Formulating Acidified Beverages with Pea Protein

Impact of Stabilizers & Processing Conditions on low pH Pea Protein Beverages
CONTENTS

ABSTRACT 3

OBJECTIVE 5

INTRODUCTION 5

PROTOCOL AND METHODOLOGY 7

RESULTS AND DISCUSSION 9

CONCLUSION 13

SOURCES 15
ABSTRACT

As pea protein increases market share in the beverage world, it is essential to understand the stabilization requirements of beverages containing pea protein. Pea protein is most stable at neutral pH where the protein is most soluble. However, pea protein may be combined with fruit juice, fruit puree, or other acidic ingredients to create delicious and innovative beverages. The acidic pH of these beverages reduces the solubility of the protein and, if not properly stabilized, the visual stability and organoleptic attributes will be negatively impacted. To ensure full enjoyment of these acidified protein beverages, stabilization is needed. In general, the stabilization of these products requires the proper selection and use level of hydrocolloids, coupled with understanding critical parameters in batching (i.e., hydration of hydrocolloids and proteins, order of addition of ingredients) and processing conditions.

The objective of this study was to evaluate the effect of a selection of CP Kelco hydrocolloids at various use levels on an acidified pea protein beverage containing 1% protein (pH 4.0).

In addition, the effect of homogenization of the pea protein before mixing with the rest of the system was assessed. To achieve this objective, GENU® Pectin, CEKOL® Cellulose Gum, a blend of GENU® Pectin and KELCOGEL® Gellan Gum, and a blend of CEKOL® Cellulose Gum and KELCOGEL® Gellan Gum were evaluated at use levels between 0.4% and 0.6%. Additionally, an unstabilized beverage containing 0.5% pea protein was prepared. The hydrocolloids and the pea protein were properly hydrated according to the hydrocolloid and protein supplier recommendations. The overall stability and quality of the beverages were graded based on visual stability (e.g., sediment), particle size, viscosity flow curves, and mouthfeel.
As expected, the use of protective hydrocolloids (i.e., pectin, cellulose gum) was required to prevent the proteins from aggregating and sedimenting at an acidic pH, especially after heat treatment. All samples containing either pectin or cellulose gum showed a smaller volume mean D[4,3] particle size and a smoother mouthfeel compared to the unstabilized sample. However, the addition of protective hydrocolloids, even at the higher use level, was not enough to provide long-term suspension of pea protein; and these beverages showed sediment within minutes to hours after processing. The homogenization of the pea protein solution before incorporation into the system reduced the particle size and slightly delayed the settling of the proteins but still was not enough to achieve long-term stability. High acyl gellan gum addition was essential to provide long-term suspension of pea protein in these acidified pea protein beverages. All beverages containing blends of pectin/gellan gum and cellulose gum/gellan gum showed small particle size, higher pseudoplasticity, no sediment, and overall good stability at ambient and refrigerated temperatures throughout the four weeks of evaluation. Additionally, the homogenization of the pea protein solution before incorporation into the system improved the mouthfeel and gave these beverages a creamier appearance.

Based on these learnings, the most stable acidified pea protein beverages will result from the combination of a pea protein solution homogenized before mixing into the system as well as the inclusion of a blend of pectin/gellan gum or cellulose gum/gellan gum, providing the beverage with protein protection and suspension. In particular, high acyl gellan gum is a key ingredient for the long-term suspension of the pea protein in these low pH beverages.
OBJECTIVE

The objective of this study was to evaluate the effect of a selection of CP Kelco hydrocolloids at various use levels on an acidified pea protein beverages containing 1% protein (pH 4.0). In addition, the effect of homogenization of the pea protein before mixing with the rest of the system was also assessed.

INTRODUCTION

Growing interest from consumers in plant-based foods as well as higher priority of protein in their diets are increasing the demand for food and beverages containing pea protein in the market. As a result, manufacturers are incorporating pea protein in a variety of applications, including dairy alternatives, bakery, snacks, meat alternatives, sports nutrition, cereals, and ready-to-eat meals, among others. Pea protein is an interesting/valuable ingredient for these applications due to its high nutritional profile (e.g., great source of protein, easily digestible, low in calories) and trending claims (e.g., vegan, allergen-free, non-GMO) (Future Market Insights, 2016). In 2016, the number of new product launches in sports nutrition with pea protein was +65% over the previous year and is rising per Innova Markets Insights (2017). Moreover, up to double digit CAGR for the next 5 to 10 years have been reported by market research companies (Future Market Insights, 2016; Grand View Research, 2017; Market and Markets, 2015; Mordor Intelligence, 2018), and leading manufactures are expanding their production capabilities to accommodate this growing market (Crawford, 2018).

Pea protein is extracted from yellow and green peas, and is commercially available at high protein levels as concentrates (~50% protein) and isolates (~85% protein). As with any other protein, good solubility is essential for optimal functionality in food applications, especially in beverages. The solubility of pea protein can be greatly influenced by pH, heat, and overall processing history (Barac et al., 2015a). Pea protein exhibits a typical U-shape of solubility vs pH, with high solubility at neutral and alkaline pH (pH=7-8), moderate at pH below the isoelectric point (pH=3), and minimum near the isoelectric point (pH=5) (Barac et al., 2015b). In addition, heat treatment can further reduce the solubility of pea proteins due to protein denaturation (Habiba, 2002).

Globally, consumers continue to demand delicious and innovative beverages, including fermented beverages, fruit-protein smoothies, and flavored drinks made from various protein sources. In the United States, pea protein beverages are currently available in the market only at the neutral pH range (~6-8), and the market is being dominated by a few manufacturers. To keep their competitive advantage or for new players to get in the game, it is important for manufactures to continuously innovate and keep the customers engaged with new product launches. For example, pea protein may be combined with fruit juice, fruit puree, or other acidic ingredients to create new beverages with delicious and refreshing flavors, different nutritional profiles, and new consumption experiences. However, the development of these acidified pea protein beverages will present different challenges to the manufacturers in comparison to the neutral products due to the reduced solubility of pea protein at lower pH (Barac et al., 2015b).
When protein beverages are acidified to a pH close to or below the protein isoelectric point and are subjected to heat treatment, the proteins will denature and agglomerate, producing large protein aggregates. As a result, the protein will curdle and/or precipitate, ultimately affecting the visual stability and organoleptic attributes of the product. In these beverages, the addition of protein protective hydrocolloids (e.g., GENU® Pectin, CEKOL® Cellulose Gum) is required to make visually stable products with good sensory profiles. These protective hydrocolloids, when used appropriately, prevent or reduce the protein agglomeration, improving the suspension stability of the proteins based on Stoke’s Law. If the particles are small enough, the suspension will be effective. However, larger and denser particles will still tend to settle over time and might require a different hydrocolloid system for good suspension [CP Kelco, 2018].

High acyl gellan gum (KELCOGEL® Gellan Gum) is a highly effective suspending agent due to its pseudoplastic fluid gel network. At rest, the fluid gel has a very high apparent viscosity giving excellent suspension of insoluble particles. Yet, the fluid gel network is easily disrupted with low shear (e.g., agitation, drinking, pouring) due to its weak molecular associations, resulting in a low viscosity and light refreshing mouthfeel. However, gellan gum cannot prevent the aggregation of proteins in acidic environments. Thus, the combination of gellan gum with a protein protective hydrocolloid is required in these low pH protein beverages. Blends of cellulose gum and gellan gum (e.g., KELCOGEL® APx-B Hydrocolloid Blend) have proven to be effective in the stabilization of acidified dairy and soy protein beverages with larger/denser particles [CP Kelco, 2009b].

The stabilization of acidified protein beverages requires the proper selection of hydrocolloids with critical parameters in their use levels, batching steps (i.e., hydration of hydrocolloids and proteins, order of addition of ingredients) and processing conditions. In particular, the selection of stabilizers for these beverages tends to be mainly driven by the beverages’ properties (e.g., protein type, protein level, pH, and viscosity), labeling requirements (e.g., clean, natural), and costs.

The order of addition of ingredients is also critical for optimum performance of the stabilizers. In general, the recommendation is to properly hydrate the protein and the hydrocolloids prior to mixing the two solutions together. The protein/hydrocolloids solutions should then be mixed for an adequate time to allow sufficient interaction between these components. The last step should always be the acidification of the system, with additional time allowed for suitable pH equilibration [CP Kelco, 2011]. Furthermore, if the hydrocolloids are not hydrated properly, they will not be able to provide good protein protection to these beverages. It is important to follow the suppliers’ guidelines for proper dispersion and hydration as these steps can be unique for each ingredient. For example, the optimal way to prepare high acyl gellan gum solutions is to disperse the gellan gum into water or into a protein solution at ambient temperature without heating to avoid pregelation of the gellan gum, which often results in product variability due to localized concentrations of gellan. However, the gellan gum still needs to be hydrated later in the process. Thus, after dispersing the gellan gum in the system and adding all the ingredients into the system, a final heat treatment (>85°C) is required for proper hydration of this gum [CP Kelco, 2009a].

Although, the stabilization of acidified dairy and soy protein beverages has been studied in the past, no work has been done to understand the stabilization requirements for acidified beverages containing pea protein. As pea protein increases its market share in the beverage world, it is essential to gain a more complete understanding of the optimum selection of hydrocolloids to enhance the long-term stability and sensory profile of these beverages.
The acidified pea protein beverages were prepared by first mixing a hydrated 10% pea protein solution with the different hydrocolloid solutions, then adding remaining water and sugar (total of 8% cane sugar), and lastly slowly acidifying the beverages to pH 4.0 with pulp-free orange juice concentrate and a citric acid solution.

The following CP Kelco hydrocolloids were evaluated at use levels between 0.4% and 0.6% in this study: (1) GENU® Pectin (high ester pectin extracted from citrus peel is recommended for protein protection of low pH protein beverages when used as a sole stabilizer), (2) Experimental blends of KELCOGEL® Gellan Gum (high acyl) and GENU® Pectin (when used in combination with gellan gum, high ester pectin extracted from sugar beet pulp is recommended for protein protection), (3) CEKOL® Cellulose Gum, and (4) Experimental blends of KELCOGEL® Gellan Gum (high acyl) and CEKOL® Cellulose Gum. The hydrocolloids were prepared following the guidelines recommended by CP Kelco. A 2% pectin solution was prepared by dry blending the pectin with five parts sugar and dispersing it with high shear into 80°C purified water. After hydrating the pectin for five minutes, the solution was cooled in an ice bath to ambient temperature. To prepare the cellulose gum, cellulose gum/gellan gum, and pectin/gellan gum solutions, the different stabilizers were dry blended with five parts sugar and dispersed into ambient temperature purified water. These solutions were mixed for at least one hour or until the solution thickened and no visible lumps or “fish eyes” were present.

To make the pea protein solution, the pea protein (80% protein) was dispersed into 45°C purified water and mixed for 30 minutes. Next, the pea protein solution was cooled in an ice bath to ambient temperature, and part of the solution was homogenized through a two-stage Gaulin® homogenizer at 2500 psi (2000 psi first stage, 500 psi second stage) and the other part was not homogenized.
Each hydrocolloid solution was then mixed with the pea protein solution to make pea protein beverages with stabilizer use levels between 0.4% and 0.6% and a target of 1% protein. These hydrocolloid/protein solutions were mixed for 30 minutes to allow for sufficient interaction between the protective hydrocolloids (e.g., pectin, cellulose gum) and the proteins. Additionally, an unstabilized beverage containing 0.5% pea protein was prepared. This unstabilized sample was prepared with half the protein to demonstrate the effect of no stabilization, while minimizing the risk of damaging the processing equipment during heating due to excessive protein aggregation. Additional water and sugar were added to the hydrocolloid/protein solutions and the matrix was slowly acidified with pulp-free orange juice concentrate and a 50% w/w citric acid to pH 4.0. After acidification, samples were gently mixed for an additional 30 minutes to allow sufficient time for pH equilibration, at which point additional citric acid solution was added, if needed, to maintain the target pH.

These beverages were processed through a MicroThermics® UHT/HTST Lab-pasteurizer-25HV Hybrid with GEA® in-line homogenizer under the following processing conditions: preheat to 70°C, homogenize at 2500 psi (2000 psi first stage, 500 psi second stage), heat treat at 121°C for four seconds, and fill at 20°C into 250mL sterile containers. The beverages were stored at refrigerated (2-4°C) and ambient (20-25°C) temperature for four weeks for visual stability evaluation.

The overall stability and quality of the beverages were graded based on visual stability (e.g., sediment), particle size, viscosity flow curves, and mouthfeel. The day after processing, the particle size and the viscosity of the beverages were analyzed. The particle size of the acidified pea protein beverages was measured by light scattering using a Mastersizer® 2000 instrument (Malvern Instruments, Malvern, UK) under the following parameters: particle RI=1.35, Dispersant (water) RI=1.33, absorption=0.001. The particle volume mean D[4,3] and the particle size distribution (particle size vs volume) for each beverage were recorded. The viscosity was measured using a Brookfield® LV viscometer with a small sample adapter and spindle #18. Measurements were done at 20°C and torque values were recorded for various speeds starting from 100rpm to 2.5rpm. Only torque values between 10% and 100% were used for further analysis. The data was transformed using the Krieger-Elrod’s equation (Clark, 2017) and viscosity flow curves were generated by plotting shear rate (1/s) vs. viscosity (cP).

Visual stability was monitored over four weeks of refrigerated and ambient temperature storage with particular attention given to protein aggregation and sedimentation. Scientists in the laboratory performed an informal sensory panel to describe the smoothness of the
RESULTS AND DISCUSSION

The stabilization of acidified protein beverages can be challenging, especially when the wrong stabilizers are used, the stabilizers are not used at a sufficient concentration, or the products are not prepared under the right batching and processing conditions. The type of stabilizers used and critical processing steps can be the difference between stable and unstable products.

In these acidified pea protein beverages the use of protective hydrocolloids (i.e., GENU® Pectin, CEKOL® Cellulose Gum) was required to prevent the proteins from aggregating and sedimenting at an acidic pH, especially after heat treatment. Both the cellulose gum and pectin were able to prevent/reduce the protein agglomeration, resulting in beverages with small particle volume size D[4,3] (Figure 1) and narrower particle size distribution (Figure 2) in comparison to the unstabilized beverage. Moreover, all beverages containing cellulose gum and pectin had a smoother mouthfeel, which can be attributed to the smaller particle size.

![Figure 1](image-url). Particle volume mean D[4,3] of acidified pea protein beverages stabilized with different CP Kelco hydrocolloids (unstabilized, 0.6% GENU® Pectin, 0.6% GENU® Pectin/KELCOGEL® Gellan Gum, 0.6% CEKOL® Cellulose Gum, 0.6% CEKOL® Cellulose Gum/ KELCOGEL® Gellan Gum) and using homogenized pea protein solution.
The addition of protective hydrocolloids, even at the higher use level, was not enough to provide long-term suspension of pea protein, and these beverages showed sediment within minutes to hours after processing (Figure 3). Moreover, the beverages with CEKOL® Cellulose Gum were more unstable than the ones stabilized with pectin and presented sediment immediately after filling. These results indicate that at the same use level, pectin is more effective than cellulose gum in preventing protein aggregation.
The homogenization of the pea protein solution before incorporation into the system improved the mouthfeel and gave the acidified pea protein beverages a creamier appearance (Figure 4). Moreover, this homogenization step narrowed the particle size distribution (Figure 5) and slightly delayed the settling of the proteins. Nonetheless, in the beverages stabilized with only cellulose gum or pectin, homogenization was still not enough to prevent sedimentation (Figure 4).

Figure 4. Visual stability of acidified pea protein beverages stabilized with only protein protective hydrocolloids (0.4% GENU® Pectin, 0.5% CEKOL® Cellulose Gum) with and without homogenization (hmg.) of the pea protein solution and stored at ambient temperature for four weeks.

Figure 5. Particle size distribution of acidified pea protein beverages stabilized with different CP KELCO hydrocolloids (0.4% GENU® Pectin, 0.5% CEKOL® Cellulose Gum) with and without homogenization (hmg.) of the pea protein solution.
High acyl gellan gum addition was essential to provide long-term suspension of pea protein in these low pH beverages. All beverages containing blends of cellulose gum/gellan gum and pectin/gellan gum showed small particle volume mean D[4,3] (Figure 1), narrow particle size distribution (Figure 2), no sediment, and overall good stability (Figure 3) at ambient and refrigerated temperatures throughout the four weeks of evaluation. In these beverages, the protective hydrocolloids prevented/reduced the agglomeration of proteins, while the gellan gum provided good suspension of the insoluble particles. In addition, the viscosity flow curves showed higher pseudoplasticity (Figure 6) for the beverages containing gellan gum compared to the ones with only protective hydrocolloids. Thus, the good suspension of the cellulose gum/gellan gum and pectin/gellan gum systems can be attributed to the pseudoplastic fluid gel network formed by the high acyl gellan gum.

Figure 6. Viscosity flow curves of acidified pea protein beverages stabilized with different CP Kelco hydrocolloids (0.6% GENU® Pectin, 0.6% GENU® Pectin/KELCOGEL® Gellan Gum, 0.6% CEKOL® Cellulose Gum, 0.6% CEKOL® Cellulose Gum/ KELCOGEL® Gellan Gum and using homogenized pea protein solution.
As the results of this study indicate, the production of stable acidified protein beverages containing pea protein require a comprehensive approach and many factors should be taken into consideration during the development of these products. In general, proper selection and concentration of hydrocolloids are requirements for good stability. In addition, processing steps, such as homogenization of the pea protein solution before incorporating into the system, can further enhance the stability, physical appearance, and organoleptic attributes of these beverages. The acidified pea protein beverages containing 0.6% cellulose gum/gellan gum or 0.6% pectin/gellan gum, with pea protein that was homogenized, had a very smooth mouthfeel and the best visual stability.

Beyond the parameters evaluated in this study (e.g., type of stabilizer, homogenization of pea protein), many other factors can affect the stability and mouthfeel of these products. In particular, the results of this study are specific to 1% pea protein beverages at pH 4.0. The required use levels and optimum type of hydrocolloids can change if the protein level, protein type, pH, and other factors are modified. It is always recommended to work with the hydrocolloid and protein suppliers during development of these beverages.

CONCLUSION

The development of stable acidified beverages containing pea protein require a comprehensive approach and many factors should be taken into consideration during the development of these products. Based on the learnings from this study, the most stable acidified pea protein beverages will result from the combination of a pea protein solution homogenized before mixing into the system as well as the inclusion of a blend of CEKOL® Cellulose Gum/KELCOGEL® Gellan Gum or GENU® Pectin/KELCOGEL® Gellan Gum, providing the beverage with protein protection and suspension. In particular, high acyl gellan gum is a key ingredient for the long-term suspension of the pea protein in these low pH beverages.
YOUR PROTEIN-PACKED FORMULATION DESERVES THE BEST NATURE-BASED INGREDIENT SOLUTIONS

CP Kelco is a nature-based ingredient solutions company with over 85 years of experience working with food, beverage and consumer products manufacturers worldwide.

We apply ingredient innovation and problem-solving to develop customized solutions that leverage our regional insights, meet manufacturers’ goals and address consumer preferences.

Why CP Kelco

Unique Portfolio. Produces extensive range of high-quality, plant-based and fermentation-derived ingredients to formulate tailored solutions.

Technical Excellence. Offers strong collaboration with a global team of scientists and applications experts, leveraging our regional state-of-the-art R&D facilities.

Sustainability. Committed to providing responsibly sourced and produced ingredients.

Market Insights. Understand market and consumer trends to help customers create relevant and innovative products.

Talk to CP Kelco about how we can help you unlock nature-powered success today.

The information contained herein, is, to our best knowledge, true and accurate. All recommendations or suggestions are made without guarantee, since we can neither anticipate nor control the difference conditions under which this information and our products are used. There are no implied or express warranties of fitness for purpose. Each manufacturer is solely responsible for ensuring the final products comply with any and all applicable federal, state and local regulations. Further, CP Kelco disclaims all liability with regard to customers’ infringement of third party intellectual property including but not limited to, patents. CP Kelco recommends that our customers apply for licenses under any relevant patents.

cpkelco.com | solutions@cpkelco.com
17. Mordor Intelligence, Plant Protein Market Reports (Global, Europe, South America), 2017.