining safety and the right

dose intake levels. It is a very logical choice to team up the goodness of soy protein and functional ingredients and bioactive compounds to create a soy juice packed with premium value.

Thanks to modern processing techniques, soy protein and extracts of a plethora of fruits and vegetables is an ideal vehicle to deliver phytochemicals rich of healthy antioxidants, polyphenols and other health promoting compounds such as plant sterols that go above and beyond what normally occur in fruit and vegetables.

On the horizon loom quite a few interesting product concepts:

- Cardiovascular Health
- Eye Health
- Cognitive & Mental performance
- Anti-Ageing
- Wellness & Well-being
- Healthy Complexion
- Nutrition Diagnostics e.g. diabetes mellitus

Formulation

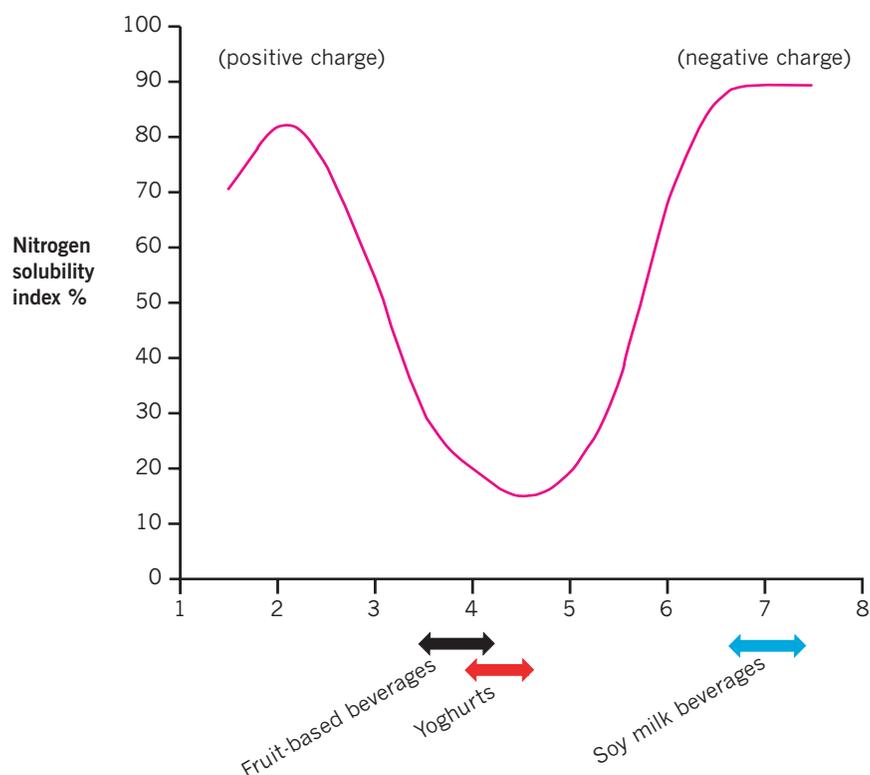
Preferred is to use a soy protein isolate (90%) that has good physical properties such as dispersibility and stability for liquid beverages. Ideally the soy protein isolate should contain a stabilised calcium phosphate, which provides the same protein/calcium ratio as cow's milk.

However, the total protein content of a calcium stabilised soy protein ingredient is approximately 80%. Soy protein purchasing price should reflect this difference in protein content, while also a small formula adjustment need to be made.

The formulation of soy milk is given below. This is a sweetened, unflavoured base formulation. The formula can be modified to eliminate sweetness (sugar) or substitute other carbohydrate sources (i.e. malted barley or seaweed). Mouthfeel can be modified by using, for example, carrageenan, pectin, monoglycerides and inulin. The polysaccharide inulin of course, also serves as a prebiotic.

The solubility of soy protein isolate is greatly influenced by pH. Good solubility is generally obtained in either low or high pH ranges. For example, soy juice or soy fruit beverages are generally between pH 3.4 and 4.0 and soy yoghurts between pH 4.0 and 5.0. At these pH ranges the solubility of soy protein isolate is at its minimum, which

Figure 3: Solubility index



nearly always means that other functional ingredients such as carrageenan and pectin is needed to enforce the soy protein network (see figure 3).

Stability

It should be noted that stability does not come from added viscosity. At neutral pH, stability comes from a weak gel network i.e. protein and k-carrageenan interaction. At an acid pH, stability comes from specific adsorption of pectin, and it has been mentioned already that soy protein does not interact with carrageenan and pectin in the



same way as sodium caseinate. The fine-tuning of the soy milk and soy beverage is mainly dependent on the intrinsic properties that are required. For example: because of synergisms, kappa carrageenan performs at very low usage levels in beverages containing milk protein. This synergism is not at the same intensity with soy protein and subsequently it is suggested to slightly increase level of addition.

Carrageenan is especially beneficial in refrigerated soy beverages. When shelf stable beverages are developed it is recommended to use cellulose gum such as Avicell in combination with carrageenan.

Insoluble source

A point of concern here can be possible unwanted gelling of soy protein because of the presence of soluble calcium sources. It is therefore suggested to select an insoluble calcium source such as calcium phosphate to fortify the soy beverage. However, in the latter case cellulose gum is often needed to prevent direct protein interaction leading to gelation. Carrageenan and cellulose gum are very effective in building up body in soy beverages. This overview would not be

complete without mentioning the unique properties of gellan gum.

This polymer ingredient is made by fermentation of polysaccharide derived from a naturally occurring organism, *Pseudomonas elodia*, that was originally found on an aquatic plant. By itself, gellan does not contribute a high viscosity, but the functional ingredient – which is proven to work under difficult conditions – is very synergistic with soy protein isolate, carrageenan, pectin and cellulose gum, to secure and completely stabilise the beverage very effectively, including richer and thicker mouthfeel.

Generally speaking; low soy protein content, higher sugar content and the presence of small amounts of salt will decrease the required dosage of pectin for stabilisation. However, when the soy beverage is UHT heat-treated or by autoclave processing, usually an increased amount of pectin will be needed. Pectin is a very effective ingredient to protect protein in terms of sedimentation, especially in acidified environments the obvious choice is pectin.

The formula given below can serve as an ideal base for further development of a wide range flavour sensations including soy smoothies and soy frosties, with or without added nutraceutical benefits.

For example:

- Solae Supro type 561 or 670 or 675
- ADM Profam 922
- Cargill Prolisse 811
- Danisco Recodan
- Gellan gum: Kelcogel

Process suggestion

1. Heat water to 25°C
2. Add soy protein isolate to disperse
3. To increase speed of hydration water temperature may be increased to approx. 55°C.
4. Cool to 25°C.
5. Pre-mix pectin and a small amount of sugar
6. Dissolve sugar-blended pectin stabiliser in hot water at 80°C
7. Cool pectin-solution to 25°C
8. Slowly add the pectin solution to the protein solution while continuously stirring for 15 minutes.
9. Add juice, vitamins, cellulose gum, flavour, colour while agitation vigorously.
10. Slow addition of citric acid to pH 3.6 – 4.0 while agitation continuously.

Processing suggestions for Shelf-S table soy milk

1. Add sufficient water for processing to batch tank. Add potassium citrate to water.
2. Add stabiliser mixed 1:15 with sucrose, to water at approximately 25°C.
3. Add soy protein isolate and disperse well using a high shear mixer.
4. Add soybean oil
5. Heat to 71°C.
6. Add sugar and flavourings, if desired.
7. Homogenise 2500 psi 1st stage and 500psi 2nd stage
8. UHT process. Individual processors need to determine appropriate UHT conditions for ensuring safe, commercially sterile product. However, 141°C for 8 seconds may serve as a starting point for low acid beverage.
9. Cool to 27°C or less and pump to sterile surge tank.
10. Fill sterilised containers or packs.

Table 2: Base soy milk formula suggestion

Composition Example	Percentage
Soy protein isolate*	2.6 %
Soybean oil	1.5 %
Sucrose	6.0 %
Stabiliser **	0.1 %
Carrageenan	0.1 %
Potassium Citrate	0.2 %
Water	89.5 %
Total	100.0 %

11. Homogenize upstream at 175 bar and 60°C
12. Pasteurize at 80°C for 15 seconds
13. Cool to 20°C and fill aseptically.



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Henk Hoogenkamp, Strategic Protein Specialist and author of "Soy Protein and Formulated Meat Products (2005) has been a proponent of creating and transferring protein technology systems to the world's food and nutraceutical industry. Mr. Hoogenkamp was President of DMV-Campina USA, and Senior Director Protein Strategy of Solae LLC (a DuPont/Bunge venture).

Table 3: Typical neutral pH soy beverage formula

Composition Example	Percentage
Water	84.13 %
Soy protein isolate	3.81 %
Soybean oil	1.05 %
Carbohydrates	10.00 %
Stabilisers (carrageenan/pectin)	0.28 %
Buffer salts (citrate/phosphate)	0.30 %
Salt	0.03 %
Vitamins, minerals	0.20 %
Flavours & colours	0.20 %
Total	100.00 %

Table 4: "Nutraceutical" soy juice beverage formula

Composition Example	Percentage
Soy milk	20.00 %
Pear juice concentrate (30%)	6.00 %
Sugar	6.00 %
Soy protein isolate	1.00 %
Stabiliser (Pectin)	0.30 %
Gellan Gum	0.10 %
Citric Acid	0.05 %
Apple flavour	0.10 %
Rhubarb flavour	0.10 %
Natural flavourings, example:	
Wheat Grass & Aloe Vera extracts	0.20 %
Natural Carothenes	0.05 %
Vitamins & Co-enzyme Q10	0.20 %
Water	balance
Total	100.00 %

Alko International BV is arguably the world's leading research & manufacturing company of premium value added cream cordials and speciality beverages. Alko's long-term goal is to create beverage concepts for the everyday food menu as well as life-enhancing nutraceutical drinks. These alcohol and non-alcohol cream-bases, fun-drinks and nutraceutical beverages are presented in a ready-to-market business proposal, including modern refrigerated, shelf-stable as well as the very latest aseptic filling technology.

Alko's in-house application scientists, protein technology and engineering know-how create sustainable organoleptical advantages over and beyond what usually is presented by primary manufacturers of single functional ingredients. This is especially demonstrated balancing and harmonising superb taste and flavour concepts together with intrinsic health-enhancing nutraceuticals. The company is leading in technologies of interactive protein systems, be it based on milk protein, soy protein or wheat protein and a wide range of synergistically-driven support ingredients such as hydrocolloids.

Alko International BV brings together resources and synergies using the very latest technology coupled on unparalleled reduction of cycle time in concept development which translates in speed-to-market efficiency. In-depth experience of a professional and dedicated staff with practical 'can-do' & 'hands-on' experience makes sure their people speak and think the language the customer prefers. Alko's multi-discipline talented professionals can be characterised by informal team spirit and welcome real challenges often resulting in out-of-the-box solutions.

Alko takes extraordinary care to be respectful of their customers' interests and understands the critical nature of compliance and proprietary information. Trust and mutual respect, together with leading edge technology will remain the basis as Alko International moves forward.



The company headquarters is nestled in a rural setting in the southern part of Holland, yet with a vision that spans the globe.