The OSCAR PUBLISHING Services
American Journal of Applied Science and Technology

VOLUME Vol.06 Issue 02 2026
PAGE NO. 211-215
DOI 10.37547/ajast/Volume06Issue02-13

Selection and Justification of Components for Protein-Carbohydrate Compositions

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Received: 31 December 2025; **Accepted:** 23 January 2026; **Published:** 28 February 2026

Abstract: This study examines the nutritional and biological characteristics of soybean, barley, and dairy whey as promising raw materials for the development of functional protein–carbohydrate food compositions. Soybean is characterized by a high protein content, reaching approximately 40%, and contains essential amino acids, vitamins, carotenoids, and tocopherols. Its ability to biologically fix atmospheric nitrogen also increases its agricultural and ecological importance. Barley is distinguished by a relatively balanced ratio of calcium, phosphorus, magnesium, and potassium, indicating its potential as a physiologically valuable cereal raw material. Comparative analysis demonstrated that soybean contains higher concentrations of β-carotene and tocopherols than several cereal crops. The amino acid composition of different protein preparations revealed considerable differences in biological value and protein utilization. Whey was evaluated as an additional source of lactose, minerals, and biologically active compounds. The chemical composition of curd, cheese, and casein whey varied depending on acidity, pH, lactose, mineral substances, and dry matter content. The findings confirm the technological potential of combining soybean, barley, and whey for developing nutritionally balanced functional food products.

Keywords: Soybean seeds, bioactivation, germination, wet dehulling, amino acid composition, antinutritional factors, protein–carbohydrate complex, hydration properties, dietary fiber, meat substitute.

INTRODUCTION:

The development of nutritionally balanced and biologically valuable food products is currently one of the major priorities of modern food science and technology. Increasing consumer demand for functional foods has stimulated research into alternative plant and animal raw materials capable of providing proteins, carbohydrates, vitamins, minerals, and biologically active compounds. Among such materials, soybean, barley, and dairy whey are considered promising ingredients for the production of protein–carbohydrate compositions and functional food products.Soybean occupies a leading position among leguminous crops because of its high protein and lipid content, favorable amino acid composition, and significant nutritional value. Soybean seeds contain approximately 40% protein and are rich in essential amino acids, particularly lysine, threonine, and leucine. In addition, soybean contains B-group vitamins, vitamin C, β-carotene, and tocopherols, which contribute to its antioxidant and biological properties. Its capacity for symbiotic nitrogen fixation also makes soybean an environmentally and agriculturally important crop. Barley is another valuable cereal raw material due to its mineral composition and relatively balanced ratios of calcium, phosphorus, magnesium, and potassium. These characteristics support its potential application in

functional foods and nutritionally balanced formulations. Dairy whey represents an important secondary raw material containing lactose, minerals, proteins, and other biologically active components. The composition of whey depends on its origin and technological processing. Therefore, the combined use of soybean, barley, and whey may provide an effective basis for developing innovative food compositions with improved nutritional and functional properties.

METHODS

The research objects included soybean seeds, barley grain, and different types of dairy whey, including curd whey, cheese whey, and casein whey. These raw materials were selected due to their nutritional value, protein content, mineral composition, and potential application in the development of functional protein–carbohydrate food compositions. Soybean was investigated as the main plant-based protein source, barley as a cereal raw material with valuable mineral characteristics, and dairy whey as a source of lactose, proteins, minerals, and biologically active compounds. The nutritional and biological characteristics of soybean and barley were evaluated by analyzing available data on their chemical composition, amino acid profile, vitamin content, antioxidant components, and macroelement ratios. Particular attention was given to the content of protein, essential amino acids, β-carotene, tocopherols, calcium, phosphorus, magnesium, and potassium. The comparative evaluation of soybean and cereal crops was performed to determine the nutritional advantages of soybean as a plant protein source and barley as a physiologically valuable cereal raw material. The amino acid composition and biological value of protein preparations from different sources were comparatively analyzed. The investigated protein sources included soybean protein, whey protein, egg protein, casein, and beef protein. Their nutritional quality was evaluated according to the content of essential amino acids and indicators of biological value and protein utilization. Special attention was given to lysine, leucine, valine, threonine, methionine, and tryptophan, as these amino acids play an important role in determining the biological quality of food proteins. The chemical composition of curd, cheese, and casein whey was evaluated according to water content, dry matter, fat, lactose, ash, titratable acidity, and pH. Comparative analysis was performed to identify differences in the technological and nutritional properties of various whey types. The obtained data were analyzed using comparative and descriptive methods. The results were presented in tables and figures to demonstrate differences in nutritional composition, mineral ratios, amino acid profiles, and physicochemical characteristics. Based on the obtained results, the suitability of soybean, barley, and dairy whey for the development of nutritionally balanced and biologically valuable functional food compositions was assessed.

RESULTS AND DISCUSSION

Among leguminous crops, soybeans are distinguished by their biological and agro-ecological properties. It has the ability to biologically fix atmospheric nitrogen in symbiosis with bacteria, which increases the level of soil nitrogen supply and serves to preserve its fertility. Therefore, soybean is considered a promising crop that can be effectively grown even on sandy and relatively low-fertility agricultural lands. According to the main nutritional criteria, such as the amount and quality of protein, the share of the oil fraction, and the content of fatty acids, soybean occupies a leading position among leguminous crops. The protein content in soybean seeds reaches up to 40%, and they are a source of high biological value with a complete proteinogenic amino acid composition. In particular, soy protein is a rich source of essential amino acids such as lysine, threonine, and leucine. According to the indicator of biological value (BV), leguminous crops are arranged in the following order: soybeans - 80%, beans - 60%, peas - 51%, lentils - 48% and other types of peas - 43%. Soybean seeds contain water-soluble vitamins (B1, B2, B6, B7, B9) and ascorbic acid (C). Compared to cereal crops, soybean seeds have a significant advantage in the content of β-carotene and tocopherols.

Table 1

Comparative indicators of soybean and grain crop seeds by β-carotene and tocopherol content

Raw materilas	β-carotene, mg%	Tocopherol, mg%
Soybean	0,32-0,55	8,5-18,0
Barley	0,30-0,49	3,9-16,2
Millet	0,014-0,018	1,1-5,0

As seen from the data presented in Table 1, soybean seeds have higher indicators for the content of β-carotene and tocopherols compared to cereal crops. In particular, the content of tocopherols (vitamin E) in soybeans is consistently higher than in barley and rice, which is an important factor ensuring the antioxidant activity and high biological value of soybean seeds.

Table 2

Ratio of macronutrients in cereals and barley

Sample	Ca:P	Ca:Mg	Ca:K
Control	1:1,5	1:0,5	1:0,75
Barley	1:1,8	1:1,1	1:1,37
Wheat	1:9,3	1:3,4	1:11,8
millet	1:4,6	1:2,3	1:2,2

Table 2 shows that the ratios between calcium (Ca), phosphorus (P), magnesium (Mg), and potassium (K) in grain crops differ significantly. In the control sample, the Ca:P ratio is physiologically relatively optimal, whereas in barley, the Ca:P, Ca:Mg, and Ca:K ratios are more balanced. In the barley sample, the Ca:P ratio is 1:1.8, and an increase in the phosphorus content is observed; however, this indicator is still close to physiological norms. At the same time, the relatively balanced ratio of Ca:Mg (1:1,1) and Ca:K (1:1,37) allows for the characterization of barley as a relatively optimal raw material among cereal crops in terms of macronutrient content. Overall, the results obtained show that barley is physiologically more balanced compared to wheat and rice in terms of macronutrient ratios, which scientifically substantiates its use as a promising raw material for the development of functional food products and protein-carbohydrate compositions.

Table 3

Chemical composition of different types of whey

Indicator	Cottage cheese	With cheese	Casein
Water, %	95,6	93,3	94,5
Dry matter, %	6,4	6,6	5,8
Fat, %	0,3	0,4	0,3

Lactose, %	4,4	5,0	4,2
Ash, %	0,6	0,5	0,8
Acidity, T °	60,0-75,0	20,0	44,0
pH	4,7	6,1	4,6

As can be seen from Table 3, the chemical composition and physicochemical indicators differ depending on the type of whey. The acidity of cottage cheese and casein sera is high (pH 4.6-4.7), which affects their biological activity and microbiological stability. Cheese whey, on the other hand, is characterized by a pH close to neutral (6.1) and a high lactose content. The obtained data indicate that the type of milk serum is of great importance in determining the feasibility of its targeted use in food technology, including bioactivation and the development of functional compositions. Due to its high acidity, cottage cheese whey is considered effective as a medium that stimulates enzymatic activity in bioactivation processes. The high pH value (6.1) of the cheese serum allows it to be used in technological processes requiring a neutral medium. The high water content in all types of serum indicates their good hydration capacity. The amount of lactose is high in cheese whey, making it valuable as an energy source. The high ash content in casein serum indicates that it is rich in mineral substances. The low fat content allows for the use of all types of whey as dietary raw materials. The close values of the dry matter content indicate the technological similarity of the serum types. The acidity level directly affects the preservation and microbiological stability of the serum. Serum components are of great importance as functional additives in the development of protein-carbohydrate compositions. The results obtained confirm that the targeted selection of whey depending on its type increases technological efficiency.

CONCLUSION

The analysis of the nutritional and biological properties of soybean, barley, and dairy whey demonstrates their significant potential for application in the development of functional food products and protein–carbohydrate compositions. Soybean is characterized by its high protein content, favorable amino acid composition, and considerable levels of vitamins and antioxidant compounds. The presence of β-carotene and tocopherols enhances its biological value and supports its use as an important plant-based protein source. However, the relatively lower content of certain essential amino acids, including methionine, indicates the importance of combining soybean protein with complementary protein sources.

Barley demonstrates promising nutritional properties due to its relatively balanced ratios of calcium, phosphorus, magnesium, and potassium. These mineral characteristics make barley suitable for use in nutritionally balanced cereal-based and functional food formulations.

Dairy whey is a valuable source of lactose, minerals, proteins, and biologically active substances. The composition and technological properties of curd, cheese, and casein whey differ depending on acidity, pH, and dry matter content, allowing their targeted application in different food technologies. Overall, the combination of soybean, barley, and whey can provide a scientifically justified basis for creating nutritionally balanced, biologically valuable, and technologically efficient functional food products.

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