



PHYSICO-CHEMICAL PROPERTIES OF WHEY PROTEIN CONCENTRATES



- Chemical, physical and functional characteristics of WPC vary according to method of their manufacture. WPC contain, on average, 4% moisture.
- Whey proteins concentrate powder recovered by ion exchange adsorption is characterized by high protein (> 85%) and low (< 0.5%) lactose, low ash and low lipid contents.
- The product prepared through heat precipitation process is in denatured form with no innate property.
- The product prepared by ferric salt precipitation is reported to be light yellow to brown in colour.
- The product prepared by molecular separation processes contains whey proteins in their native form and possess exceptional functional properties including high solubility of considerable value to the food industry.
- WPC produced by UF
- process have a protein content typically ranging from 34 to 80% and spray dried WPC has bulk density of 0.35 to 0.5 g/cm³.
- As the protein levels increase, the percentage of lactose and minerals decreases.

Protein Content

- Commercially available WPC contain from 35 to 85% protein.
- If they are added to food on a solid basis, there will be large differences in functionality owing to the differences in protein content.
- Most food formulations call for certain protein content and thus WPC are generally utilized on a constant protein basis.
- In this case the differences due to protein content as such should be eliminated.
- As the protein content increases, the composition of other components in the WPC must also change (Table 33.1.) and these changes in composition might be expected to have an effect on functionality.

Lipid content

- WPC contain residual lipid despite attempts by producers to remove as much lipid as is possible from the whey.
- The lipid found in WPC does not have the same composition as the bulk lipid of milk, but is greatly enriched in phospholipids and milk fat globule membrane material.
- Removal of residual lipid from whey has been shown to increase ultrafiltration flux and to improve WPC functionality.
- The lipid content of WPC tends to increase as the protein content increases.
- Typical changes in WPC composition that occur as the protein content of the product is altered is shown in Table 33.1.

- Residual lipid has long been recognized as being detrimental to the quality of WPC with particular attention to the foaming and flavour qualities of the product.
- Small amounts of fat in whey protein solutions cause the rapid collapse of foams that are otherwise stable.
- It has been demonstrated that the removal of residual lipids from whey protein solutions by ultracentrifugation resulted in a three-fold increase in overrun.
- Further, the residual lipid is detrimental to the foaming properties and also inhibits the gel-forming properties of WPC.

Typical composition of whey protein concentrates powders

Composition (%)	Percent protein			
	35	50	65	80
Moisture	4.6	4.3	4.2	4.0
Crude protein	36.2	52.1	63.0	81.0
True protein	29.7	40.9	59.4	75.0
Lactose	46.5	30.9	21.1	3.5
Fat	2.1	3.7	5.6	7.2
Ash	7.8	6.4	3.9	3.1

Mineral content

- The mineral content of whey is altered as the whey is concentrated to form WPC.
- The method of processing can have a large effect on both the total ash content and the mineral present.
- Ash contents for commercially available WPC produced by ultrafiltration, electrodialysis and metaphosphate complex formation range from 0.5 to 15%.
- Calcium content ranges from 13.9 to 2180 mg/100 g sample, while the phosphorous content ranges from 0.26 to 3.53%.
- The samples precipitated as metaphosphate complexes, as expected, contain the largest amount of phosphate.
- High ash content may inhibit the emulsion and foaming characteristics of WPC. WPC have been shown to function better in a number of applications, where minerals have either been removed or their content modified.
- Such applications include uses in ice cream, infant formulas, bakery products and dietetic foods.
- The mineral that has received most attention regarding its effect on functionality is calcium.

- The solubility of WPC was improved by calcium replacement, with the largest improvement occurring at the isoelectric point.
- The textural parameters of heat-induced gels also increased as sodium replaced calcium, as did the time to form a coagulum at 70°C.
- Overrun was decreased by calcium replacement while foam stability and solution viscosity were affected in a non-linear manner.
- It has long been known that calcium concentration has a large effect on the heat stability of both β -lactoglobulin and α -lactalbumin.
- The dependence of heat denaturation on calcium content is probably responsible for the effects of heat denaturation on gel strength.

- At very low concentrations, the addition of calcium increases gel strength.
- As the calcium concentration increases past a certain maximum, further increases cause decreases in gel strength.
- At low concentrations, calcium can increase gel strength by aiding in the formation of crosslinks that are necessary for proper gel formation.
- At higher concentrations of calcium, protein precipitation occurs at a faster rate than does crosslink formation and gel strength is weakened.

Lactose content

- As the concentration of protein in WPC increases, the lactose concentration decreases.
- Values for the lactose content of commercially available WPC range from 0.1 to 46%.
- Values below 5% are derived from products produced by an ion exchange procedure, while the value of 46% was for a 35% protein WPC.
- Generally, lactose is considered filler that has little effect on protein functionality.
- Lactose is a reducing sugar and can react with proteins via non-enzymatic browning to produce less nutritious and lower functional products.
- This should not be a problem for WPC stored at reasonable moisture levels. Lactose can increase the heat stability of proteins and lactose concentration has been related to the solubility of whey proteins following heat treatment.
- This should not, however, be a significant factor in the solubility characteristics of most WPC.
- Care is certainly warranted in the processing of products that contain very low concentrations of residual lactose and this may explain the observation that WPC produced by ion exchange are difficult to manufacture with high solubility.

Protein yields and concentrations of principal classes of dried whey protein products

Basis of recovery									
	Heat Precipitation	Molecular size ^b		Adsorption ^c		Phosphate Complex	Removal of ^d		
		UF	GF	Cell.	Sil.		Lac	Min.	Lac+ Min
Yield %	70-80	90	50-90	50-90	70-85	90	90	90	90
Concentration %	65	30-80	30-80	30-80		30-85	40	20	45
Product name ^e	WPC	WPC	WPC	WPC	WPC	WPC	DLW	DMW	DLDMW

^a Expressed as percentage of (total-nonprotein N) X 6.38 in original whey.

^b Ultrafiltration, UF; gel filtration, GF

^c Regenerated cellulose, cell; silica, sil. Pilot-scale data only.

^d Lactose, Lac; Minerals, Min.

^e Whey protein concentrate, WPC; delactosed whey, DLW; demineralized whey, DMW; delactosed, demineralized whey, DLDMW.

Percentage composition of whey protein concentrates

Method of Isolation	Composition/Source of Whey														
	Protein			Carbohydrate			Fat			Ash			Moisture		
	CW	AW	PW	CW	AW	PW	CW	AW	PW	CW	AW	PW	CW	AW	PW
Gel filtration	83.1	86.2	65.6	1.4	1.3	4.1	2.4	1.6	6.2	0.04	0.04	2.48	8.2	7.1	11.4
Ion Exchange	77.4	85.4	46.6	0.4	0.4	1.9	0.3	0.1	4.1	13.2	13.0	28.8	7.5	5.3	14.3
Hexmetaphosphate complex	62.3	59.4	33.9	9.7	12.8	14.5	6.8	1.5	35.0	17.8	19.6	19.1	3.1	4.5	6.1
Carboxy methyl Cellulose complex	60.99	69.63	28.0	17.8	18.0	32.8	15.6	4.5	19.0	1.9	1.2	3.6	2.2	5.1	2.1

CW= Cheese whey;

AW= Acid whey;

PW= Paneer whey