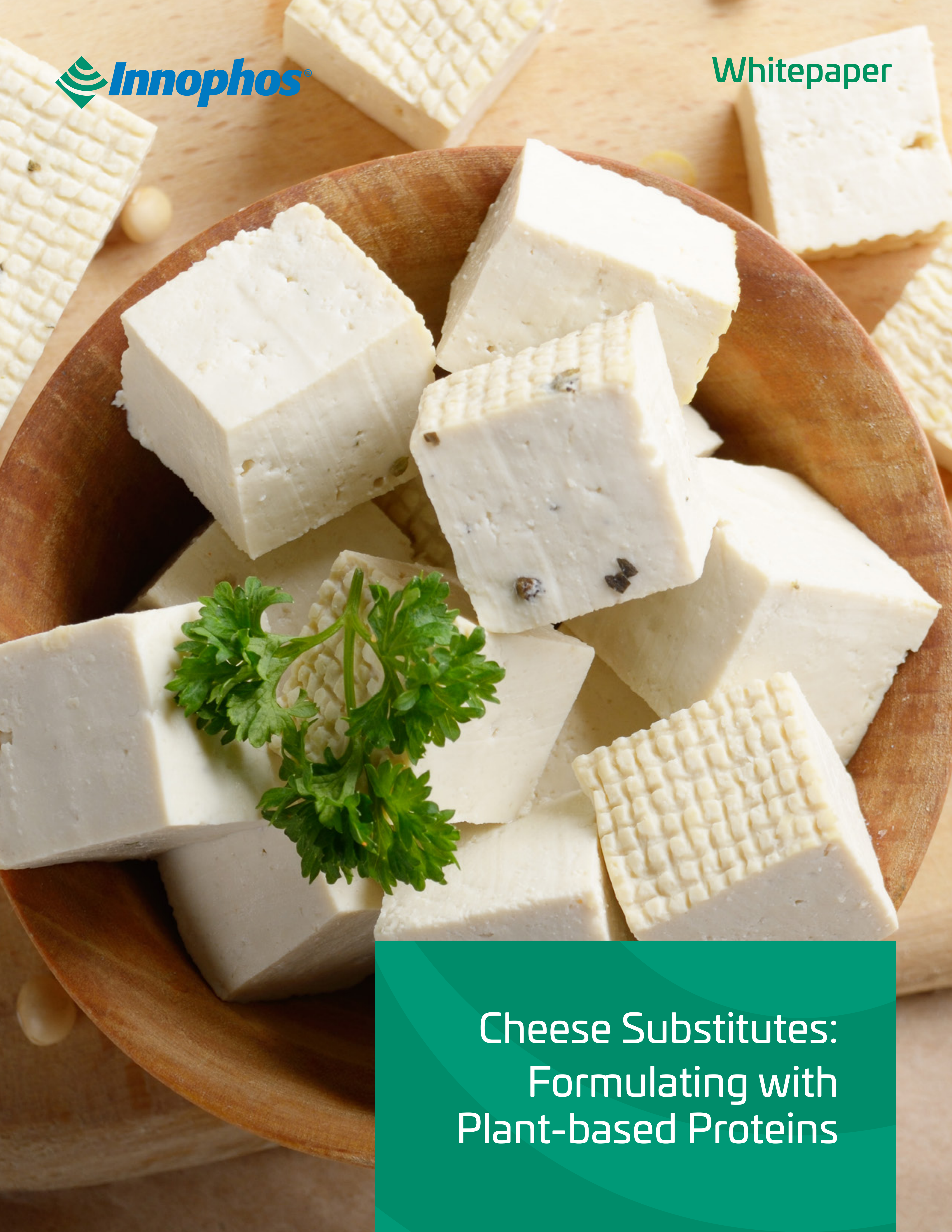
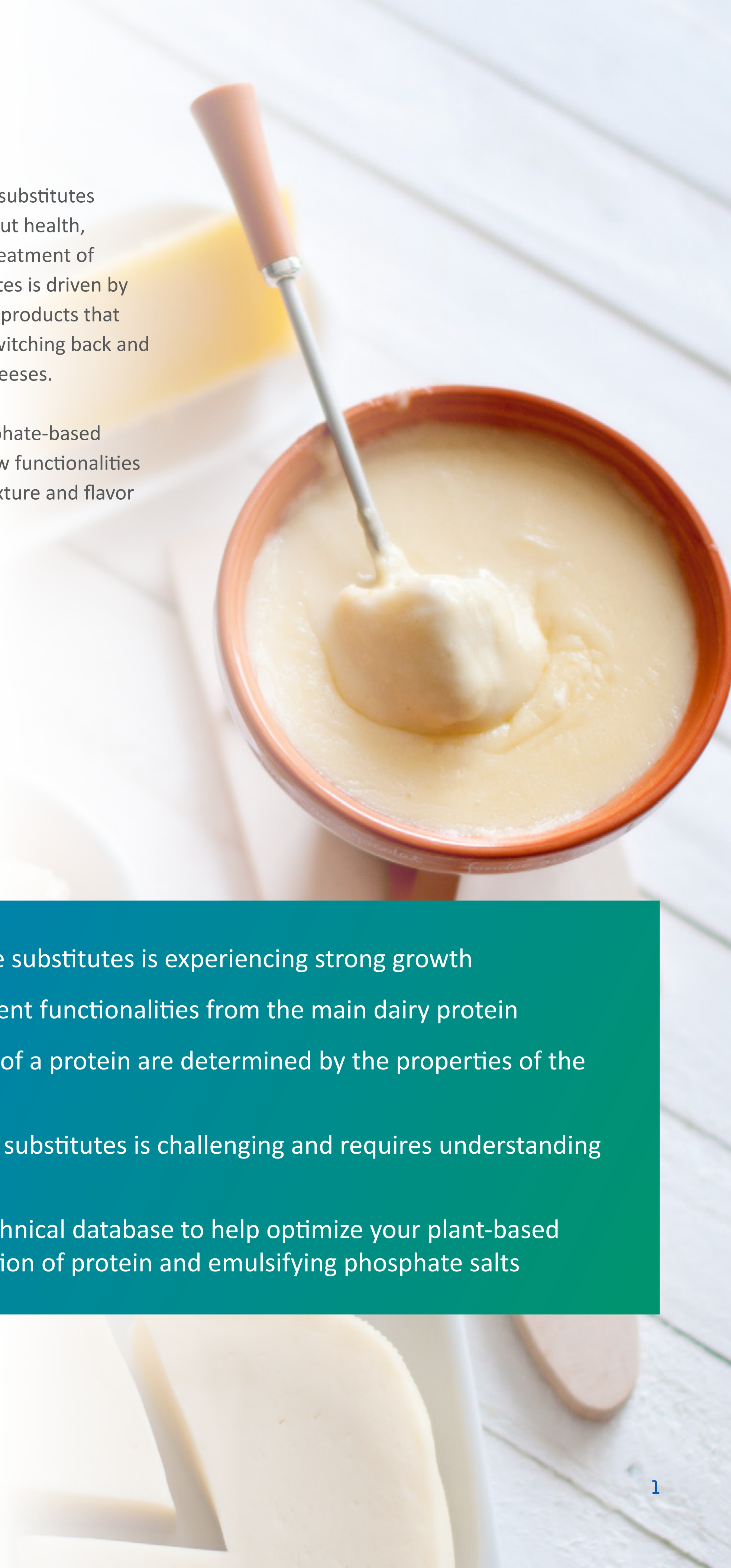
Whitepaper



Cheese Substitutes: Formulating with Plant-based Proteins



Formulating Appealing Cheese Substitutes

Consumers are seeking non-dairy plant-based substitutes to traditional cheeses to address concerns about health, environmental sustainability and the ethical treatment of animals. The recent growth of cheese substitutes is driven by new ingredients and processes which result in products that satisfy the taste buds of consumers who are switching back and forth between dairy-based and plant-based cheeses.

At Innophos, our deep understanding of phosphate-based technology allows us to offer solutions and new functionalities that help overcome the challenges of taste, texture and flavor when formulating with plant-based proteins.

Key Messages:

- The market for non-dairy cheese substitutes is experiencing strong growth
- Plant-based proteins have different functionalities from the main dairy protein
- The physicochemical properties of a protein are determined by the properties of the amino acids in it
- Formulating high quality cheese substitutes is challenging and requires understanding of protein functionality
- At Innophos, we have built a technical database to help optimize your plant-based cheeses with the right combination of protein and emulsifying phosphate salts

Market Opportunity for Cheese Substitutes

Non-dairy cheese substitutes are experiencing a strong growth in the U.S., accounting for 10% of total new product cheese launches in 2020, up substantially over the past five years.[1] The percentage of cheese substitute introductions doubled in 2020. And plant-based claims, while small, grew by 165% CAGR over the past five years, with its strongest growth occurring over the past two years. As plant-based cheese substitutes gain acceptance, consumer expectations regarding flavor, taste and texture are driving increased levels of innovation and quality.

Plant based claims grew by 165% CAGR over the past five years.

Meeting the Challenge of Plant-Based Cheese Substitutes

Understanding the underlying mechanisms that influence protein interactions and developing strategies for improving plant-based protein functionalities is critical to formulate similar physical, chemical, and sensory attributes. Plant-based proteins function differently than dairy proteins because of their different amino acid compositions and sequences, protein structure and conformation. The functional properties of dairy proteins (e.g. caseins) allow them to form gels, hold water, foam, emulsify, absorb fat and solubilize under different conditions.[2] Caseins have very good solubility and heat stability above pH 6, but it is their unique amphiphilic structure which bring about their emulsifying properties. They form suspensions called casein micelles. These caseins micelles are held together by calcium ions and hydrophobic interactions.[3] In addition to the nutritional attributes provided by the dairy protein, the functionality of the casein impacts heat stability, meltability and sensory attributes. Innophos has built an extensive technical database supporting an in depth understanding of how to formulate vegan cheese products with similar physical, chemical, and sensory properties as their dairy counterparts.

Technical Database of Plant Proteins

At Innophos, we constructed a technical database with key functional properties of the most used plant-based proteins in cheese substitutes including pea, fava, and potato. For example, the database shows that while the emulsification capacity of the potato protein isolate is the highest when compared to pea and fava protein isolates, its emulsification stability is the lowest. Similar results are observed with foaming capacity and stability. Regarding the gel strength, pea protein isolates are better than potato and fava in providing gel strength.

Our database shows how the use of different emulsifying salts (ES), including orthophosphates, polyphosphates and sodium citrates, can help you modify the inherent functional properties of the different protein isolates.

Emulsifying Capacity (EC) and Emulsifying Stability (ES) – Measures the ability of the protein to participate in emulsion formation and stabilizing the newly created emulsion.

Foaming Capacity (FC) and Foaming Stability (FS) – Measures the ability of the protein to form and stabilize foams.

Gel Strength – Measures the firmness and the ability of the protein to form solid viscoelastic gels.

Table 1. Emulsifying salts influence the functional properties of plant-based proteins

COMMON NAME	PLANT SOURCE	% PROTEIN	FUNCTIONAL PROPERTIES		
			EMULSIFYING	FOAMING	GELATION
Pea Protein Isolate	*Pisum sativum*	83%	ES6, ES8	ES3, ES6	ES3 (harder); ES7 (softer)
Potato Protein Isolate	*Solanum tuberosum L.*	90%	ES5, ES9	ES3	ES10 (harder); ES11 (softer)
Fava Protein	*Vicia faba*	60%	ES1, ES10	ES3, ES5	ES4 (harder); ES6 (softer)

ES1 - 11 represent different emulsifying salts

Pea Protein Isolate Case Study

Let's take as an example pea protein isolate, which can have a nutritional quality comparable to that of casein.[4] Pea protein has been used as an emulsifier and shown to decrease the interfacial tension between water and fat by forming a rigid membrane at the oil-water interface.[5] The capacity of pea protein isolate to stabilize food emulsions can be further optimized. In our studies, the addition of an emulsifier salt (ES6) offered the best results to improve both the emulsification capacity and stability of the pea protein isolate with the addition of emulsifying phosphate salts.

Table 2. Emulsification properties of pea protein isolate with different emulsifying salts[1]

PROTEIN	EC - %	ES - %
Pea Protein Isolate - Control	65.6	65.6
Pea Protein Isolate + ES6	70.0	68.8
Pea Protein Isolate + ES8	68.1	68.1

[1]Note: Experimental conditions - 8 g protein, water/corn oil, with and without 1% emulsifying salt.

Another important functional property in the cheese manufacturing process is gelation. Gelation contributes to the formation of solid viscoelastic gels, improves water absorption, thickening and participates in emulsion stabilizations. It is a process during which proteins unfold, rearrange, associate and aggregate to establish a three-dimensional network of molecular structure. The example below shows the effect of two different emulsifying salts on the gel strength of the pea protein isolate.

Figure 1. Pea protein isolate with different gel strength[2]

[2]Note: Experimental conditions - 10% protein (w/w) + with or without 1% ES (w/w); Heated with shear at 90°C for 25 min. Cooled for 24 hours under refrigeration temperature before measuring firmness with a texture analyzer.

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Application Science

Finished Product: Pea Protein Cheese Block

Using the same pea protein isolates and various emulsifying phosphate salts, we can make a plant-based cheese block (Example 1) or a plant-based cheese sauce (Example 2) by bringing about different textural attributes of the vegan proteins.

Example 1. Cheese Block Formulation

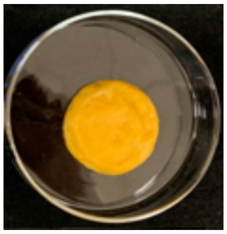
FORMULA FOR CHEESE BLOCK	%
Pea Protein Isolate (80%)	5.0
Palm Oil	23.7
Tapioca Starch	11.2
Potato Starch	7.0
Textur-Melt® NM69 (emulsifying salt)	2.0
Salt	1.8
Annatto	0.2
Water	49.1
TOTAL	**100.0**

Figure 2. Shredability and Melt Properties

Pea Control

Pea Textur-Melt® NM69

Pea Control



Pea Textur-Melt® NM69

The addition of Textur-Melt® NM69 to cheese block formulation containing the pea protein isolate resulted in improved moisture content, shredability and melt properties of the vegan cheese.

	pH	MOISTURE (%)	SCHREIBER MELT #	SHREDABILITY	COMMENTS
Control	6.4	46.8	1.9	Tacky Less shredable	Oiling out Minimal melt, Dull color
+ Textur-Melt® NM69	6.5	49.3	2.0	Shredable	Better melt Emulsion retained

Finished Product: Pea Protein Cheese Sauce

Example 2. Cheese Sauce Formulation

FORMULA FOR CHEESE SAUCE	%
Pea Protein Powder	13.3
Water	61.0
Canola Oil	21.4
Textur-Melt® WM86 (emulsifying salt)	2.1
Pea Starch	2.1
Color	0.1
TOTAL	**100.0**

Figure 3. Texture and Appearance

Pea Control

Pea Textur-Melt® WM86

Pea Control

Pea Textur-Melt® WM86

The addition of Textur-Melt® WM86 to a cheese sauce containing pea proteins provided better emulsification properties and adherence, and improved texture and creaminess, thus, resulting in a much more appealing product.

	pH	BROOKFIELD VISCOSITY (cP)	SOFTNESS (g)	BOSTWICK VISCOSITY (cm@25°C)
Control	6.9	20,000	10.7	9.8
+ Textur-Melt® WM86	7.8	80,000	12.6	3.5

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Conclusion

Phosphate-based emulsifying salts alter protein functionalities by changing the chemical and physical properties, which can improve the hydrophobicity, solubility, dispersibility and emulsification properties. By understanding the plant-based protein functionalities and modulating with emulsifying salts, we can achieve dairy alternative cheeses with desirable textural profiles while addressing consumer needs of newer alternative healthy and sustainable food products. Innophos has a robust understanding of plant-based protein functionalities and extensive application know-how to help you formulate high-quality cheese alternatives.

Reach out to our technology team to optimize your plant-based protein products.

www.innophos.com

[1.] Innova Market Insights, Plant based Trends 2021.

[2.] Aryee, A. N. A., Agyei, D., & Udenigwe, C.C. (2018). Impact of processing on the chemistry and functionality of food proteins. In R. Y. Yada, Woodhead Publishing Series in Food Science, Technology and Nutrition, *Proteins in Food processing* (Second Edition), 27.

[3.] Kapoor, R., & Metzger, L. (2008). Process Cheese: Scientific and Technological Aspects - A review. *Comprehensive Reviews in Food Science and Food Safety*, 194.

[4.] Yang, H. et. al. (2012). Evaluation of Nutritional Quality of a Novel Pea Protein. *AgroFood Industry vol23*(6), 8.

[5.] Lu, Z. X., HE, J. F., Zhang, Y. C., & Bing, D. J. (2019). Composition, Physicochemical Properties of Pea Protein and Its Application in Functional Foods. *Critical Reviews in Food Science and Nutrition,* 1.