The drive for innovation has food companies willing to incorporate new ingredients derived from traditional or novel food sources into formulations. Grain legumes or pulses (peas, beans, lentils, and chickpeas) are examples of traditionally used foods penetrating the modern ingredient market. Pulse products are now found in retail stores in a variety of formats, including raw, unprocessed pulses; splits; ground flours; canned products; hummus and other dips and spreads; and as an ingredient in processed foods, such as soups, stews, frozen entrees, retort pouch packaged entrees, dried snack mixes, and specialty dough mixes (57). However, knowledge on how to include these nutritionally packed pulses into convenient, tasty, and healthy food products remains a challenge for the food industry.

Pulses are rich in dietary complex carbohydrates and proteins, minerals, and B vitamins (Table I) and are a key component of the diet in many cultures. They are gluten free, high in dietary fiber, low in saturated fat, and contain no cholesterol. They are not genetically modified and contain high levels of lysine to complement lysine deficiencies in cereal-based diets. When consumed together, pulses and cereal grains provide all of the necessary amino acids and serve as a complete source of protein. Pulses can be added to gluten-free, and texturally or nutritionally weak food products to provide body, texture, taste, and increased nutritional value. In particular, pulses are a source of iron, B vitamins, including folate, and fiber. In addition, grain legumes have a low-glycemic index, offering potential benefits to diabetics. Recent clinical research has demonstrated that the regular consumption of pulses can help protect against cardiovascular disease, diabetes, obesity, and colon cancer (36,41). These nutritional and health attributes are spurring the incorporation of pulses into more foods.

Not only are pulses beneficial for their healthy components, they are also an environmentally friendly crop. Due to their ability to fix nitrogen, they require half of the amount of fossil fuel inputs necessary during growth compared to other field crops. With protein contents double that of other cereal crops, pulses are an economical, environmentally sustainable protein source.

This article will focus on the functional characteristics of legume flours, and pulse fibers, starches, and proteins, as well as the opportunities to provide interesting, healthy products to consumers.

**Pulse Flours**

Milling whole or dehulled legumes produces raw flours. Legume flours have higher levels of protein, ash, and fiber and lower contents of moisture and carbohydrates than wheat flours (Table II), and can be substituted in many applications that use wheat and other traditional flours. Of the four common North American pulse flours, lentil flours tend to have a higher protein content (28.7–31.5%) than pea (25.5–26.8%), bean (23.1–26.6%), and chickpea flours (20.7–25.0%) (15,16).

Starch and amylose contents vary among species and varieties, with peas generally having higher concentrations than lentils, chickpeas, or beans. This in turn affects swelling power, amylose leaching, and gelatinization parameters (pasting, peak viscosity, breakdown, setback, and final viscosity) of individual legume flours, as well as starch digestibility. Differences in starch types are attributed to the variability in starch source, granule size, amylose/amylopectin ratio, crystallinity, and amylopectin molecular structure (15,16). Flours are an inexpensive way to improve the nutritional value of bread, bakery products, and pastas. They also have value as extenders in processed meat products.

**Pulse Flour Food Formulations**

Popular consumer foods can benefit from the inclusion of legume flours to produce healthier food products. Due to different types and characteristics of pulse flours, the ingredient production method and substitution levels must be experimentally determined for each application (26).
Purdue University investigated whether white bean and red cooked bean purees could be substituted for the traditional corn masa that is used in tortillas. A 50% white bean (navy)/50% corn masa tortilla was acceptable to consumers and would permit manufacturers to consider nutrient content claims for folate and, depending upon the formulation, a “low in fat” or “saturated fat free” claim on U.S. food package labels (38). A 25 to 75 pinto bean flour/wheat flour combination, with added guar gum, produced highly acceptable tortillas targeted toward health conscious consumers (5). The two different optimized formulations were the result of differing sensory panel demographics, the method of production of the bean ingredient, differences in the production method of the food product, and as differences in the other ingredients present in the food matrix. All of these criteria must be carefully evaluated and formulations modified to accommodate functionality changes when developing novel pulse food products.

Cake

Chickpea flours were also incorporated into soft wheat flour formulations for layer and sponge cakes. It was found that pulse additions lowered cake volumes and caused a firmer, less cohesive texture than control samples made entirely of wheat flour (26). However, further testing to optimize product formulation could improve product characteristics.

Bread

Processing raw beans or flours may help to improve functional characteristics of flours. The germination of pulses prior to flour production, micronization, heat treatments, extrusion, or fermentation of legume flours results in flours with modified functionalities, increased digestibility and nutrient bioavailability, and enhanced aroma and sensory attributes (2,63). Roasting navy beans, prior to flour milling, results in flour with increased water-holding capacity and breads with higher loaf volumes than bread made with untreated bean flours (20).

Pasta

Although pasta is already generally considered to be a low-glycemic index food due to its slow release of sugars during digestion, adding legume flours to conventional pasta formulations increases its nutritional value and produces pasta with an even lower glycemic index.

In durum wheat applications, the addition of 5–20% chickpea flours to lasagna noodles improved physical characteristics of the dough. Sensory characteristics, such as flavor, appearance, and overall acceptability, were most acceptable at the 5% level (55). As previously indicated, a variety of pulse flour treatments has also helped to improve the acceptability of pulse flours as ingredients. For instance, fermented (tempeh) chickpea flour has been shown to have a higher gelatinizing temperature, dispersibility, and resistant starch content than unfermented chickpea flour (3).

Table I. Proximate composition of raw, dry pulses (g/100 g)a

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Protein</th>
<th>Carbohydrate</th>
<th>Total Dietary Fiber</th>
<th>Fat</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lens culinaris</td>
<td>Lentils</td>
<td>25.8</td>
<td>60.1</td>
<td>30.5</td>
<td>1.06</td>
<td>2.7</td>
</tr>
<tr>
<td>Pisum sativa</td>
<td>Split peas</td>
<td>24.6</td>
<td>60.4</td>
<td>25.5</td>
<td>1.16</td>
<td>2.7</td>
</tr>
<tr>
<td>Cicer arietinum</td>
<td>Chickpeas (garbanzo, Bengal gram)</td>
<td>19.3</td>
<td>60.7</td>
<td>17.4</td>
<td>6.04</td>
<td>2.5</td>
</tr>
<tr>
<td>Phaseolus vulgaris</td>
<td>Kidney beans</td>
<td>22.5</td>
<td>61.3</td>
<td>15.2</td>
<td>1.06</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>Pinto beans</td>
<td>21.4</td>
<td>62.6</td>
<td>15.5</td>
<td>1.23</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Navy beans</td>
<td>22.3</td>
<td>60.8</td>
<td>24.4</td>
<td>1.5</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>Black beans</td>
<td>21.6</td>
<td>62.4</td>
<td>15.2</td>
<td>1.42</td>
<td>3.6</td>
</tr>
<tr>
<td>Vicia fava</td>
<td>Broadbeans (faba beans)</td>
<td>26.1</td>
<td>58.3</td>
<td>25.0</td>
<td>5.7</td>
<td>3.1</td>
</tr>
</tbody>
</table>

a Source: U.S. Department of Agriculture, Agricultural Research Service (66).

Table II. Comparison of pulse floursa,b and wheat flour nutrient compositionsc

<table>
<thead>
<tr>
<th>Flour</th>
<th>Variety Description</th>
<th>Protein (%)</th>
<th>Starch (%)</th>
<th>Moisture (%)</th>
<th>Resistant Starch (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chickpea</td>
<td>Desi</td>
<td>25.0</td>
<td>42.9</td>
<td>7.5</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>Kabuli</td>
<td>20.7–22.8</td>
<td>46.25</td>
<td>7.4–7.5</td>
<td>3.1–4.7</td>
</tr>
<tr>
<td>Lentil</td>
<td>Two varieties</td>
<td>28.7–31.5</td>
<td>46.0–47.1</td>
<td>8.6–8.8</td>
<td>14.4–14.9</td>
</tr>
<tr>
<td>Pea</td>
<td>Three varieties</td>
<td>25.6–26.8</td>
<td>46.6–49.4</td>
<td>7.7–8.2</td>
<td>10.1–14.7</td>
</tr>
<tr>
<td>Beans</td>
<td>Dark kidney</td>
<td>24.0</td>
<td>40.3</td>
<td>10.3</td>
<td>36.0</td>
</tr>
<tr>
<td></td>
<td>Light kidney</td>
<td>23.1</td>
<td>39.8</td>
<td>9.7</td>
<td>35.5</td>
</tr>
<tr>
<td></td>
<td>Navy</td>
<td>26.6</td>
<td>36.8</td>
<td>9.1</td>
<td>32.4</td>
</tr>
<tr>
<td>Wheat</td>
<td>10% protein, industrial</td>
<td>9.71</td>
<td>64.5</td>
<td>12.1</td>
<td>NAd</td>
</tr>
<tr>
<td></td>
<td>13% protein, industrial</td>
<td>13.07</td>
<td>61.22</td>
<td>12.82</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>15% protein, industrial</td>
<td>15.33</td>
<td>59.22</td>
<td>12.85</td>
<td>NA</td>
</tr>
</tbody>
</table>

a Chung, et al. (15).
b Chung, et al. (16).
c Source: U.S. Department of Agriculture, Agricultural Research Service (66).
d NA = data not available.
Heat treatments have also demonstrated the positive effects of pulse ingredients when incorporated in food product formulations. Roasted and nonroasted navy bean, pinto bean, and lentil flours have been combined with semolina flour in up to a 25% concentration of flour or protein concentrate in spaghetti formulations (6). The addition of flours or protein concentrates in up to 10% substitution levels in pasta provided sufficient protein to comply with FDA fortification levels as well as acceptable sensory characteristics. It appears that pretreated (roasted) flours have the best overall sensory characteristics compared to unroasted legume flours or protein concentrates.

**Extruded Food**

Low-temperature, low-pressure extrusion has also been utilized to produce pretzel-like snacks containing navy bean and whole wheat flours using twin-screw extrusion (4). However, with increased concentrations of unprocessed pulse flours, beany off-flavors dictate the acceptability of the final product. This can be overcome with high-temperature extrusion processing.

The high-temperature, high-pressure conditions used in extrusion are a model method to create products using legume flours. The high starch content of legume flours is ideal for extrusion in order to produce expanded snack products with a higher protein content and superior protein nutritional quality than traditional wheat or corn snacks (14). Red lentil flours, combined with corn grits, produced an acceptable puffed wafer with a higher protein content and reduced glycemic index than corn grit wafers where red lentil flour was omitted (30). The replacement of cornstarch by bean flour in corn starch-based extruded snacks appears to be feasible at levels of 30–100%, depending on the apparatus and extrusion parameters (39).

**Gluten-Free Food Products**

High-temperature extrusion also offers opportunities for nutritional and functional gluten-free alternatives. Pulse flours alone can be used to prepare gluten-free, nontraditional pasta products made without the use of durum semolina. Pasta derived entirely from pea flour and prepared with high-temperature, twin-screw extrusion results in a gluten-free pea pasta with better integrity, more acceptable flavor, and superior texture after cooking than pea pasta prepared with conventional, low-temperature extrusion (69). Enzymes, such as transglutaminase, can also be used to produce reasonably acceptable noodle products from yellow pea flour by cross-linking lysine and glutamine amino acids to fortify protein networks (necessary in the absence of a gluten protein matrix) (64). Pasta products containing lentil, mung bean, chickpea, faba bean, or pea flours are currently sold in the gluten-free market.

Pulse flours and fractions have great potential in other gluten-free food applications. Commercial prototypes of gluten-free cracker snacks using chickpea flour scored highly in consumer acceptance testing and contained higher levels of iron than commercially available crackers, imparting an added nutrient fortification benefit (29).

**Meat Product Applications**

Legume flours and ingredients can also be used in comminuted meat products to reduce fat content while enhancing nutritional and sensory qualities. Examples of legume ingredients used as fillers, binders, or extenders include faba bean, lentil, lupin, and chickpea flours in beef sausages and meatballs (58). Legume flours from chickpea have also been incorporated into low-fat comminuted buffalo meat (44).

As demonstrated in the examples above, the optimization of pulse/legume ingredients is necessary to produce a high-quality final product. Factors, such as the type of pulse, method of ingredient processing, interaction with other ingredients present in the food matrix, and product processing methods, will alter the end product quality. Research and development is still required to determine the role that these factors have on the end product quality of ingredients containing pulse flours.

**Pulse Fractions**

While all legume flours are a good source of protein, starch, and dietary fiber, it is only dry field peas that are currently commercially processed into fractionated products—starch and protein with fiber are primarily coproducts of flour production or fractionation processes. Both soluble and insoluble fiber may be sourced from pulses. Insoluble fiber is produced from the hulls of the pulse, which are ground to make a fine powder. Soluble fiber is found within the cotyledon of the seed.

Field peas have been given special attention because they are an accepted part of the human diet throughout the world. Peas are available in large supply relative to other pulses and have the greatest potential to benefit from value-added use in the processed food market sector. Processing protocols to efficiently concentrate and isolate fractions from other grain legumes are still under development.

Two processing methods—one dry, and the other wet—are used to yield pea protein and pea starch products with different characteristics and functionalities. The first step in both processes is the milling of whole or dehulled peas to yield flours with specific particle sizes.

In the dry method, air-classification is used to separate the flour particles to yield an enriched light or fine (protein) fraction containing about 50–60% protein and a heavy or coarse (starch) fraction. Both air classification and wet-milling of field pea can fractionate the flour into starch concentrates containing up to 60–80% starch (65). These separated fractions are suitable for feed, food, and nonfood ingredients.

More concentrated protein fractions (70–92%) can be obtained by the wet extraction of pea flours (61,67). Wet separation processes using different extraction
and washing steps, precipitation, and drying produce high-purity protein isolates. Recovery of different pea protein isolates is usually obtained through isoelectric precipitation or by using membrane separation technologies, such as ultrafiltration, diafiltration, or reverse osmosis. Processing parameters can be modified to give protein isolates with different proportions of legumin and vicilin. These components can readily be used in the food industry as nutritional and functional ingredients.

Pulse Fibers

The consumption of dietary fiber is low in North America. It ranges from 10 to 15 g, well below the recommended daily intake of 25 g of fiber. There is increased interest in adding fiber into foods to boost the fiber content and decrease the energy (caloric value) by substituting fat with fiber. Legume fibers can be considered a viable alternative to cereal-based fibers.

Pulse fibers can be used to formulate special diet foods, such as low-glycemic or low-calorie foods, and may also function as a fat mimetic. In Canada, pea hull fibers are recognized as a dietary fiber for use in specified food products (12). The total dietary fiber in legumes ranges from 18 to 20% for seeds and 11 to 16% for flours. Legume fibers are derived from two sources—the outer hulls, which are comprised mostly of insoluble fiber (75–89%), and the split flours, which are comprised of 4–6.5% insoluble dietary fiber and 7.5–9% soluble dietary fiber (18). The cotyledon (inner fiber) cell walls contain a range of polysaccharides, including pectic substances, cellulose, and nonstarch glucans. The seed coat (outer fiber) contains large quantities of cellulose and lower amounts of hemicelluloses and pectins (50). Legume fibers contain unique polysaccharides, including the hemicellulose arabinoxylan and the pectin xylogalacturonan, which exhibit potential prebiotic effects (37,59). Fiber extracts also contain variable amounts of starch and protein. Cotyledon fibers tend to have higher water-binding and water-holding capacities than hull fibers (17).

Commercial legume dietary fibers are used in a variety of food products. Inner fibers are used primarily as texturizing or bulking agents owing to their high water-binding capacities, and fat-binding and texturizing effects. Hull-derived fibers are used to enrich the fiber content of food without modifying the fiber’s technical properties (27).

Pulse Fiber Food Formulations

The most commonly used pulse fiber—yellow pea fiber—has a bland flavor, is colorless, and due to its fine particle size, does not disrupt food matrix structure as other brans do. It can be ground to different particle sizes in order to gain unique functionalities, including high water- and fat-binding capacities, and texture. Due to its bland flavor, it can be used to enrich the fiber content of food without affecting sensory characteristics (21,27,50,51,52).

Baked Goods

Chocolate cakes, with a low concentration of fat and sugar and a high level of dietary fiber and acceptable flavor and texture, were produced by the addition of yellow pea hulls (35). Depending on the wheat used, breads fortified with 5% hulls or insoluble fiber and 3% soluble fiber from peas, lentils, or chickpeas resulted in increased total fiber content and improved the moistness of the bread without significantly affecting crust firmness during storage (19). Up to 15% prehydrated pea hull fibers can be added to hard red spring wheat breads to produce high-fiber breads (62). Roasted or unroasted navy bean hulls milled to uniform size to avoid physical and sensory effects were added to sugar-snap cookies. Sensory attributes for color, texture, mouth feel, and flavor were improved with high-temperature roasting of navy bean hulls as compared to the use of raw navy bean hulls. No significant differences were observed between control cookies and cookies with a 10% addition of high-temperature roasted navy bean hulls for all sensory attributes studied (23).

Meat Product Applications

Legume fibers are not limited to use in baked goods. The addition of soluble pea fiber to pork sausage favors greater gel strength and hardness and no effect on juiciness or flavor was noticed when pea fiber was added to ground beef patties. It has also been used to produce a healthy, low-fat, high dietary fiber hake fish sausage (13). The high fat- and water-holding capacities of soluble pea fibers appear to be a positive attribute for the development of food products.

Pulse Starches

Legume starches are of interest to the food industry due to their high amylose content. Starches from most legume species contain about 30% amylose and 70% amylopectin, although the amylose content in mutant pea varieties can reach as high as 88% (68). This high amylose content gives legume starches particular properties, such as high viscosity; strong gel, heat, and mechanical stability; stability to low pH; and restricted swelling. Legume starches have a characteristic “C” pattern as determined by wide angle X-ray diffraction analysis, in contrast to maize starch that is typically an “A” pattern, and potato starch that is a “B” pattern. The functional properties of starch depend on the starch granule structure and are related to conformational changes in the granule when a solute, such as water, or water solutions of salts and sugars, are introduced (9).

In beans (Phaseolus vulgaris), total carbohydrate and starch composition vary from 54.6 to 64% depending on the cultivar. Starch is the most abundant carbohydrate in beans with concentrations ranging from 27 to 56% (54). Amylose content can vary—for instance from 30.13% in pinto beans to 37.3% in black beans (31).

Pea starch is utilized most extensively for industrial applications because of its high concentration of amylose, leading to extensive retrogradation (53). However, with increased interest in resistant starch and its positive effects on satiety, diabetes, and weight management, interest in pulse starches is being revitalized. Pea starch is used in deep-frozen dishes, dressings, puddings, extruded bakery and breakfast cereal products, pastas, noodles, instant soups, and pet foods.

Starch functionalities, such as swelling factors, pasting temperatures, viscosity, and degree of set back and extent of syneresis values, differ among legume starches. Of the legume starches, pea starch is the best characterized, but research on other grain legumes to compare chemical composition, dietary fiber, starch contents, digestibility, and GI values is underway (15,16,22).

Legume starches have a wide variation in swelling power and solubility. At 90°C, the swelling power and solubility are in the range of 4–30% and 8–25%, respectively (32). The swelling power of pea starch ranges from 4 to 27% in the temperature range of 50–95°C, while beans can range from 10 to 30%. Lentil starches tend to have a higher water-binding capacity (92.4–98%) than faba bean, pea, and Phaseolus bean starches and are similar to wheat starch (83–91%) (8). Starch concentration in chickpeas varies from 37 to 51%, with amylose ranging from 31.8 to 45.8%. The wide variation in peak gelatinization temperatures seen with some chickpea varieties could represent a unique range of functional properties (42).

Starch Modification

Prior to their use in many industrial processes, common starches are chemically modified to alter and improve their physical properties, such as viscosity and gel-forming ability, and to prevent crystallization. Similar improvements occur
with modification of legume starches. Improved freeze-thaw stability, paste viscosity, paste clarity, and reduced syneresis are seen in pea starches when compared to the native pea starch, creating more opportunities for food use (33). For instance, a commercial acylated pea starch could successfully be used to produce low-fat (5%) ice cream with acceptable sensory characteristics (1).

**Resistant Starch**

Pulses provide three types of starch: rapidly digestible starch (RDS), slowly digestible starch (SDS), and native resistant starch (RS). Beans appear to be higher in native RS (32.4–36.0%) than lentils (14.4–14.9%), peas (10.1–14.7%), and chickpeas (3.1–6.4%) (15,16). These values can be compared to that of native RS found in wheat (3.3–5.8%), corn starch (~3%), or high-amyllose corn starch (~21%) (43,56).

Legume resistant starches may be a natural novel food component with health-promoting activities. Prevention of colon cancer, hypoglycemic effects, providing a substrate for growth of probiotic microorganisms, reduction of gall stone formation, hypocholesterolemic effects, inhibition of cancer, hypoglycemic effects, providing a substrate for growth of probiotic microorganisms, reduction of gall stone formation, and acting as a fat replacer. Pulse fibers are seen in pea starches when compared to that of native RS found in wheat (3.3–5.8%), corn starch (~3%), or high-amyllose corn starch (~21%) (43,56).

**Pulse Proteins**

The storage proteins in grain legumes can be used in food and nonfood products. Storage proteins are classified as water-soluble albumins, salt-soluble globulins, ether-soluble prolamins, and acid- or alkali-soluble glutelins, depending on the solvent in which they can be dissolved (40) (Table III).

Globulin proteins contribute most to the texture of food products. The relative contents of globulins increase by processing legume flours into concentrates and isolates. All grain legume globulins are composed of two major proteins characterized by their sedimentation coefficients (the 11S legumin and the 7S vicilin). Both the globulin to albumin and the legumin to vicilin ratios contribute to the differences in the physicochemical properties of legume seeds (46). Among the grain legumes, peas provide the most accessible, highest concentrations of globulins, making them a good choice for commercial protein concentrates and isolates. In peas, globulins make up 65–85% of the proteins present (62).

Although pea protein functionalities have been studied to the greatest extent, research is ongoing into chickpea (48,60), bean (24), and lentil (10) protein characterization and functionality. The solubility of pea protein is similar to other legume proteins. It is characterized by high solubility at alkaline pH, minimum solubility at isoelectric point (pH 4.5), and moderate solubility in acidic conditions. Pea proteins absorb between 1 and 3.3 times their weight in water. The water-absorbing capacity increases with elevating protein contents. In general, legume flours tend to have poorer emulsification properties than do the protein concentrates or isolates. Legumin and vicilin have different properties. Vicilin produces more stable foams and emulsions, while legumin has greater foam expansion, emulsion capacity, and gelling capacity.

Compared to soy protein isolates, pea protein isolates exhibit relatively good emulsifying activity and moderate foaming properties with slightly lower emulsion stability and water- and oil-binding capacities. However, chemically modifying or hydrolyzing pea proteins improves solubility at acid pH and increases the emulsifying capability, emulsion stability, foam capacity and stability, and water-absorption properties (7,34,49).

Pean protein powders, depending on the purity of their concentration, are usually colorless and bland, allowing for individual flavorings and modifications. New technologies, such as fermentation or enzymatic and chemical hydrolysis, are being investigated to achieve proteins with not only desirable functional attributes but also preserved biological activity and improved organoleptic characteristics (11).

Incorporating pulse flours, proteins, starches, and fibers in food products enhances the nutritional qualities and functional characteristics of foods (Table IV). Flours can be used for the fortification of bakery products, snack foods, and pastas, or as meat extenders in processed meats. Protein preparations can be used in these same foods, as well as added to beverages (drinks, smoothies, shakes), nutrition bars, meat products, or used as texturized proteins in meat-replacement products. Pea proteins, in combination with inulin and oligofructose, are being offered as weight management ingredients, providing satiety and acting as a fat replacer. Pulse fibers can provide ingredient options to increase dietary fiber and provide beneficial health effects for cardiovascular disease and dia-

### Table III. Storage protein compositions in grain pulses^a,b,c,d^  

<table>
<thead>
<tr>
<th>Protein</th>
<th>Peas (Pisum sativum) (% dry basis-whole seed)</th>
<th>Beans (Phaseolus vulgaris)</th>
<th>Chickpeas (Cicer arietinum) (%)</th>
<th>Lentils (Lens culinaris) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein</td>
<td>15–32</td>
<td>18–25</td>
<td>−22</td>
<td>27.9–32.1</td>
</tr>
<tr>
<td>Globulins</td>
<td>65–85</td>
<td>55–80</td>
<td>42</td>
<td>51</td>
</tr>
<tr>
<td>Albumins</td>
<td>20–35</td>
<td>10–20</td>
<td>16</td>
<td>11–16</td>
</tr>
<tr>
<td>Glutelins</td>
<td>NA^a</td>
<td>10</td>
<td>9.9</td>
<td>9.9</td>
</tr>
<tr>
<td>Prolamins</td>
<td>NA^a</td>
<td>−1</td>
<td>0.48</td>
<td>3.5</td>
</tr>
</tbody>
</table>

^a Deshpande, S. S., et al. (25).  
^b Gupta, R., and Dillon, S. (28).  
^c Neves, V. A., et al. (45).  
^d Silva, M. A., et al. (60).  
^e NA = data not available.

### Table IV. Pulse applications  

<table>
<thead>
<tr>
<th>Pulse Ingredient</th>
<th>Application</th>
<th>Reason for Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flours</td>
<td>Baked products (bread, crackers, tortillas), extruded snacks and cereals, and gluten-free products</td>
<td>Fiber enrichment; protein fortification; gluten free</td>
</tr>
<tr>
<td>Inner fibers</td>
<td>Low-fat crackers, cakes and pastries, ground beef/chicken, and fish burgers</td>
<td>Fat replacement; moisture control (reduced staling, increased shelf life); binding; improved cooking yield; improved mouthfeel</td>
</tr>
<tr>
<td>Outer fibers</td>
<td>Fiber-rich breads, crackers, and flat breads. Comminuted meat products (sausages and meat balls)</td>
<td>Fiber enrichment; water- and fat-holding capacities</td>
</tr>
<tr>
<td>Protein</td>
<td>Sausage, sauces, vegetable spreads, nutrition/sports beverages, infant foods, and texturized proteins for meat analogs</td>
<td>Emulsification; to increase protein; foaming properties; meat analogs</td>
</tr>
<tr>
<td>Starch</td>
<td>Pastas and noodles, extruded products (snack foods)</td>
<td>Gluten free; resistant starch for health benefits</td>
</tr>
</tbody>
</table>
betes. The image of pulses as traditional, natural, and wholesome, and with increasing consumer interest in healthy foods, creates endless opportunities to use pulse ingredients in order to produce innovative food products.

References


67. Carol Ann Patterson is president of Pathfinders Research & Management Ltd., an agri-food consulting business specializing in the evaluation of functional attributes and health benefits of ingredients derived from plant, animal, and microbial sources. She has worked with the food industry and producer organizations for more than 20 years. Patterson has a Ph.D. degree in applied microbiology and food science from the University of Saskatchewan, Canada. Patterson can be reached at capatterson@thepathfinders.ca.

68. Heather Maskus joined Pulse Canada as manager of the food innovation project after completing her M.S. degree in food science at the University of Manitoba in August 2008. Her master’s thesis explored the functionality of pea flour, hull, and starch as ingredients in tortillas and extruded puffed snack foods. Maskus’s work at Pulse Canada consists of exploring the functional properties of pulses and working with food companies and the research community to find solutions to the incorporation of pulse ingredients into a range of food product applications that meet consumer demands. Maskus can be reached at office@pulsecanada.com.

69. Chantal M. C. Bassett is currently doing post-doctoral work at the Canadian Centre for Agri-Food Research in Medicine in Winnipeg, Manitoba. She has a Ph.D. degree from the University of Manitoba in the Department of Physiology. Her M.S. and Ph.D. work was related to the effects of flaxseed and trans fatty acids on the development of plaques in arteries. Bassett has held graduate fellowships from CIHR, HSFC, and NSERC and is a joint author of several papers in peer-reviewed journals. She received a B.H.Ec. (human nutritional sciences) in 2002. She can be reached at cbassett@pulse canada.com.