Chapter 5

Utilization of Pulses – Value Addition and Product Development

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Introduction

Consumer awareness of health, quality of food and healthy nutrition options, and convenience and ready to eat (RTE) food products is growing. Access to affordable good quality protein delivered in a convenient format, especially for the vegetarian population in the SAARC countries, is a major need to be addressed in order to ensure nutritional security. Pulses are a rich source of protein and also have documented proof of their beneficial micro-nutrient, bioactive and functional properties (Philanto and Korhonen, 2003). Today in the SAARC countries the large population of youth, growing middle class and urban working women; are all demanding global/cross regional cuisines right at their doorsteps with the need for delivering health and wellness. This important trend in the SAARC countries is what the policy makers and industry needs to take into consideration towards promoting utilization of pulses through value addition.

The above drivers of consumer demand may be addressed by making available pulse based quality staples as well as ready to eat products. Industry in the region is already exploring for whole grains, and legumes across different segments-breakfast, lunch, dinner and snacking, and that too in innovative convenient formats. Focus and use of new raw material based on pulses will be the top wave of new product development in the near future. Lowering cholesterol, managing diabetes, energy foods and beverages, infant food formulations, therapeutic, geriatric foods etc. are all opportunities to value add to pulses. Specifically the nutritional properties of pulses can beexploited towards addressing malnutrition and hidden hunger, rampant at the bottom of the pyramid in the SAARC countries. With this background this chapter on "Utilization of pulses - Value addition and product development" attempts to understand the key attributes of pulses encompassing their nutritional and functional properties in the context of value addition both at the primary and secondary level, leading to exploiting the market opportunities through innovative pulse based products and ultimately addressing food and nutritional security of the vulnerable populations in the SAARC region.

Nutritional and Nutraceutical Properties of Pulses Relevant to Product Development

Pulses form an important part of a healthy, balanced diet and have an important role in providing food and nutritional security in the SAARC region. In addition the pulses have health benefitting properties and help in preventing illnesses such as cancer (Vohra et al., 2015), diabetes (Ramdath et al., 2016) and heart disease. Pulses are a source of carbohydrates (60-65%) of which starch is the primary carbohydrate. Slowly digesting nature of starch in pulses make pulses diabetic friendly [low glycemic index (GI)] (Rizkalla et al., 2002). Pulses are very high in fibre, containing both soluble and insoluble fibres. Soluble fibre helps to decrease blood cholesterol levels and control blood sugar levels, and insoluble fibre helps with digestion and gut health. Pulses are also a source of vitamins and minerals. Some of the key minerals in pulses include: iron, potassium, magnesium and zinc. Pulses are also particularly abundant in B vitamins; including folate, thiamin and niacin. Pulses typically contain about twice the amount of protein found in whole grain cereals like wheat, oats, barley and rice. In most developing countries pulses constitute the main source of protein. They contain high amounts of lysine, leucine, aspartic acid, glutamic acid and arginine and provide well -balanced essential amino acid profiles when consumed with cereals and other foods rich in sulphur containing amino acids and tryptophan. In the SAARC countries pulses complement well with rice or wheat, thus providing a nutritionally balanced diet to the populations. The typical nutritional composition of pulses common to the SAARC region is presented in Table 1.

Table 1: Typical nutritional composition of common pulses (per 100g)*

Pulses	Energy (Kcals)	Protein (g)	Fat (g)	Mineral (g)	Carbohydrate (g)	Fibre (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)
Bengal gram whole	360	17	5	3	61	4	202	312	5
Bengal gram Dal	372	21	6	3	60	1	56	331	5
Bengal gram roasted	369	22	5	2	58	1	58	340	9
Black gram, dal	347	24	1	3	60	1	154	385	4
Cow pea	323	24	1	3	54	3	77	414	9
Field bean, dry	347	25	1	3	60	1	60	433	3
Green gram, whole	334	24	1	3	57	4	124	326	4
Green gram dal	348	24	1	3	60	1	75	405	4
Horse gram, whole	321	22	0	3	57	5	287	311	7
Khesari, dal	345	28	1	2	57	2	90	317	6
Lentil	343	25	1	2	59	1	69	293	7
Moth beans	330	24	1	3	56	4	202	230	9
Peas green	93	7	0	1	16	4	20	139	1
Peas dry	315	20	1	2	56	4	75	298	7
Peas roasted	340	23	1	2	57	4	81	345	6
Rajmah	346	23	1	3	61	5	260	410	5
Red gram, dal	335	22	2	3	58	1	73	304	2
Red gram tender	116	10	1	1	17	6	57	164	1
Soybean	432	43	20	5	21	4	240	690	10

*Source: Nutritive value of Indian Foods (Gopalan et al., 2004)

In addition to contributing to a healthy, balanced diet, the nutraceutical qualities of pulses makes them particularly helpful in the fight against some non-communicable diseases. Thus, pulses have been used and have the potential to be used in development of different value added food products (Figure 1).

Figure 1: Opportunities for using pulses in innovative food product development applications.

The World Health Organization (WHO, 2003), estimates that up to 80% of heart disease, stroke, and type 2 diabetes and over a third of cancers could be prevented by eliminating risk factors, such as unhealthy diets and promoting better eating habits, of which pulses are an essential component. Pulses have been extensively studied for their nutraceutical or health benefitting properties (Jukanti et al., 2012). Pulses have been reported to have beneficial effects in control and management of some of the important human diseases like cardiovascular disease, type 2 diabetes, digestive tract diseases and some cancers (Duranti, 2006). Scientific evidence show that consumption of pulse protein as part of regular diets may help prevent or treat a number of lifestyle diseases such as cardiovascular conditions, cancers, type 2 diabetes or gluten intolerance (Janzen et al., 2006). The major health benefits of pulses attributed to their nutritional and nutraceutical properties is summarized in Table 2. Pulses can help lower blood cholesterol and attenuate blood glucose, which are key factors in managing diabetes and cardiovascular disease. Eating pulses as a replacement to some animal protein also helps limit the intake of saturated fats and increases the intake of fibres. Pulses have also been shown to be helpful in the prevention of certain cancers, because of their fibre content but also because of their mineral and amino-acid contents, and vitamins in particular folate. Pulses are also rich source of carotenoids (Giovannucci et al., 1995), isoflavones (Yanagihara et al., 1993) and precursors of short chain fatty acids (SCFA) (Fernando et al., 2010) which have proven anti-cancer properties. Pulses are included in all 'food baskets' and dietary guidelines. The World Food Programme (WFP) for instance includes 60 grams of pulses in its typical food basket, alongside cereals, oils and sugar and salt. Pulses not only support simple, quiet labels but formulating recipes using pulse-based ingredients also allows food manufacturers to make a range of consumer-friendly on-pack claims (Meissner, 2016). Pulse proteins with their naturally high protein content, are able to support 'high protein' claims (where 20% of the energy value of the food must be from protein) and 'source of protein' claims (12% of the energy value of the food is protein-derived) while still being gluten-free and suitable for vegetarians (Rohwer, 2015).

Table 2: Dietary attributes of pulses, effect on health and role in management of lifestyle diseases*

Dietary attribute of pulses	Effects on body metabolism	Health Benefits
Fibre Protein	• Satiation	• Weight management
Soluble fibre, Resistant Starch	• Assists in lowering cholesterol, triglycerides	• Management of Cardio-vascular disease (CVD)
Soluble fibre, Resistant starch, Slowly Digestible Starch	• Slows glucose absorption	• Diabetes and weight management
Insoluble fibre	• Adds bulk to stools, • increases colonic transit, promotes growth of probiotic	• Weight management
Plant Protein	• Diet lower in saturated fat	• Management of CVD
Low Fat Nutrient Dense	• Diet lower in fat • More nutrients per calorie	• Weight management, • Disease prevention

*Source: Pulse Canada, 2012a

Value Addition to Pulses

Value addition to pulses happens both through primary as well as the secondary processing. In the SAARC region primary processing of pulse for marketing of pulses as a commodity has been traditionally carried out. However the region is still lagging behind in secondary processing and use of pulses in development and marketing of innovative products. The opportunities for value addition extends from development of gluten free in baked food products, snacks and breakfast cereals; improvement of texture and colour of gluten free breads and batter; texture and colour improvement of fresh and dry gluten-free pasta; development of gluten-free soups, sauces, gravies; protein enrichment in fruit smoothies and vegan protein drinks; egg-replacement products etc.

Primary Processing of Pulses

The most basic form of value addition to pulses in the SAARC region occurs in the form of converting the grain legumes into “Dal” (Lal and Verma, 2007). Dal is obtained by splitting of the whole seed of the respective food legumes. Processing of grain legumes into dal involves the use of dal mills, which mostly operate in the small and medium scale sector. Traditional dal mills have lower recoveries of dehusked and splits (65-70%) as compared to the newly introduced improved dal mills in the region (NABARD, 2016). The improved dal mills are highly versatile and energy efficient with dehusking efficiency of about 95% and the yield of split pulses of about 80-85% depending on the variety of pulse and conditioning of the pulse grain.

The steps involved in the processing of pulses are detailed in Figure 2. The process involves cleaning of the pulses to remove the stones and mud. The surfaces of the pulses are then "pitted". Pitting is done to cause some cracks and pores on the surface, to enable penetration of the various conditioning effects carried out to facilitate loosening of the husk.

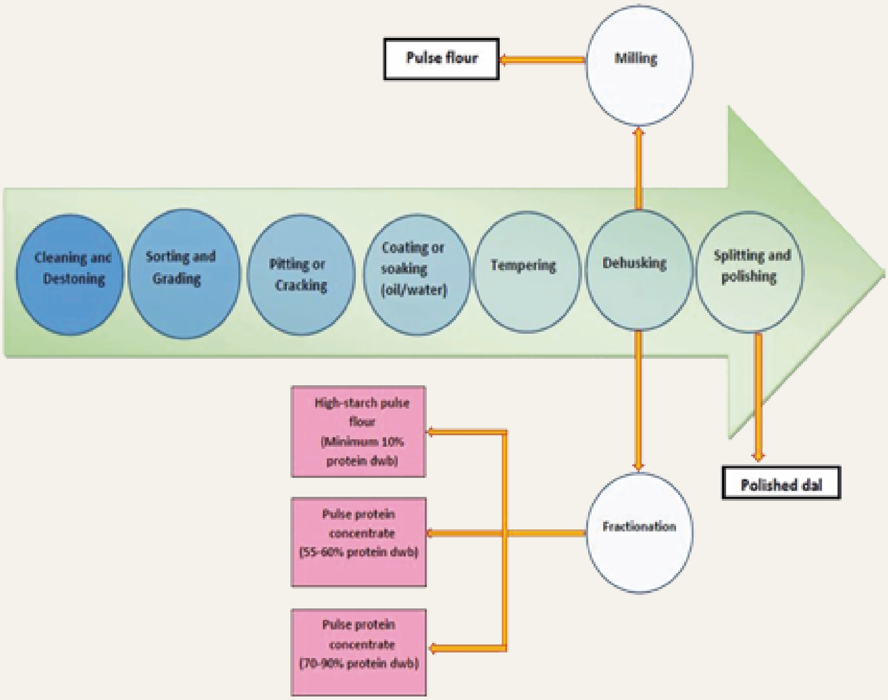

Figure 2: Processing of pulses to dal and other value added products.

The conditioning process depends on the type of pulse and typically involves either soaking of the cleaned and pitted pulses in a mixture of water and vegetable oil or water or coating with oil etc. The different dehulling practices for processing of different types of pulses as reported in literature (Lal and Verma, 2007) are summarized in Table 3. The use of enzymes and chemical agents (Krishnamurthy et al., 1972) such as sodium bicarbonate, sodium carbonate, sodium hydroxide and ammonia has been also reported (Verma et al., 1993). Use of enzymes was found to improve the efficiency of dehusking as well as improve the protein digestibility and decrease the flatulence factors. The conditioned pulses are subjected to a process of tempering (heating and cooling cycle) and in certain cases sun drying before being passed through rollers for splitting of the cotyledons to obtain dal.

Table 3: Typical milling processes involved in primary processing of different pulses*

Pulse and their milling process

Pigeon pea: Most difficult kind of pulse to mill (because of tight attachment of husk to the seed coat)

- Clean and graded grains are pitted (scratched over the seed surface)
- Oil smeared (0.2-0.5%)
- Tempered for ½ to 1 day in bins, treated with water (in the ratio of 1:20-25), stored overnight and sundried for 2-3 days before passing through the emery roll.
- This type of husk loosening and dehusking operations are repeated 2-4 times till more than 90% grains are dehusked.
- *Dal* obtained during this method is termed as Grade-II *dal* as edges of most of the *dal* gets rounded off during milling.
- The mixture of dehusked and unhusked whole grain is further sprinkled with water and tempered for few hours, sundried and splitted in horizontal or vertical *chakkies* or by using *patka* machine.
- The *dal* thus obtained is considered as Grade-I *dal* since it has no chipped edges and has better customer acceptability.
- The recovery of pigeon pea varies from 68-75%, depending upon variety milled and method followed.

Chickpea: Easy-to-mill category of pulse

- Dehusking after cleaning and grading is done in roller mills.
- Splitting of '*gota*' (dehusked whole grain) is carried out by treating the grain with water in ratio 1:2.5 to 3.0, followed by tempering for 12 hours and splitting using a disk sheller.
- Does not require oil application for loosening of husk.
- The process is repeated till all the grains are dehusked.
- Recovery from *dal* varies from 78-82%.

Urdbean: Difficult-to-mill category of pulse

- Process involves cleaning, grading and pitting in emery roller mills.
- Two or three passes are required to complete dehusking and pitting operation.
- Husk and powder produced in each pass is removed after every pass.
- About 0.5% oil is applied to the pitted grains, and stored for 12 hours.
- The grains are then sundried for about 2-3 days followed by water spraying in the ratio of 1:25-30 and tempered overnight.
- These grains are passed through rollers for dehusking.
- The *dal* splits obtained during the processes is called Grade-II *dal*.
- The '*gota'* obtained is passed through burr mill to make Grade-I quality *dal*.
- To give luster and enhance market value, *dals* are polished using soapstone powder.

Mung bean: Difficult-to-mill category of pulse (husk have the high degree of adherence to cotyledons)

- Husk is thin, soft and slippery in texture.
- Bond between the two cotyledons is weak, therefore, splitting occurs prior to dehusking.
- In order to achieve proper dehusking of mung bean grains, oil treatment is applied.
- Pitting, oil smearing and sun drying are followed by dehusking and splitting in roller machines.
- The loss in form of broken and powder is large in case of mung bean due to its thin seed coat and rubbing operation during dehusking.

Pulse and their milling process

Peas: Easy to dehusk category of pulse

- Whole grains of peas are sold as such in the market generally after polishing to enhance the customer appeal.
- The milling process includes cleaning, grading, moisture application, tempering and sun drying up to the milling moisture content (10-12%, dwb).
- Dehusking and splitting can be achieved in roller mills or disk sheller.
- Recovery of dal from peas ranges from 80-82%.

Lentil and Khesari: Easy-to-mill category of pulse

- The practice usually applied involves moisture addition after cleaning and grading process, followed by tempering and sun drying.
- Dehusking and splitting is carried out in roller machines.
- Dehusking process is repeated till all grains are split and dehusked.

*Source: adapted from Lal and Verma, 2007

Value Added Fractions from Pulses

Different value added fractions, with different food applications can be obtained from pulses in addition to the primary processing for obtaining dal. Dehulled pulses can be directly milled into flour. Dehulled pulses can be further fractionated into starch rich pulse flour, protein concentrates and protein isolates. Two different methods of fractionation are typically used –dry fractionation and wet fractionation. The fractionation methods are schematically represented in Figure 3.

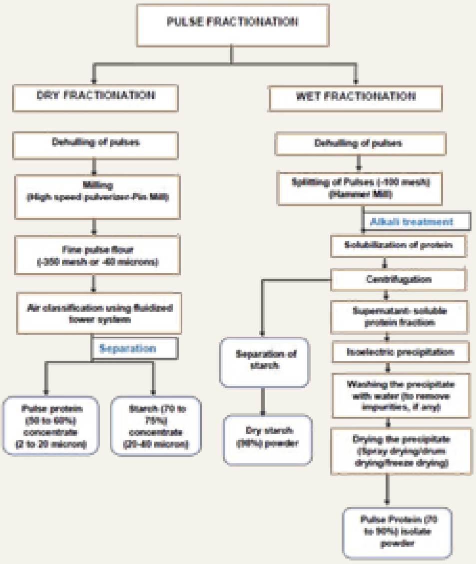

Figure 3. Steps involved in fractionation of pulses by dry and wet fractionation methods.

Dry fractionation of pulses is used to obtain pulse protein concentrate (50 to 60% protein) from milled dehulled pulse flour. This typically involves use of a high speed pulveriser (Pin mill) resulting in very fine (-350 mesh or -60 microns) pulse flour. After milling fractionation is carried out using air classification using a fluidized tower system. The air classification system results in the separation of pulse protein concentrates (2 to 20 micron) and starch concentrate (70 to 75% starch, 20 to 40 micron).

Wet fractionation of pulses is typically used in obtaining protein isolates (70 to 92% protein) from pulses. The process involves dehulling of the pulses followed by solubilizing the protein, by alkali treatment, and separation of starch. The soluble protein fraction is then separated by centrifugation as the supernatant. The protein isolate is then recovered from the soluble protein fraction by isoelectric precipitation at the isoelectric pH of the respective pulse proteins. In the final step the precipitate obtained is washed with water to remove any impurities present and protein isolate powder is obtained by either spray drying, drum drying or freeze drying (Aurelia et al., 2009). The process also yields pulse starch of high (98% starch) purity.

Branding of Pulses

The most recent development in the region has been the entry of the different private players with branded and differentiated pulses (Table 4) into the market catering to specific demands from different consumer segments and using innovative marketing channels (IPGA, 2014). According to experts this trend of branding of pulses would bring value addition in the commodity (Business Standard, 2012). However along with increase in branding and value addition, there is also the risk that the pulses become more expensive and thus less affordable to the common masses, especially the rural poor. On the other hand, the private players as part of their branding efforts also strive to develop a strong eco system by bringing in rural prosperity through empowering farmers, women and providing a direct linkage to the consumers thus building a sustainable business environment that shall indirectly enhance their purchasing power. Thus, parallel policy support from the government towards facilitating establishment of processing facilities by the private sector in the rural areas, ensuring buy back arrangements from the local farmers by the private sector, adhering to the minimum support price (MSP) for pulses, and ensuring availability of affordable quality pulse products in rural areas needs to be effectively designed and implemented, in the SAARC region.

Table 4: Trends in branding of pulses in the SAARC region*

Marketing attributes of some branded pulses in India	Beneficiaries and Impacts
• Hygienically packed "Unpolished pulses" having better dal yield and consistency due to low moisture content	• The pulses are locally sourced by the private sector, focus on community development and supporting pulses growers of India
• Wide network of distributors/reach using associated and alternate channels such as telephonic and online have been introduced for direct delivery of pulses at doorstep.	• Easy access to consumers.
• Mineral (Iron, Calcium, Magnesium and Phosphorus)-enriched pulses using the technology of high pressure impregnation.	• Population affected with Protein deficiency as well as micronutrient deficiencies
• Unique "Gota"/un-split toor dal which is only one of its kind of product in India. The shape and technology retains the germ of seed for greater taste, high nutrition, faster cooking and thicker dal especially for making sambar.	• Faster cooking properties beneficial for housewives • Enhanced nutritional properties beneficial for population affected with protein deficiency as well as micronutrient deficiencies.
• Focus on safer and quality product through highest standards maintained in procurement, modern advanced processing in state-of-the art facilities in safe and high quality packaging.	• Quality and hygienically packed product for the consumer.
• Rich taste and superior in quality through processing technology where the dal is not rubbed off around the edges during processing, the grains of the dal are preserved in its natural state, guaranteeing finer taste and better health. The dal is unpolished and without any colors and chemicals.	• Enhanced nutritional properties beneficial for population affected with protein deficiency as well as micronutrient deficiencies • Consumer assured of adulteration free product.
• Uncontaminated, hygienically processed, free from adulteration and pure, product range and quality focus on meeting the local taste requirements of North India.	• Consumer assured of taste and quality • Consumer assured of adulteration free product
• Processing technology ensures retention of all natural properties during all the stages of processing, without employing artificial means of coloring or washing.	• Enhanced nutritional properties beneficial for population affected with protein deficiency as well as micronutrient deficiencies.
• Organically grown pulses in the right kind of soil, minimally processed and un-polished, free from any kind of pesticide residues.	• Consumer assured of taste and quality • Consumer assured of adulteration free product • Enhanced nutritional properties beneficial for population affected with protein deficiency as well as micronutrient deficiencies • Environmental sustainability.

*Source: adapted from IPGA, 2014

Functional Properties of Pulse Fractions for Product Development

Pulses due to their nutritional, functional, and health benefits, are used in food product development as important constituents leading to different food formulations. Some of the properties of pulses useful for product development activities are their high protein and fibre content, gluten free status, low glycemic index (GI), antioxidant levels, as well as functional properties like water binding and fat absorption capacities. Two important aspects of pulse functionality important to product development namely- "Functional properties of pulse flour, dietary fibre and starches" and "Functional properties of pulse proteins" are discussed here in detail.

Functional Properties of Pulse Flour, Dietary Fibre and Starches

Pulse flours in general have high levels of water and oil absorption capacities, good gelation in addition to the emulsifying and foaming capacities (Ladjal and Chibane, 2015), and are useful in formulating variety of food products, such as bakery products, soups, dairy products etc. The ability to pulse flours to bind high amounts of water effectively is important for developing shelf stable food products (low water activity).

Pulse flour and low GI flours and fibre-rich fractions obtained from pulse crops can be incorporated into processed foods to increase dietary fibre content and/or serve as functional ingredients (Tosh and Yada, 2010). Moreover, as the in vitro starch digestibility value (ISDV) values of pulses in general are lower than cereals due to higher amylose content (Madhusudhan and Tharanathan, 1996), pulses are the right ingredient for use in preparation of food products for diabetics. Most pulse based starches have greater stability against heat and mechanical shear; they represent a good source of resistant starch, which can make these starches an exciting food ingredient for a number of food applications. Pulse starches can be used in processed meat products, particularly where extensive heating and mechanical stirring is required. Canned foods, cooked sausages, soups, sauces, noodles and vermicelli prepared using pulse starches have better sensory attributes than those made from starches from traditional sources. The thickening effect of pulse starches is used to increase viscosity of different food products.

Legumes were identified as low GI foods during the early 80's (Rizkalla et al., 2002, Jenkins et al. 1981, Jenkins et al., 1983, Thorne et al., 1983). Further, it was also successfully (Kabir et. al., 1998) demonstrated that when starches with different amylose: amylopectin ratios (waxy corn starch, 0•5:99•5 %; mung beans, 32:68 %) were incorporated into a mixed meal, the meal with the high amylopectin starch (waxy corn starch) showed a higher glycemic response than that of the low amylopectin starch (mung beans). In general it may be highlighted that pooled analyses of results from a number of research publications demonstrated that pulses, alone or incorporation of pulses in low-GI or high-fibre diets, improve markers of longer term glycemic control in humans (Sievenpiper et al., 2009, Powell et al., 2002)

Appropriate accurate information on GI of different legumes and varieties are important in order to understand their role in diabetes management and in designing food products for the management of diabetes. Data on glycemic load and GI of different foods include a few select legumes are available in literature and these have also been collated and published as International Tables of GI and Glycemic Load Values: 2008 (Atkinson et al., 2008). Table 5 presents the GI compiled from international literature for some of the pulses and pulse based products and shall be a useful resource for the product developers in the SAARC region. Further it is important that this list be further populated with research on the GI and starch digestibility profile of locally grown pulses and pulse based products of the SAARC region.

Table 5: GI of pulses and pulse based products*

Pulse and Pulse based product	**GI[1] (Glucose =100)**	**GI[1] (Bread =100)**
Baked Beans		
Baked Beans, canned (Canada)	40±3	57
Baked Beans, Heinz Vegetarian baked haricot beans (HJ Heinz Company, Dandenong, VIC, Australia)[2]	40	57
Baked Beans in Cheesy Tomato sauce (HJ Heinz, Australia)	44±4	63
Baked Beans in Barbecue sauce (HJ Heinz, Australia)	47±4	67
Baked Beans in Ham sauce (HJ Heinz, Australia)	53±4	76
Baked Beans in Mild Curry sauce (HJ Heinz, Australia)	49±5	70
Baked Beans in Sweet Chili sauce (HJ Heinz, Australia)	46±3	66
Baked Beans in Tomato sauce (HJ Heinz, Australia)	40±5	57
Baked Beans in Tomato sauce, canned, reheated in microwave for 1.5 min (HJ Heinz, Australia)	57±7	82
Beans, dried, boiled		
Beans, dried, type NS (Italy)[3] Blackeyed beans/peas (Cowpeas), boiled	37	52±25
Blackeyed beans (Canada)	33±4	47
Blackeyed peas (*Vigna unguiculata*), boiled (Nigeria)[2,4]	52	74
Blackeyed peas (*Vigna unguiculata*), boiled, consumed with 4.24 g salt (Nigeria)[4,5]	38	54
Butter Beans		
Butter beans, canned, drained, Edgell's™ brand (Simplot Australia, Cheltenham, Australia)[5]	36±3	51
Butter beans, dried, soaked overnight, boiled 50 min (UK)	26±7	37
Butter beans, dried, soaked overnight, cooked in salted water (South Africa)	28±7	40
Butter beans (Canada)	36±4	51
Mean of four studies	**32±3**	**45±4**
Cannellini beans, canned, drained, Edgell's™ brand (Simplot Australia, Cheltenham, Australia)[5]	31±5	44
Chickpeas (Garbanzo beans, Bengal gram), boiled	32±3	45±4
Chickpeas (*Cicer arietinum* L.), dried, soaked, boiled 35 min (Philippines)	10	14±3
Chickpeas (Canada)	36±5	51
Chickpeas, canned, drained, Edgell's™ brand Chickpeas, canned, drained, Edgell's™ brand	38±3	54

Pulse and Pulse based product	**GI[1] (Glucose =100)**	**GI[1] (Bread =100)**
Chickpea Hommus dip, Chris' Traditional brand (Capitol Chilled Foods Pty Ltd, ACT, Australia)[5]	22±5	31
Four bean mix, canned, drained, Edgell's™ brand (Simplot Australia, Australia)[5]	37±5	53
Haricot/Navy beans		
Haricot/Navy beans, boiled (Canada)	31±6	44
Haricot/Navy beans (King Grains, Canada)	39	56±16
Haricot beans, home-cooked, soaked overnight, boiled 1h in water, baked in tomato sauce 2 h[2] (HJ Heinz, Australia)	23	33
Kidney Beans		
Kidney/white bean (*Phaseolus vulgaris* L.), soaked, boiled 17 min (Philippines)	14	19±5
Kidney beans (*Phaseolus vulgaris*) (India)	19	27
Kidney beans (*Phaseolus vulgaris* L.), red, soaked 20 min, boiled 70 min (Sweden)	25	36±6
Kidney beans (Canada)	29±8	41
Mean of four studies	**22±3**	**31±5**
Kidney beans (*Phaseolus vulgaris* L.), autoclaved	24	49±5
Kidney beans, dried, soaked 12 h, stored moist 24 h, steamed 1 h (India)[4]	70±11	100
Black bean (*Phaseolus vulgaris* Linn), soaked overnight, cooked 45 min (Philippines)	20	28±4
Dark Red Kidney beans, canned in brine, drained, Edgell's™ brand (Simplot Australia, Australia)[5]	43±5	61
Red Kidney beans, canned, drained, Edgell's™ brand (Simplot Australia, Australia)[5]	36±4	51
Red Kidney beans, dried, soaked overnight, boiled 60 min (UK)	51±5	73
Lentils		
Lentils, type NS (Canada)	29±3	41
Lentils, brown, canned, drained, Edgell's™ brand (Simplot Australia, Australia)[5]	42±5	60
Lentils, green, dried, boiled (Australia)	37±3	53
Lentils, red, split, dried, boiled 25 min (UK)	21±7	30
Marrowfat peas, dried, boiled (Canada)	47±3	68
Mung beans		
Mung bean (*Phaseolus* areus Roxb.), soaked, boiled 20 min (Philippines)	31	44±6
Mung bean, fried (Australia)	53±8	76±11
Mung bean, germinated (Australia)	25±4	36±5
Mung bean, pressure cooked (Australia)	42±5	60±7
Pigeon Pea (*Cajanus cajan* (L). Huth.), soaked, boiled 45 min (Philippines)	22	31±4
Pinto beans		
Pinto beans, steamed (USA)[2,4]	33	47
Refried Pinto beans, Casa Fiesta™ brand (Capital Foods Pty Ltd, Australia)	38±3	54
Soya beans		
Soya beans, dried, boiled (Canada)	15±5	21
Soya beans, dried, boiled (Australia)	20±3	29
Soya beans, canned (Canada)	14±2	20

Pulse and Pulse based product	GI[1] (Glucose =100)	GI[1] (Bread =100)
Soya beans, canned in brine, drained, Edgell's™ brand (Simplot Australia, Australia)[6]	14±3	20
Split peas, yellow, dried, soaked overnight, boiled 55 min (UK)	25±6	36

*Source: Atkinson et al., 2008

1. Mean ± SEM. Two GI values are shown for each food – one in which glucose sugar was used as the reference food and one in which white bread was used as the reference food.

2. GI calculated from the 180 min AUC data included in the original article using the AUC food/AUC reference food formula.

3. Portions of the test food and the reference food contained 30 g carbohydrate.

4. Portions of the test food and the reference food contained 75 g carbohydrate.

5. Portions of the test food and the reference food contained 25 g carbohydrate.

6. Portions of the test food and the reference food contained 10 g carbohydrate.

In the context of the above table it may be noted that, as highlighted by the authors, some research laboratories continue to use white bread as the reference food for measuring GI values, whereas others use glucose (dextrose); therefore, two GI values are given for each food. The first value is the GI with glucose as the reference food (GI value for glucose = 100; GI value for white bread = 70), and the second value is the GI for the same food with white bread as the reference food (GI value for white bread = 100; GI value for glucose = 143). When bread was the reference food used in the original study, the GI value for the food was multiplied by 0.7 to obtain the GI value with glucose as the reference food. The table lists the reference food that was originally used to measure the GI value of each food (Powell et al., 2002). This it is evident from the data that there is a wide variability in the GI values of pulse and pulse based products and the pulse type, variety and processing conditions affect the GI values of the end product.

Functional Properties of Pulse Proteins

Pulses are good sources of protein as evidenced from the nutritional profile (Table 1) and have a balanced amino acid profile (Table 8) and superior protein digestibility. In addition the protein and protein isolates from pulses have excellent functional properties that make them useful ingredients in innovative food product development. Examples of such functional properties include solubility, water and oil binding capacity, foaming and gelation and viscosity imparting properties. The functional properties of pulse proteins have been exploited in the preparation and development of products such as bakery products, soups, extruded products and ready to eat snacks (Boye and Pletch, 2010).

The excellent emulsification properties of pulse proteins and protein isolates is attributed to the presence of hydrophilic amino acids that promotes formation of "oil in water" emulsions.

Specifically, in pulse proteins, water-soluble albumins, and salt-soluble globulins predominate (Macrone et al., 1998), with prolamins and glutelins present in smaller concentrations. Globulin proteins contribute most to the functionality in food products. As pulses are a source of the most accessible, highest concentrations of globulins they are a good source for commercial protein concentrates and isolates. All pulse globulins are composed of two major proteins – 11S legumin like and 7S vicilin-like proteins. Both the globulin: albumin ratio and the 11S:7S ratio contributes to differences in the physicochemical properties of pulse flours and protein concentrates and isolates (O'Kane, 2004). Vicilin-like globulins have high foaming capacity and legumin-like globulins have high emulsifying capacity. Table 6 provides an overview of the protein profile of different pulses.

Table 6: Typical protein profile of different pulses*

Protein	Peas	Beans	Chickpeas	Lentils
Crude Protein (dry basis-whole seed)	15–32%	18–25%	~22%	27.9–32.1%
Globulins	65–85%	55–80%	42%	51%
Albumins	20–35%	10–20%	16%	11–16%
Glutelins	12%	10%	9.9	11%
Prolamins	~1%	~1%	0.48%	3.5%

* Source: Pulse Canada, 2011a

Some of the functional characteristics of pulse proteins that needs to be considered for product development of different value added products are:

Solubility: Solubility is the main characteristic of proteins selected for use in liquid foods and beverages. High soluble protein possesses good dispersibility of protein molecules or particles, and lead to the formation of finely dispersed colloidal systems. Potential applications of proteins can be dramatically expanded if they possess high solubility.

Water binding capacity (g or ml water/gm of protein): may be defined as the amount of water that can be absorbed per gram of protein material.

Oil holding capacity (g or ml oil/gm of protein): is calculated as the weight or volume of oil absorbed per weight of protein powder or legume flour.

Emulsifying properties: Emulsifying activity (EA) and emulsifying stability (ES) are two indices often used to evaluate the emulsifying properties of protein flours. Proteins act as emulsifiers by forming a film or skin around oil droplets dispersed in an aqueous medium, thereby, preventing structural changes such as coalescence, creaming, flocculation or sedimentation.

Foaming properties (% volume increase): Foams are formed when proteins unfold to form an interfacial skin that keeps air bubbles in suspension and prevents their collapse. Foam formation is important in food applications such as beverages, mousses, meringue cakes and whipped toppings.

Gelation (least gelling concentration-LGC): Protein gelation is important in the preparation of many foods (e.g., puddings, jellies and in many dessert and meat applications). An important index of gelling capacity is the least gelling concentration (LGC) which may be defined as the lowest concentration required to form a self-supporting gel. Proteins with lower LGC, therefore, have greater gelling capacity. The functional properties of some of the pulse proteins as reported in literature are presented Table 7.

Table 7: Functionality of Pulse Proteins*

Pulse	Protein	Water Holding Capacity (WHC) (g or ml H_2O/g protein)	Oil Holding Capacity (OHC) (g or ml oil/g protein)	Foam Capacity (% volume increase)	Emulsion Capacity	Gelation
Cicer arietinum (Chickpea)	Micelle protein conc. (87.8%)	4.9 g/g	2.0 g/g	43.3	63.7%	
	Isoelectric protein conc. (84.8%)	2.4 g/g	1.7 g/g	47.5	72.9%	
	Desi protein Isolates (89.9-94.3%)	2.6-3.4 g/g	2.08-3.75 g/g	30.4-44.3%		Least gelation concentration ranges from 14-20%
	Kabuli protein isolates (94.4%)	2.4 g/g	3.96 g/g protein	40.0 % High foam stability		Least gelation concentration ~18%
Lens culinaris (Lentils)	Native protein isolate	1.08 ml/g protein	2.61 ml/g protein	83.8-88ml	54.2%	
	Acylated (62.5-93%) protein isolates	1.67-2.33 ml/g protein	1.76-2.17 ml/g protein	67-89 ml	52.3-56%	

Pulse	Protein	Water Holding Capacity (WHC) (g or ml H_2O/g protein)	Oil Holding Capacity (OHC) (g or ml oil/g protein)	Foam Capacity (% volume increase)	Emulsion Capacity	Gelation
Phaseolus vulgaris (Dry beans)	Whole bean flours	1.43-2.03 g/g	1.05-1.32 g/g	115-129	63.88%	Requires 10-20% protein to make "instant gel"
	Dehulled bean flours	1.66-4.36	1.34-1.59 g/g	121-133	64-94%	
	Protein Isolates (75.6-88.7%)	2.63-3.09	3.26-3.48	38.3%	55.12%	Least gelation concentration ~14%
Pisum sativum (Field pea)	Flour (25% protein)	0.78 g/g	0.41 g/g	300	34.6 ml/100g sample	
	Protein fraction (47.2%)	1.09 g/g	1.59 g/g	565	37.2 ml/100g sample	
	Protein isolate (80.3% protein)	2.52 g/g	0.98	315	36.6 ml/100g sample	
Soybean	Protein isolate (82.3%)	2.65 g/g	1.03 g/g	120%	45.1 ml/100g sample	

*Source: Sathe, 2002; Sathe et al., 1984

The positioning of food products with enhanced protein content is now a leading trend in product development in the food industry. Similarly, a growing demand for non-animal protein sources has led to an interest in plant-based proteins, including pulses. The crude protein content of pulses (Table 1) positions it as plant-based alternative to meat within international dietary guidelines. A major consideration with respect to the inclusion of pulses in processed foods relates to the quality of the dietary protein. Protein quality is generally assessed as a function of the ability of the constituent amino acids found within the food to meet the biological needs of the consumer. Different methods exist to determine the quality of dietary proteins, each with their own advantages and disadvantages. As processing steps also alter the protein quality of foods, these factors must also be considered when formulating food products to deliver quality protein using pulses and other ingredients (Nosworthy and House, 2016).

As mentioned, the amino acid composition of pulses is of significance in defining the role of pulses for being considered as an important dietary component to improve the quality of protein being consumed. From the nutritional viewpoint, all pulse proteins are relatively low in sulphur containing amino acids, methionine, cysteine and tryptophan, but the amounts of other essential amino acid, such as lysine, are much greater than in cereal grains (Rockland & Radke, 1981; Ampe et al., 1986). Therefore, with respect to lysine and sulphur amino acid contents, legume and cereal proteins are nutritionally complementary. Thus, these essential amino acid deficiencies have traditionally been overcome by integrating pulse-based dishes with cereal foods (roti, pasta, rice, bread, etc.). The typical amino acid composition of various legumes is presented in Table 8.

Table 8: Typical amino acid composition (mg/g N), of various grain legumes*

Amino acid	Chick pea	Lentil	Lima bean	Mung bean	Broad bean	Faba bean	Flat pea	Field pea	Field bean	Lupine	Soy bean
Arginine	528	426	292	523	541	558	520	609	427	772	465
Histidine	157	150	175	185	149	155	154	148	178	139	138
Isoleucine	268	270	285	266	250	253	219	248	278	238	296
Leucine	486	448	526	531	438	465	419	451	517	428	466
Lysine	437	471	398	464	391	391	346	450	418	280	401
Methionine	97	76	72	42	72	57	44	56	56	87	86
Phenylalanine	342	302	331	354	248	260	240	289	348	194	309
Threonine	237	227	259	220	212	217	208	234	252	196	234
Tryptophan	78	56	79	67	46	63	32	64	66	34	84
Valine	260	304	288	314	285	286	227	300	301	189	306
Cystine	73	64	65	60	48	66	27	71	45	25	69
Tyrosine	165	182	228	183	184	190	167	187	212	212	216
Alanine	257	272	250	271	258	260	220	278	240	198	271
Aspartic acid	746	702	754	745	651	709	626	762	746	594	719
Glutamic acid	1062	982	824	1156	992	1073	1034	1132	1007	1364	1143
Glycine	249	258	236	241	256	272	214	282	234	237	266
Proline	266	218	257	286	224	259	223	251	238	238	319
Serine	322	292	391	332	271	299	265	283	357	297	282
Total AA	6030	5700	5710	6240	5520	5830	5190	6090	5920	5720	6070
Total EAA	2440	2400	2530	2500	2170	2247	1930	2350	2490	1880	2470

*Source: Adapted from Sosulski and Holt, 1980.

However, amino acid composition only represents the potential quality of a protein food, digestibility and bioavailability of proteins are critical for ensuring utilization of amino acids by the human body. A number of experimental approaches, devised to assess the bioavailability of amino acids in foods have concurrently demonstrated that seed proteins have a lower overall nutritional quality than animal proteins. This is attributed to their low content of sulphur containing amino acids (Sarwar and Peace, 1986), the compact proteolysis-resistant structure of the native seed proteins

(Deshpande and Nielsen, 1987) and the presence of anti nutritional compounds, which may affect digestibility of proteins themselves and other components (Bressani et al., 1982; Aw and Swanson, 1985). It may be noted that the nutritional quality of food proteins is determined largely by the composition of essential amino acids and digestibility and is often reported as biological value, protein digestibility, protein efficiency ratio or net protein utilization (Young & Pellet, 1994). Thus, the nutritional value of high protein foods is based on both protein quantity and quality. Thus in formulating food products using pulses and with the aim of delivering protein quantity and quality consideration to the elements of protein value namely- net protein utilization (NPU), true digestibility (TD) and protein digestibility-corrected amino acid score (PDCAAS) needs to be appropriately considered. In this context it is important for product developers to understand the concept of PDCASS as well as have access to the data on PDCASS of different protein sources. The PDCAAS is a product of the amino acid score and the percent true protein digestibility, and should be defined for each pulse type. The PDCASS data (Pulse Canada, 2011b) for some of the common pulses and grains is presented in Table 9. Recently, it has been proposed to replace PDCASS with a more effective "Digestible Indispensable Amino Acid Score (DIAAS)" for assessing the dietary protein quality of in human nutrition (FAO, 2011).

As mentioned above, the role of pulse protein as a complementary protein source to improve the overall protein quality of a diet or food product formulation is based on the knowledge of their PDCASS of the respective pulse protein and the PDCASS of the protein from other plant/animal sources being used in the formulation. For example in the food industry protein claims on multi ingredient foods is calculated using PDCAAS values obtained from a weighted average procedure. Thus as an example to product developers, the weighted PDCAAS for the reformulated pasta (25:75 blend of lentil and durum wheat flour) containing a complementary blend of lentil and durum wheat flour was found to have a higher score (0.71) than the regular pasta containing 100% durum wheat (0.43). Thus, addition of 25% lentil flour improves both the protein quality and quantity in the pasta, and thereby qualifying the reformulated product as a "Good Source of Protein". This highlights the importance of understanding the protein quality of pulses in order to effectively use pulse ingredients to reformulate cereal-based foods to increase the protein quality of the overall food product.

Table 9: PDCAAS values for pulses and select cereal gains*

Pulses	Amino Acid Score[1]	True Protein Digestibility[2] (%)	PDCAAS[3]
Pea (yellow, split)	0.73	87.9	0.64
Pea (green, split)	0.59	85.2	0.50
Lentil (green, whole)	0.71	87.9	0.63
Lentil (red, split)	0.59	90.6	0.54
Chickpeas	0.61	85.0	0.52
Pinto Beans	0.77	76.2	0.59
Kidney Beans	0.70	78.6	0.55
Black Beans	0.76	70.0	0.53
Navy Beans	0.83	80.0	0.67
Soy Flour	0.92	83.5	0.77
Wheat Flour[#]	0.47	92.3	0.43
Rice Flour[#]	0.54	92.0	0.50
Lentil-Wheat (25:75) Blend[#]	0.78	91.0	0.71
Lentil-Rice (20:80) Blend[#]	0.82	90.0	0.74
Black Bean-Rice (25:75) Blend[#]	0.81	93.0	0.75
Pea-Wheat (30:70) Blend[#]	0.83	90.0	0.75
Casein	1.04	96.6	1.00

*Source: Pulse Canada, 2011b

1. Amino acid score is limiting the amino acid with the lowest ratio relative to the established amino acid requirement values for humans, aged 2 to 5 years old.

2. AOAC Method 991.29 (n = 10).

3. PDCAAS = Amino Acid Score × % True Protein Digestibility

#Calculated data obtained from the 1989 WHO/FAO Report

Thus, database on PDCASS and DIAAS values need to be generated for the pulses of the SAARC region in order to empower product developers to effectively utilize the pulses of the region in the development of new value added products. In addition, the role of food processing operations such as fermentation, baking, extrusion etc. should be factored in when formulating high protein pulse based products as each of these food processing operations will differently affect the digestibility (protein as well as starch), as well as quality and functionality of various food components.

Pulse based Product Concepts

Pulses due to their nutritional and health benefits, have been traditionally used as important constituents in different food formulations in the SAARC region. Dal (split chickpea/pigeon pea) and food items prepared from besan (dal flour) and other pulses are regularly consumed in the countries of the region. 'Phutna'-roasted grains, 'Pakora'- oil fried, 'Kadi'- boiled in buttermilk, 'Roti'- chickpea flour in combination with wheat flour, 'Dhokla'-fermented pulse based product and 'Satu'- roasted, chickpea flour with cereal flours (Jambunathan & Singh, 1990) are few such examples. Soya beans among pulses have been most successfully exploited for development of a number of value added innovative products. From soya beans, the following meat replacement products are made: tempeh, tofu (also known as soya curds or tahoe) and soya nuggets.

Pulses are process tolerant, easy to formulate and work well with other free-from ingredients. They can be milled into flour easily and together with pulse proteins, then incorporated into a range of applications including producing and enriching nutritious snacks, bread, cakes, cereals, batters and breads, pasta, soups, sauces and dips etc. (Meissner, 2016). Thus, pulses have the opportunity to be used in innovative product development in meeting the growing consumer demands for healthy foods and snacking options in the SAARC region.

However, the present day consumers are looking for convenience and are looking for options at reducing length of time it takes to soak, cook and prepare pulse based recipes. Consumers today are striving to have greater variety and healthier foods in the diet with the convenience of ready-to-eat (RTE) and fast cooking meals. Pulse protein flours, concentrates and isolates, therefore, offer opportunities for novel product development. Understanding the different flavor and colour profiles of pulses and how these are impacted by different manufacturing environments will also determine product choice. It is reported that the typical flavour intensity of pulses decreases in low moisture applications and higher the heat treatment, the lower the flavor intensity. Colour of different pulses also vary from light yellow to green or red and can be used to obtain natural colour diversity in snack products and to differentiate these products from non "free-from" goods (Meissner, 2016).

Product innovations using pulses from different parts of the world indicate a growing trend towards new product concepts using pulses to suit the local palate and health needs of the consumers. As evidenced from Table 10 different pulses have been innovatively used in developing food products having improved nutritional and functional properties. Pulses have been successfully used for diverse applications such as: protecting the probiotic bacteria using pulse proteins as encapsulating agents, using high-fibre micronized pulse flours for developing low fat bakery products with increased fibre content, in developing gluten free, lactose free and egg free products. Pulses have also been used in yoghurt preparations to enhance the prebiotic as well as probiotic content. Pulses are a source of allergen free protein and protein concentrates and have been used to improve the amino acid profile in food products.

In addition to the above mentioned products a wide variety of pulse-derived fermented foods can also be developed. The microorganisms involved in legume fermentation hydrolyze and metabolize pulses constituents resulting in the production of valuable products. Fermentation of pulses causes desirable changes including the improvement of nutritional value and sensorial properties and increased nutrient and phytochemical bioavailability (due to reduction/ elimination of anti nutritional factors), and also favors the formation of new bioactive compounds (Frias et al., 2016).

Table 10: Innovative pulse based product concepts*

S. No	Product	Ingredient	Importance/benefit of the product
1	Chocolate fudge probiotic ice-cream	Pea protein	Uses pea protein based capsules to protect the probiotic bacteria
2	Muffins	Made from coarsely-ground dried peas and pea fibre	Gluten-free, high-fibre baked delight
3	Lentilly Burger	Contain micronized lentil flour,	Frozen burger patty, boosting the fibre and reducing the fat content as compared to regular burgers
4	Crepe-ups	Made using chickpea flour and yellow pea starch in a 1:1 ratio	Gluten-free, heat-and-serve stuffed breakfast crepes
5	YoPulse	Pea protein	Pea protein-based, yogurt. Contains pre-biotics and probiotics
6	Smoothie	Pea protein curd	This smoothie includes a pea protein curd, which is blended to provide an allergen friendly source of protein.
7	Heartbeats	Made with red beans and green tea.	Heartbeats are a healthy, high-fibre popsicle treat
9	Candies	Pea protein concentrate	Fruit flavoured gummies fortified with pea protein and essential fatty acids.
10	Pea Tarts	Made with a sweet potato and chickpea	Vegetarian and gluten-free
11	Heart Healthy Sausages	Pea protein concentrate.	Low fat high protein sausage
12	Indi-Bean	Made from lentils and adzuki beans.	A gluten-free, vegetarian frozen
13	Pea-rogy	Made with chickpea flour and wheat flour and	This product is higher in protein and fibre content than the classic pierogi

S. No	Product	Ingredient	Importance/benefit of the product
		the filling is made of mashed chickpeas and potatoes	
14	Pulse Pasta Pods	Made from chickpea flour and whole wheat flour	High Protein and High fibre Pasta
15	Gluten-free Berry Muffin	Made with chickpea flour	These are gluten-free muffins.
16	Fruitein	Made with yellow pea protein	A high protein, fruit leather snack low in fat, a high source of fibre and contains no added sugar.
17	Chocolate Whoopie Pie	Made with pureed black beans and chickpea flour.	It is a mini dessert that is gluten- and lactose-free. It consists of two moist chocolate cake layers.
18	Be-LITE	Prepared with chickpea flour and pea fibre.	Be-LITE is a pre-scaled, dry cake mix designed for the consumer to add water, stir, and bake! The product is gluten- lactose- and nut-free without the addition of fat. Be-LITE has a higher fibre content than most standard cakes.
19	Pasta	Blended with chickpea, bean and yellow pea flours.	It is a 100% gluten-free and an excellent source of fibre. It is also low in sodium and is egg-and dairy-free.
20	Twisted roll	Made with yellow pea and wheat flour to provide	It is higher in fibre than the traditional steamed bun. It is intended to bring a new use of pulses to the traditional Chinese steam bun with the potential of introducing it into the Chinese food market.
21	Chocolate Truffle Torte	It contains pureed black beans and a crunchy chickpea and nut crust	The addition of pulses increases the nutritional content, while leaving a moist final product. The chickpea and nut crust provides a satisfying crunch, and a great source of fibre and protein.
22	Veggie Samosa Patty	Chickpea flour	Chickpea flour used helps to bind the samosa while adding fibre and protein.
23	Chickpea Clouds	Contains roasted chickpeas, dried cranberries, roasted whole lentils	Chickpea Clouds is a cluster pulse snack with a white chocolate coating. The inclusion of pulses makes for a healthier alternative to other high sugar snacks on the market.
24	Health Nut Doughnut	Contains white bean flour and adzuki bean purée frosting.	Health Nut Doughnuts are a nutritious low-fat and high fibre snack.
25	Power Dressing	Made with chickpea flour	Power Dressing is a creamy salad dressing. It is vegetarian, lactose-free, egg-free, gluten-free and nut-free.
26	Cocoa Buttons	Black bean and chickpea flours	Cocoa Buttons are a cocoa flavoured cereal, in the shape of smooth buttons made with a blend of black bean and chickpea flours. The product can be enjoyed as a cereal with milk, but can also be eaten dry as a snack.

S. No	Product	Ingredient	Importance/benefit of the product
27	Chickitos	Made with chickpea flour	Chickitos are a gluten-free, healthy alternative to traditional potato chips.
28	Benny Bar	Formulated with lentil flakes, granola and a syrup mixture.	Benny Bar, is promoted as the "beneficial pulse bar". Chickpea butter is added to mimic a peanut butter flavour without the allergenic risk.
29	Dip n' Go	The crisps are made with chickpea flour, kidney and romano beans.	Dip n' Go is the perfect handy snack for adults.
30	Zuki Bar	Made from whole small red bean flour and yellow pea hull	Zuki Bar is a novel, healthy, all-natural pulse snack bar and covered with a thin layer of delicious dark chocolate.
31	Pulsations	Black beans, dates, coconut, dried cranberries and oats.	Pulsations are high fibre and protein snack and are available in two formats: fresh-frozen with a coconut coating and dried, ready-to-eat.
32	Pulse Medley Gnocchi	It is made with a robust blend of pinto beans, dark red kidney beans, chickpeas and pea flour	The Pulse Medley Gnocchi is a variation to the traditional Italian potato gnocchi. This is a gluten-, egg-, lactose-free. This gnocchi is an excellent source of fibre, low in saturates, trans fats and salt.
33	Pulse Noodles	Made with a blend of wheat and pulse flour, including chickpea, lentil and split pea flours	These sheeted noodles have a neutral flavour and can be accompanied with seasoned soups or sauces. The complementary effect of blending plant-based proteins from wheat and pulse flours provides a product with a more balanced amino acid profile leading to enhanced protein quality.
34	Pulse Power Bar	This is made with a blend of chickpea and pumpkin flour mixed with bananas, hemp seed and egg.	This power bar is an energy dense and high protein product
35	Chickpea Perogies	The dough can be made with whole wheat flour, or completely replaced with chickpea flour, thus allowing the latter to have gluten-free status in addition to high fibre and iron.	This product is a variation of the traditional perogy. By replacing the potato with chickpeas in the filling, a healthier alternative is created.
36	Yo Pop	Chick pea flour.	Yo Pop is made with a smooth tasting vanilla yogurt blended with a grape-flavoured juice and fortified with chickpea flour.
37	Cheeky Cookies	Roasted and ground Kabuli chickpeas offering consumers a tasty and healthy treat	The product is a gluten-free, high fibre and is a healthier alternative to high fat and sugar cookies.

S. No	Product	Ingredient	Importance/benefit of the product
38	Dreamy Strawberry Mousse	This mousse contains pea starch and pea fibre	This product is a strawberry flavoured mousse that is fluffy and spongy in texture with chunky strawberries suspended in the mixture. The use of pulse based ingredients in the product provides texture as well as makes it a good source of fibre.

*Source: Pulse Canada, 2010; Pulse Canada, 2011c; Pulse Canada, 2012b

Use of Pulses in Development Complementary Food Supplements towards Addressing Malnutrition in SAARC.

It is quite evident that protein–energy malnutrition is one of the most serious problems facing all the SAARC countries (Kumar and Gurung, 2015). Hence given that pulses are already an important part of the diet in the SAARC countries, though there has been a decline in the dietary intake of pulses among populations in the region (MoWCD, 2011) and being the only source of protein for the vegetarian population, pulses find use in different product formulations for addressing malnutrition in the SAARC region. Globally the use of soybean as a protein source in providing cost effective ready to¬ use therapeutic food (RUTF) formulations has been well established (Bahwere et al., 2016). In India pulses are being used as protein source in the food formulations being provided as part of the supplementary nutrition program of the Integrated Child Development Scheme (ICDS). The National Institute of Nutrition (NIN), India has recommended the use of local pulses in different food recipes for different age groups in its "Dietary Guidelines for Indians-A Manual" (NIN, 2011). The use of pulses, as a protein source, in locally made weaning food formulations is popular in Nepal. Traditionally, roasted pulses in combination with roasted cereals have been used by Nepalese mothers to prepare a super-flour porridge or "sarbottam pitho ko lito" (Krantz, 1993). This recipe has now been further adopted worldwide by different development agencies towards addressing malnutrition. The UN World Food Programme (WFP) is distributing a chickpea-based ready-to-eat supplementary food, known as "Wawa Mum" or "Good food, Mum" in Pakistan and Afghanistan (IRIN, 2011). The paste contains a rich vitamin and mineral formulation blended with the cooked chick peas and each packet is designed to meet the daily nutrient requirements of children in the targeted age group. In Bangladesh Lentils (mashur dal) is recommended as an ingredient, to enhance the protein content, in "Khichuri" and "Halwa" formulations as part of the countries national guidelines for the management of severely malnourished children in Bangladesh (IPHN, 2008). The effectiveness of a cost effective chickpea and rice-lentil based RUTF was found to show good nutritional recovery among malnourished children in Bangladesh (Christian et al., 2015). Porridge type weaning foods can be prepared from germinated/ malted, boiled, mashed mung bean or other pulses along with the other selected cereals. The process of germination or sprouting decreases the anti-nutritional factors in pulses and increases the protein digestibility (Marero et al., 1991). Pulse protein fractions can be introduced into baby foods while using other ingredients that can contribute additional beneficial nutrients. The use of soy proteins in imitation milk applications is well known for children who suffer from lactose intolerance and cannot consume milk.

Conclusion

Despite the many appreciable qualities of pulses, value addition to pulses in the SAARC region has been restricted to mainly primary processing of pulses to be consumed as staples. With the UN General Assembly having declared the year 2016 as the "International Year of Pulses" it is the right opportunity to identify and launch appropriate interventions supported by appropriate policies in order to promote value addition through product development and marketing of pulses in the region. In addition to identifying new market opportunities, there is also the need to progress towards adoption of industry-wide grading standards and classifications of individual pulses, in order to address to demands of different segments of the trade. A concerted campaign towards increasing awareness on the benefits of pulses involving the mass media, the private sector and all other stakeholders across the pulses value chains needs to be undertaken in the region. Further, promoting awareness on the nutritional value of pulses can help consumers adopt healthier diets. With economic development and increase in purchasing power, it is noted that the trend in dietary choices tends to go towards more animal based protein and cereals, thus retaining pulses in diets is an important way to ensure that diets remain balanced and to avoid the increase in non communicable disease often associated with diet transitions and rising incomes.

One of the important policy interventions that need to be considered is support and advocacy towards encouragement of value addition and use of pulses in the governmental nutritional programs. This could be in the form of directives and awareness campaigns on the benefits of incorporation of new pulse based, protein and micronutrient rich foods in the national programs of nutritional support to children, adolescent girls and pregnant women and school mid day meal programs.

Funding for Research and Development towards understanding the effect of processing on the nutritional and functional properties of pulses and pulse based locally acceptable products is needed in the SAARC region, in order to create a demand pull for pulses through establishment of a continuous "innovation funnel" delivering new scientifically validated product concepts. Additionally, it is important to highlight that lack of policy support (Exim Bank, 2015) and post harvest innovations has been attributed to be the major obstacle in the region not only to increased pulses production but also new product development and innovations. Hence appropriate policy interventions for establishment of "Pulse Innovation Centers" and "Pulse Value-Chain Business Incubators" may be actively pursued in the SAARC region to promote demand driven innovations and sustainable enterprises through value addition and innovative product development.

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