Food texture and nutrition: the changing roles of hydrocolloids and food fibres

Sarah Hotchkiss

Creating healthy food formulations is one of the key challenges facing the food industry at present. In the past, the production of food ingredients has led to the purposeful extraction, removal, substitution and even throwing away of many nutritional components. With the drive towards "naturalness" and the use of "less processed" food ingredients, the food texture industry is responding and changing. We are seeing:

1. hydrocolloids, that have traditionally been used to provide texture only, being used for their nutritional functionality;
2. intelligent processing of food fibres that allows for their use as food ingredients with a nutrition and texture function;
3. the emergence of new clean label functional food fibres with texture and nutritional functionality.

The texture of food is one of the primary attributes that affects its quality. Along with taste and smell, texture defines a food and how we perceive that food in terms of its flavour and mouthfeel. Having the right texture i.e. the texture that we perceive as appropriate for the foodstuff concerned, is vitally important to our enjoyment of food. For example, if we eat a low fat yoghurt that has a rich and creamy texture then it is less likely to be perceived as low fat and we will enjoy it more. With the current drive towards healthier eating, food texture and the development of creative texture solutions is becoming increasingly important.

Hydrocolloids have traditionally been used to provide textural functionality in foods e.g. gelling in jams, fruit fillings & confectionery, thickening in dairy based drinks & desserts and water binding in meat products. By definition, hydrocolloids are substances that form colloidal systems when dispersed in water. Also known as gums, they are typically polymers of carbohydrates (also proteins) and are derived from a wide range of natural sources or are produced synthetically. Hydrocolloids are widely exploited in industry, not only in the food sector, for their ability to control important functional properties including thickening and gelling, stabilisation, dispersion and emulsification.

As gelling and thickening agents, hydrocolloids are classed as food additives and their use is subject to EC Regulation 1333/2008. They are generally added at very low dosages (<2 %) as they typically have high molecular weight and technological functionality can therefore be achieved using such low levels of inclusion. They are a versatile group of food additives that can be used to create a spectrum of different gel types and viscosities, as appropriate for their intended application. The intrinsic properties, functional behaviour, gelling mechanism and nature of the colloidal systems that are formed, vary between different hydrocolloids. Each hydrocolloid behaves differently under different processing and formulation conditions such as pH and temperature, both of which can affect key parameters like solubility and gel stability. All of these factors can be manipulated to produce exactly the right texture solution. Furthermore, blends of hydrocolloids can be used synergistically (Figure 1).

The demand for food hydrocolloids has risen significantly in recent years, partly in response to the rapid expansion in the convenience foods and ready meals sector but most importantly as a response to the rise in consumer awareness and growing demand for healthier foods. Recent projections by Marketsandmarkets.com (October 2014[1]) estimate the market for hydrocolloids to exceed € 7,900 million by 2019. Hydrocolloids are finding ever increasing application on the basis of functional properties that allow for the formulation of healthier foods. Formulating for no/low fat, sugar and salt (sodium) is a key driver. However, removal of such ingredients from foods has significant implications for the functional, textural and organoleptic attributes of the food. Hydrocolloids can be used to provide functional solutions that allow for the reduction and replacement of these ingredients. For example:

Reducing sugar. Pectin is a natural polysaccharide that is found in the cell walls of higher plants. It is widely used to gel, thicken and stabilise foods, in particular, fruit based applications. It is possible, through processing, to modify the basic galacturonic acid backbone of pectin to produce LM (Low Methoxy) and amidated LM pectins (LMA) which have specific gelling properties. These pectins will gel in low sugar concentrations (<60 %) and thus have wide application in low sugar jams, marmalades & jellies and specialist fruit based dietary products e.g. for diabetics.

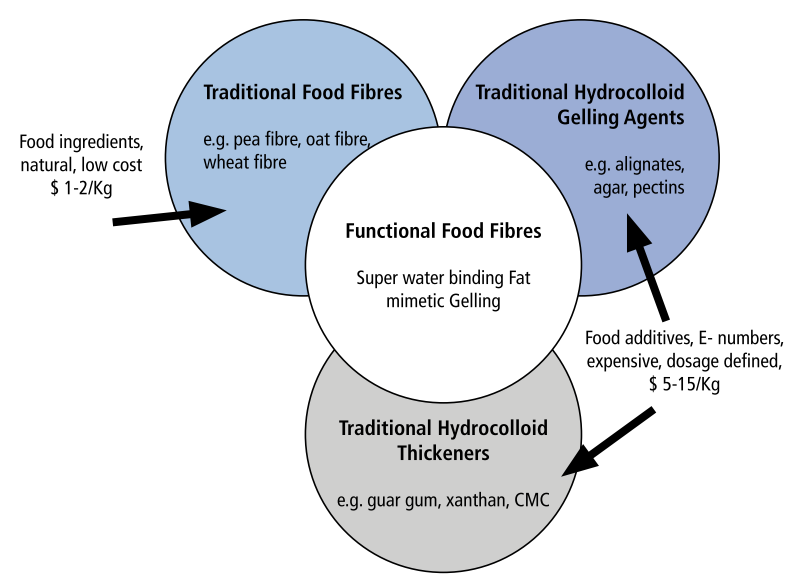

Fig. 1. The emergence of functional food fibres showing the overlap in functionality between hydrocolloid gelling agents and thickeners and traditional food fibres.

Reducing fat. By using hydrocolloids, calorie dense fats and oils can be replaced with what is essentially structured water. Initially, starch gels were used, being characteristically soft, fat-like and spreadable. Improved formulations now exist that make use of hydrocolloids as "*fat mimetics*". Cellulose derivatives like MCC (Microcrystalline cellulose) are used in low fat/no fat ice creams and dressings. When activated in water with high shear, MCC forms a 3D network with unique fat mimetic properties with shear thinning, thixotropic behaviour and plastic texture.

Reducing salt: The relationship between viscosity and flavour perception is well established, changes in viscosity are known to affect the release of both aroma compounds and of tastants like salt and sugar. Viscosity itself also contributes to the overall mouth feel of a foodstuff. Innovative advances are being made in the use of hydrocolloids to control the microstructure of foods.

Although not widely commercialised outside of Asia, there is substantial scientific support for the potential health benefits to humans of low molecular weight (LMW) hydrocolloids. This is not surprising given that many hydrocolloids including agar, konjac and gum arabic are used as traditional medicines in different cultures. Some LMW agars have demonstrated prebiotic potential in vivo, also antioxidant and hepatoprotective effects; similarly, LMW alginates have demonstrated prebiotic effects and also evidence for cytotoxic activity; LMW pectins are known for their immunomodulatory properties.

Hydrocolloids can also be exploited for their inherent nutritional value as they can contain a large proportion of dietary fibre, between 60–90 % (Viebke et al 2014). In general terms, dietary fibre is primarily derived from the cell wall material of plants (cereal foods, fruits, pulses, nuts and vegetables) and is composed of complex, non-starch carbohydrates (e.g. cellulose, hemicellulose, pectins, gums, mucilages) of 10 or more monomeric units and lignin. None of which are hydrolysed in the small intestine of humans. From a regulatory perspective, a precise definition of dietary fibre was agreed by Codex in 2009, this is discussed in detail by Viebke et al (2014[2]).

Dietary fibre can be further classified on the basis of its solubility. Fibres are classified as either soluble (e.g. pectins, gums and mucilages) or insoluble (e.g. cellulose, hemicellulose and lignin). Both types of fibre are important to human health as they have different physiological effects and both have different implications for texture, Hydrocolloids are potential sources of both. The majority of commercial fibres in the USA are insoluble whilst in Europe both soluble and insoluble fibres have similar market share. Insoluble fibres are typically derived from cellulose, oat, wheat and pea, amongst others, and provide textural functionality such as water binding, thickening, anticaking and dough improvement. The soluble fibres market is dominated by inulin along with polydextrose and resistant starches. These fibres are used primarily for fibre fortification and some for sugar replacement. According to a *Markets and Markets* report (March 2014), the global market value for fibres in 2013 was $2,272 million with a forecasted value in 2019 of $4,210 million (a CAGR of 13.1%[3]).

In the past, hydrocolloids have not been widely used for fibre fortification, primarily on account of cost and formulation issues. The use of hydrocolloids is relatively expensive at $5–$15/kg versus the cost of traditional dietary fibre ingredients such as those derived from pea, wheat and oat (typically $1–$2/kg). The superior gelling and thickening properties of hydrocolloids also makes it difficult to include them at physiologically beneficial levels or at a sufficient level to make a fibre claim.

An exception is PHGG (partially hydrolysed guar gum) which is a variation of standard guar gum that is sold in the marketplace. As the name suggests it is a hydrolysed version of guar gum. It is a clear and colourless material unlike traditional guar which is cloudy and has a viscosity in the range of 7–12cps at 5 % whereas standard guar typically has a viscosity of 3000–5000 cps at 1 %. Commercially available PHGG comprises approxi-

mately 80 % dietary fibre and low viscosity allows it to be used at concentrations sufficiently high to have a dietary fibre effect.

With the rapidly accelerating growth of the soluble fibres market, the challenge for hydrocolloids manufacturers must be to push the development of innovative and cheaper processing methodology that will allow for the production of lower molecular weight products with nutritional potential.

Traditionally, the hydrocolloids and fibres sectors have been viewed as distinct entities, albeit with some overlap in functionality (technical or nutritional), but with advances in processing technology and the drive towards “naturalness” and “less processed” food ingredients, we are seeing the overlap expanding and the emergence of a new entity of “functional fibres” (Figure 1). These are generally minimally processed vegetable, fruit and cereal materials that contain both soluble and insoluble fractions with different functionalities. Successful products currently in the market place are derived from citrus and oat.

From the legal point of view, in Europe, the manufacturing process determines whether a functional fibre is an additive (with E-number) or a food ingredient. As previously mentioned hydrocolloids fit into the first category, being extracts of the original source material and generally modified physically and chemically so that they can no longer be considered food ingredients. Traditional fibres (e.g. fruit fibre, pea fibre, oat fibre, inulin, FOS, resistant starch) are food ingredients, however, the distinction is somewhat blurred with regard to functional fibres.

More sophisticated processing techniques are being employed to produce functional fibres, including chemical, enzymatic, mechanical (shearing and microfibrillation), thermal or thermo-mechanical (extrusion) treatments. The resultant products have more controllable particle size and superior water binding ability that can also give viscosity and gelling behaviour that is on a par with some hydrocolloids. Consequently, functional fibres are now being used to provide textural functionality that has, until recently, been fulfilled by hydrocolloids. Functional fibres are mainly used in bakery and meat applications where water binding is key but also as stabilisers in beverages, to prevent the formation of ice crystals in frozen food s and as a barrier to oils and fats in breaded/fried foods.

With the general global push towards achieving food security, resource efficiency and minimisation of waste, the future of functional fibres looks interesting. Smart usage of agricultural waste and processing by products is at the forefront of many research agendas. Many biomass streams have already been successfully converted to functional ingredients for the food industry and fibre producers are continuously looking for promising new candidates.

References

[1] Hydrocolloids Market by Type (Gelatin, Xanthan, Carrageenan, Alginate, Agar, Pectin, Guar, Locust Bean, Arabic, CMC), Source, F&B Application, Function (Thickener, Stabilizer, Gelling, Fat Replacer, Coating) & Geography - Global Trend & Forecast to 2019. http://www.marketsandmarkets.com/Market-Reports/hydrocolloid-market-1231.html

[2] Viebke, C., Al-Assafa, S. & Phillips, G.O. (2014).Food hydrocolloids and health claims. Bioactive Carbohydrates and Dietary Fibre 4: 101-114.

[3] Dietary Fiber Market by Product Type (Conventional/ Novel & Soluble/ Insoluble) and Application (Food & Pharmaceutical) – Global Trends & Forecasts up to 2019. http://www.marketsandmarkets.com/Market-Reports/novel-dietary-fibers-market-858.html

For more information, please contact

Sarah Hotchkiss, projects manager at CyberColloids. CyberColloids are experts in hydrocolloid and polysaccharide chemistry. The company is engaged in research activities aimed at developing novel processing methodologies, new ingredients, and innovative applications for new raw materials and downstream products that are derived from plants and seaweed – thus providing creative research solutions and adding value to existing processing practices. sarah@cybercolloids.net.