

Wheat Protein Isolates—Alternative to Sodium Caseinate



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Wheat protein isolates have various attributes ranging from gluten-like vitality to 100% solubility. Alternatively, they can possess gliadin-like extensibility with film-forming properties on the microscopic level.

These functions are desirable in numerous food applications, however, until now, wheat protein isolates have been primarily commercialized within the baking realm and related wheat-based industries.

Further advancements in wheat protein modification have created a new generation of functional ingredients with unique benefits such as emulsification, foaming capacity and stability, gel viscosity, and water binding. Importantly, these modifications have been coupled with further patented technologies to ensure excellent organoleptic appeal, high nutritional value, easy scale-up, genetic integrity, and cost effectiveness—factors, which in the past, have limited their past commercialization in nonwheat-based food systems.

Although many products were developed utilizing these modified proteins, this article is focused on sodium caseinate replacement in coffee creamers and other food products such as cream sauces and whipped toppings.

Sodium Caseinate

Casein is the foundation of sodium caseinate and deserves a brief discussion of its chemical properties. Caseins can be classified as phosphoproteins, and these phosphate groups help give the characteristics of water-binding capacity, solubility, and stability.

Casein is an insoluble protein at pH 4.6 and contains a large amount of proline residues (a hydrophobic amino acid). Because of this proline interfering with the helix and sheet structure, it possesses virtually no tertiary structure but rather a quaternary structure, or often known as a casein micelle. Hence, their structure is amphoteric and provides hydrophobic and hydrophilic regions.

The choice of salt is extremely important and affects important properties such as solubility and emulsification. For example, calcium caseinate forms more of a colloidal suspension rather than a true solution. In addition, the calcium ions form cross-bridges between the casein molecules, making them somewhat bulbous. This interaction restricts the casein tail from properly associating with fat globules, leading to poor emulsification capacity.

Consequently, the sodium salt of casein has been the traditional salt of choice in applications such as nondairy creamers, ice cream, cream sauces, and in nonfood areas such as sizing agents in paper and dye fixing in textiles.

Converting the science into application, sodium caseinate is well suited to coffee creamers because its amphoteric structure binds water and oil extremely well, thus providing a creamy mouthfeel, opacity, and a characteristic milky white color.

It also has some unique attributes that until now have been hard to substitute economically. Apart from getting sufficient emulsion capacity, there are a number of distinct challenges that can be solved in the lab but typically come undone when added, as part of a complex oil-in-water emulsion, to a cup of coffee.

Issues such as heat, pH, solubility, water hardness, and emulsion stability are all factors that need to be addressed to ensure that the mouthfeel, texture, and color of the final product, through heating, cooling, and acid cycles, remain in tact.

Evidence of the severity of hot coffee on a creamer is supported by the fact that sodium caseinate, a superb emulsifier, needs to be reinforced by other emulsifiers such as mono- and diglycerides, sodium stearoyl lactylate, and soy lecithin to ensure a stable emulsion.

Wheat Protein Isolates Alternative to Caseinates

In recent years, imitation coffee creamers, milks, whipped toppings, cheese, sour creams, etc., have increasingly been accepted by consumers as a replacement for the most costly natural dairy products. The functional attributes of milk proteins

in natural and synthetic cheese products are unique. However, milk protein casein is expensive and has low solubility for imitation dairy products. Vegetable proteins are sensitive to a wide variety of conventional food processing and recipe conditions that do not normally affect milk proteins. Relatively mild physical processing conditions such as heating, drying, moisture level, etc., are known to adversely affect its properties. Factors such as the nature and character of the recipe additives, concentrations, ionic strength, pH, temperature, and recipe preparation affect these interactions and functional properties. Vegetable protein molecules undergo complex association, disassociation, and chemical reactions with one another as well as with other molecules that may be present in any given system. Consequently, vegetable protein isolates can be utilized to provide functional attributes to products such as imitation cheeses and nondairy creamers among others.

Wheat gluten can readily be separated from wheat flour simply by working wheat flour dough under a stream of water. The suspendible starch fraction of the flour is washed away, leaving mainly water-insoluble wheat gluten normally containing approximately 75% by weight protein, 8% by weight lipid, and with the remainder being ash, fiber, and residual starch. Wheat gluten can then be separated into its primary proteinaceous components, gliadin and glutenin. The protein in wheat consists of four separate fractions that differ distinctly in their solubility; globulins at 3%, albumins at 15%, gliadin at 33%, and glutenin at 49%. Gliadin and glutenin are prominent in vital wheat gluten, which has approximately 75% protein.

Wheat gliadin, with very low ionic strength, shows hydrophilicity and hydrophobicity and possesses excellent film-forming ability. Although insoluble in water, a surfactant or pH adjustment will result in its dissolution. Wheat glutenin, the other fraction of gluten, has highly elastic and rubbery properties, shows resistance to shear in dough systems, and helps strengthen frozen and refrigerated dough. It is insoluble in alcohol and neutral water, requiring the addition of a surfactant or a pH adjustment to dissolve.

Gluten in its native form is insoluble unless mechanical shear or a modification such as chemical reduction, acid modified, or hydrolysis is performed. By solubilizing gluten, it becomes surface active just like sodium caseinate, again because of the amphiphilic characteristic that soluble proteins possess.

Table I. Emulsification of a modified wheat protein versus sodium caseinate

	Emulsification Stability ^a		Whiteness (L)	Emulsifying Capacity (mL)
	400 × g (%)	1,600 × g (%)		
Modified wheat protein isolate	80	61	87.1	640
Caseinate	67.5	56	87.1	820

^a Emulsification stability = 1 g of protein + 99 g of water (50°C) + 100 mL of oil, mix for 5 min, and centrifuge for 3 min.

Table II. Generic creamer formula

Ingredients ^a	%
Water	49.9
High fructose corn syrup	31.7
Dipotassium orthophosphate	0.9
Hydrogenated palm oil	15.9
Defatted and decaffeinated isolated wheat protein (Manildra Group USA)	1.1
DATEM	0.3
Distilled monoglyceride	0.3

^a Percentage of solids before drying = 45.5; after drying, protein = 2.5 and fat = 35.

The ability of wheat protein to whip, form an emulsion, and ultimately stabilize foams depends on the type and extent of modification on the wheat protein.

For example, wheat protein can be modified so that the gluten structure, responsible for holding more water than sodium caseinate, unfolds and exposes nonpolar side chains. The extent of this unfolding has been one of the keys in binding fat and becoming an effective emulsifier.

Table I shows the emulsification stability (at two various shear levels), emulsion color, and emulsion capacity of the modified wheat protein versus sodium caseinate. At pH 7, the ability to whip and form a water-in-oil emulsion capable of capturing air depends largely on solubility or high net charges on the protein. However, this does not always equate to a stable product. Even though sodium caseinate has a higher emulsification capacity, its stability is significantly less than the modified wheat protein. This can provide some real benefits when formulating products such as coffee creamers, in which additional emulsifiers are required to help support existing ingredients such as sodium caseinate. This resistance to coalescence and flocculation under various different environments of pH, heat, and shear makes this a very functional ingredient.

On an equal weight basis, wheat protein isolates can be directly and easily substituted for sodium caseinate in a creamer formula (Table II). When directly substituted, there were no signs of feathering or insolubility when the creamer was placed into a hot cup of coffee. The procedure includes two phases—water and oil. The steps for the water phase are: heat water to 65°C, add high fructose corn syrup and then add dipotassium orthophosphate. The steps for the oil phase are: heat oil to 65°C (149°F), add protein to oil and mix well, add emulsifiers to water and mix well, and then add oil phase to the water phase and blend thoroughly. The homogenization is a two stage process. Stage one = 250 bar and stage two = 50 bar. Last, spray dry.

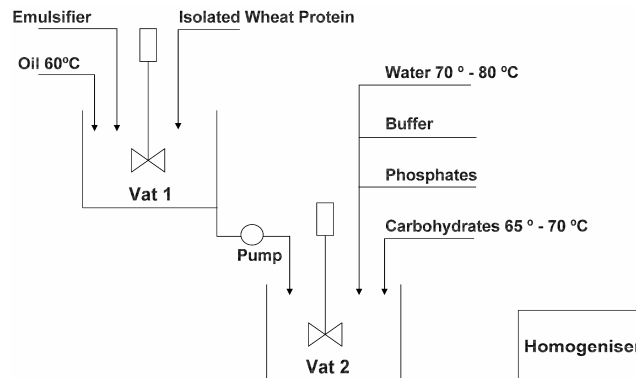


Fig. 1. Proposed coffee creamer method.

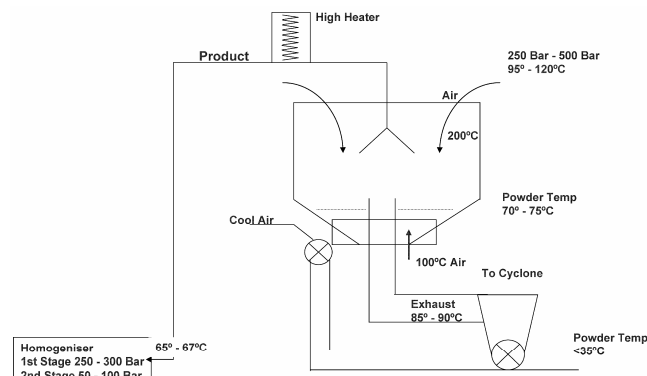


Fig. 2. Proposed coffee whitener method.

In addition, no extra process steps are required. This is demonstrated in Figs. 1 and 2 with a generic process flow diagram.

The benefits are numerous. Primarily, there is significant savings compared with sodium caseinate plus the potential bonus of removing other emulsifiers that leads to a cleaner label and further financial benefits. Sodium caseinate prices also tend to fluctuate significantly, making any forecast on formula's using this ingredient challenging.

Flavor

Cereal and legume proteins have been used in the past, particularly soy and wheat, but their inherent flavor limited their application to extension rather than substitution. In wheat, the characteristic flavor has been a consequence of the lipid that is extremely well bound to the protein. However, this fat can be efficiently removed, leading to a clean mouthfeel with no unpleasant aftertaste. Color has also been enhanced as a consequence of using this specific technology to remove removing this bound lipid.

Allergen

Allergens are always a point of consideration and deserve some comment. The celiac population in the United States has been estimated at 0.75% (University of Maryland Center for Celiac Research). These figures are at, or below, other members of the big eight such as seafood at 2.3% and peanut/tree nut at 1.1%. Of the big eight allergens, gluten represents the lowest risk, in that there have been no recorded fatalities.

One must question whether dairy-intolerant people avoid nondairy creamer because it is a dairy derivative even though it possesses no lactose. Whatever the case, the substantial economic and functional benefit of using cereal proteins in nonwheat-based

applications should be closely examined before being dismissed purely on the grounds of allergenicity alone.

Other industries have analyzed allergen issues and have proceeded to successfully cross-mix allergens. Such examples include soy in meat analogues, wheat in vegetarian meat substitutes, dairy in baked goods, and wheat in beef jerky.

Conclusion

Wheat protein isolates and hydrolyzates possess a varying array of solubilities, viscosities, pH values, protein levels, vitality, and strength. Leveraging these properties provides formulators with cost-effective alternatives to obtain emulsification stability, foaming capacity, and gel viscosity, to mention a few, in their food systems.

As an alternative to sodium caseinate, the modified wheat protein provides

1. Increased functionality,
2. No off-flavors, color or odor
3. A very cost-effective alternative
4. A readily available and consistent ingredient
5. Consistent performance in a given food system.
6. A potentially cleaner ingredient label (void of ingredients such as DATEM and mono- and diglycerides).

These significant advantages should not be ignored based purely on allergen concerns that affect a small amount of the population.

Going forward, wheat proteins isolates will continue to evolve and offer an additional tool to improve ingredient functionality and minimize overall formula costs without sacrifice to taste, appearance, or manufacturing efficiency. Ultimately, this additional resource will help create products that meet consumer expectations that are heavily geared toward taste, price, and value perception.

An advertisement appeared here
in the printed version of the journal.