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PEAS OVERVIEW

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USES OF PEA AS AN INGREDIENT FOR HUMAN FOODS AND ANIMAL FEED

Background

Pisum sativum L., specifically green and yellow dry peas, also known as smooth peas or field peas have been grown a since 4400bc, but only popular as a food since 1700AD (APG 2019).

Peas are a northern climate growing crop with Canada predicted to be the largest global grower of the all crop types by 2020, in contrast the UK grows an estimated. In most regions of the UK, pea crops have the potential to yield 11.6tons per hectare, however due to the weather conditions yields are approx. 7tons per hectare (ADAS 2019).

There are three main types of large-scale peas crops in the UK (Redmans 2015);

Marrowfat peas sown in the spring and consumed in the UK and abroad as canned products (mushy peas), snack foods or as ingredients in processed foodstuffs. Marrowfat peas are typically the premium pea product, grown to a supply contract at considerable premiums over feed quality,

Large blue peas (also known as greens) are the most popular dried pea type grown in the UK for canning markets and fried and roasted snack foods. They are largely micronized (roasted, cracked and rolled) for pet foods for small pets and in dog foods. These peas are also used as ingredients and as whole foods; presenting a large range of potential market opportunities

Yellow peas (also known as whites) are grown for a variety of purposes including splitting, whole processing and even milling for ethnic food processing in the UK. They are a very niche crop in the UK covering about a thousand hectares having fallen in recent years. However, they are the most widely produced pulse in the world and present a large range of potential market opportunities,

There are also other pea varieties which are specialised for specific end-uses and therefore grown in small quantities; these include *maple peas* and *capucijner peas.*

Market

The global pea protein market was valued at £26.6 million in 2017, and is projected to reach £144 million by 2025, registering a CAGR of 23.6 % (GrandViewResearch 2019). There are even projections as high as $49bn by 2029 (Ruters 2019).

There has been a marked rise in the past decade in the numbers of vegetarians and vegans in high-income countries, especially among the generation of millennials (Godfrey 2018). The reasons for this trend are complex and still unfolding, yet research indicates enhanced health consciousness, multiple health benefits, and increased demand for meat protein alternatives have increased the demand of pea protein, therefore propelling the growth of peas in food industry. Additional factors, such as plant-based, consistent increase in food & beverages industries, raised demand for organic-based foods, and innovations in protein-based products, have supplemented the global pea protein market growth.

Although pea and pea-derived ingredients are of increasing importance in quickly growing numbers of applications in the food industry, there is still a strong need to improve the quality of these ingredients in relation to their flavour profile. Expanding the applications of pea protein ingredients is commercially very appealing but conflicted due to because the off-flavour, developing more bland variants of the currently marketed materials will deliver new opportunities, especially in protein-enriched foods and beverages with a mild taste and flavour. Formulation of, and the flavour of pea-based protein products is the most challenging factor for pea protein products may affect the growth of the market (McKinsey 2019).

Currently the inclusion of pea protein in sports nutrition, RTD's and weight management products have been well received and expected to increase the popularity and demand of pea protein in the upcoming years but main use chemical processes or flavour masking agents to maintain appeal.

Figure 1; A selection of commercially available products containing pea.

Marketing of pea protein

proteins also fit into the category of "freedom foods," (Gelski, 2015). In particular, "freedom foods" are not constrained by worries pertaining to human disease, animal welfare, and food safety concerns specific to animal-based proteins. In fact, plant proteins from pulses, seeds, and grains have significant roles within "freedom foods," "free-from," and "good-for-you" foods. Five to ten grams or more of plant protein per serving are often promoted on many foods, beverages, and healthy snacks. Plant proteins are regularly associated with energy; and labels may include wording such as "plant-powered protein". Plant proteins have been marketed to offer a "boost" of protein for energetic workouts, as well as for good breakfasts and most important part of the day to keep you moving

Uses

Pea protein is extracted from green and yellow peas and is used in some protein supplements and protein-enriched foods. Pea protein contains all the essential amino acids required for healthy body function (FDA 2018). Pea protein is vegan and lactose-free and is safe for people with allergies or sensitivities to dairy and eggs. Thus, vegetarians and vegans prefer pea protein products to supplements with protein derived from dairy, such as casein, whey proteins, eggs, or meat.

Pea proteins can be produced with dry-milling and wet-milling technologies which result in protein content ranging from 48% to 90%. Nutritional benefits, water-binding capacity, oil-binding capacity, foam expansion, foaming stability, gel forming, emulsion stability and emulsion ability are positive functional properties of pea protein concentrates and isolates (Tulbuk et al, 2017).

Recent studies regarding pea protein functionalities have revealed unique properties compared to soybean protein isolates. In terms of functionality, gels made from pea protein isolates are weaker than soybean protein isolates (Garber 2014). Pea proteins are a better emulsifier and foaming agent at pH 7.0 compared to soy protein isolates (Tulbuk et al, 2017). The functional properties of pea proteins can be improved by applying enzymatic treatments Transglutaminase treatment improved the gel strength while acid proteases increased its emulsification capacity. Enzymatic treatments help transform pea protein isolates into functional proteins comparable to egg-white proteins and soy protein isolates (Soderburg 2013).

Applications of differing pea components for food processing.

Pea Protein

- Plant based protein has become a significant protein source for the diet. Providing a high content of amino acids, glutamic acid, lysine and arginine. High protein content, sugar free, gluten free and allergen free.
- Pea protein provides an important role in food industrial manufacturing particularly to soups, baked goods, snacks, sauces, as a diary substitution, meat substitute and to increase the overall nutritional quality of a product,

Pea fibre

- Pea fibre is a great source of dietary fibre, consisting of two main components; inner structure and seed coat. Within food applications the inner fibre is most commonly used due to its high-water binding capacity, oil absorption capacity, enhanced texture, longer shelf life, increased volume and increased dietary fibre content.
- The use of the inner pea fibre lends itself to soup, sauce. Meats, fish, baked goods, pasta and noodles.

Pea starch

- Rich is amylose (35%) giving pea starch its thickening and gelling properties which are considered to be more effective than other commonly used starches. Pea starch is also more stable at higher temperatures.
- Uses of pea starch lend themselves well to baking, coating, dairy, pasta, noodles, snacking, potatoes-based products, sauces, meat and confectionary due to its binding, expanding, textural and thickening properties.

Off flavours

Off-flavours can be either inherent to pulses or developed during harvesting, processing, and storage (Wibke et al., 2017). Off-flavours inherent to the pulse can only be removed, modified, or masked, but they cannot be prevented other than by breeding new cultivars with less off-flavour, whereas the developed off-flavour can be limited by the processing of the seeds. The main cause for off-flavour development during harvesting, processing, and storage is oxidation of the unsaturated fatty acids, linoleic and linolenic acids. Furthermore, off-flavours can develop from heat changing the sugars and amino acids, known as Maillard Browning reactions. Degradation of polyunsaturated fatty acids is believed to be a major cause of undesirable off-flavour development in legumes (Roland et al., 2016).

Off flavours in pea

Among pulses, off flavours are mostly seen in peas (Zhen et al., 2016). The volatile compounds in peas that cause off-flavours are partly inherent to peas and partly developed during harvesting, processing, and storage. Three different 3-alkyl-2-methoxypyrazines have been identified as aroma constituents inherent to green peas;

1) 3-isopropyl-2-methoxypyrazine,
2) 3-sec-butyl-2-methoxypyrazine,
3) 3-isobutyl-2-methoxypyrazine.

These compounds are present in extremely low concentrations but are the main compounds that contribute to the perceived green pea aroma in peas. Besides the 3 listed, a combination of several classes of volatile organic compounds such as aldehydes, ketones impact the pea off flavours. These volatile compounds are to a large extent generated by oxidation of unsaturated fatty acids as well as during harvesting, processing and storage (Heng no date).

Aldehydes and ketones, which are present in small quantities but significant as they possess stronger. Hexanal is responsible for the hay-like off-flavours in frozen peas and has also been described as grassy and leafy. Sulfuric containing compounds and aliphatic and aromatic hydrocarbons also contribute to off-flavour of peas (Kaneko et al. 2011) The protein, fats and carbohydrates in peas tend to adsorb flavour compounds, resulting in their retention (Guichard 2007).

Health Attributes of Pea in Food Manufacturing

Pulses have long been important component of the human diet due to the content of starch, protein and micronutrients. The health benefits other that direct nutritional intake have attracted much interest (Mudryi et al., 2014).

Epidemiological, in vitro and interventional studies all have demonstrated the role of peas and pea constituents in maintaining metabolic, cardiovascular and gastrointestinal health in humans (Table presenting intervention studies in appendix 1).

These health benefits are derived mainly from the concentration and properties of starch protein, fibre, vitamins, minerals and phytochemicals in peas.

Fibre from the seed coat and the cell walls of the pea contributes to gastrointestinal function and health and reduces the digestibility of starch in peas. The amylose content of pea starch also contributes to its lower glycaemic index and reduced starch digestibility. Pea protein, when hydrolysed, yields peptides with bioactivities, including angiotensin-I-converting enzyme inhibitor activity and antioxidant activity (Dhal et al., 2012).

The vitamin and mineral contents of peas may play important roles in the prevention of deficiency-related diseases, specifically those related to deficiencies of Selenium and folate (Chyan et al., 2010).

Peas contain a variety of phytochemicals including polyphenolics, in coloured seed coat types, which may have antioxidant and anticarcinogenic activity, saponins which may exhibit hypo cholesterolaemic and anticarcinogenic activity, and galactose oligosaccharides which may be beneficial prebiotic effects in the large intestine (Dhal et al., 2012).

The high fibre content in peas may mediate the glycaemic response as compared with low-fibre foods with equal carbohydrate proportions. A study comparing the use of yellow pea flour and pea starch with maize starch on glycaemic response and found a benefit with both pea flour and pea starch. found that bread containing 17 % pea hull fibre significantly reduced glycaemic response; however, the fibre breads also contained higher protein (Lunde et al 2011).

In 2018 the Peas Please pledge was launched to encourage the consumption of peas in the UK from school children to adults as it was deemed that peas are widely accepted by all age groups in the aim to also encourage the consumption of more vegetables (Peas Please Pledge 2018).

Environmental benefits of peas

As with the health benefits, pea have a positive environment impact driving a reduction of greenhouse gasses. Peas do not require nitrogen fertiliser and provide some residual nitrogen for the following crop. Growing pea reduces greenhouse gas emissions and the use of pea crops in simple agriculture rotations can decrease nitrogen use substantially, by adding soil nitrogen otherwise provided by synthetic fertilisers. This is particularly important as synthetic nitrogen fertiliser manufacture is the largest single contributor to greenhouse gas (GHG) emissions in agriculture, accounting for up to 40% of emissions (Redman 2015).

The greening regulations in the reformed 2015 Common Agriculture Policy have encouraged farmers to introduce pulses into their rotations, which is predicted to increase their production by 30%. This has the potential to bring many benefits. Considering 70% of proteins fed to animas in the EU are imported and its increasingly difficult to source GM-free varieties is a strong case for growing more home-grown proteins in the UK for both human and animal consumption. Pulses such as peas are attractive to pollinating insects and adding bio-diversity (Sustainable Food Trust 2015).

Animal Feeds

Field peas compare favourably with other grains for several nutrients. Peas are considered a crude protein source in most diets. Energy levels are similar to corn for most livestock species with starch (54%) and digestible fibre accounting for most of this fraction. Fat is low at 1.55% (Anderson 2002). Amino acids are important for pig and poultry feeds but not a major factor for ruminants as the microbes within the rumen provide the amino acids required. However, the quantity of starch and protein for ruminal degradation are important to ruminant's health and growth. Field pea complements most other grains and can serve as a pellet binder for manufactured feeds.

Table 1; comparison of nutrient values in animal feed from field peas aqnd commonly used livestock feed

	FIELD PEA	CORN	BARLEY	OATS	WHEAT	SOY HULLS
Crude protein	24.5	9.5	13.2	13.1	17.8	12.2
Acid detergent fibre	8	3.3	5.8	14	12.2	11
Neutral detergent fibre	15.1	10.8	18.1	29.3	40.7	66.1
Est. TDN	90	90	85	8.3	81	80
Fats	1.5	4.3	2.25	5.05	5.05	2.10
Ca	0.05	0.08	0.05	0.10	0.11	0.53
P	0.48	0.31	0.37	1.73	0.95	0.18

K	0.01	0.33	0.56	1.89	1.10	1.29
Dry matter	89	89	89	89	90	91

Beef cattle

Field pea is categorised as a very palatable feedstuff for all classes of beef cattle. This feed may best be used in diets where nutrient density and palatability is important. Energy values (NEg) for field peas in growing cattle diets can be as high as 0.71 Mcal/lb. Finishing cattle have demonstrated some improved performance traits with up to 20% field peas in the diet also low starch fermentation makes peas a potentially desirable complement for stabilising the ruminal pH when more rapidly fermented feeds like wheat and barley are fed (NDSU 2019).

Field pea trials have worked well in beef cow supplement formations. The nutrient density will provide additional benefits as fewer pounds of feed will be required for the same nutrition, resulting in lower transportation and storage costs. Field pea may be fed in place of range cake as a protein and energy source for wintering cows or incorporated into range cake at any level required. Field pea makes an excellent binder for pelleting or cubing. No anti-nutritional traits are observed in field peas.

Dairy cattle

Field peas have been used successfully implemented in lactating cow diets. With research suggesting ground field peas contributing up to 40 to 50% of the daily feed, replacing portions of corn, barley, or soybean meal (NDSU 2019b).

Field pea can be used as the sole protein source for growing heifers, due to dry peas slow degrading quality. Cows in early lactation may require additional undegradable protein from sources other than peas. However, feed trials in Alberta USA, replaced field peas where soybean meal has been traditionally used as a protein source. The results were very promising as there was no change to feed intake, milk yield, or 4% fat corrected milk. Undegradable protein requirements are met by using distillers' grains (beer producing by-products). The field pea trials also improved ruminal pH when substituted for barley in lactating cow diets (Vander et al., 2008).

Summary

There are great opportunities for the development of a neutral flavoured pea variety as this is seen as pea products limiting factors. Already a wide range of food products contain peas, with the plant-based demand increasing product innovation.

Benefits for pea consumption are seen in human health, potentially increasing the nutritional intake of all generations, sitting well with the Future Generation Act 2015.

The environmental benefits of pea protein reduce the need for nitrogen fertilisers and therefore reduce the risk of eutrophication and pollution to wildlife and waterways. The inclusion of a pulse crop in the rotation provides the only opportunity to fulfil the Ecological Focus Area (greening) requirements of the revised Common Agricultural Policy whilst also gaining a profit on the area by maintaining land in production.

Global markets are growing; a rise in UK production would help build markets in animal feed, exporting higher value foods and drive new product innovation in added-value food manufacturing for highly nutritious foods and health food markets.

The UK research base has the capability to improve yield and quality traits to meet production and market needs

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Appendix 1; Studies assessing the health attributes of peas.

Reference	Study type	Study size/participants	Length of study	Treatment products	Control products	Background diet	Percentage change
Glycaemic response and insulin resistance							
Marinangeli & Jones (2011)[42]	Randomised, controlled clinical study	Twenty-three hypercholesterolaemic, overweight patients	28 d followed by 28 d washout periods	50 g carbohydrate from WPF or 50 g FPF	50 g carbohydrate from white wheat flour	NCEP-Step 1 diet, energy intake adjusted based on individual RMR so participants did not gain or lose weight	WPF: 13·5 % reduction in fasting insulin and 25 % reduction in insulin resistance (HOMA-IR) FPF: 9·8 % reduction in fasting insulin and 25 % reduction in insulin resistance (HOMA-IR)
Marinangeli *et al.* (2009)[41]	Randomised, controlled cross-over clinical study	Twenty-two healthy patients	1 d	50 g carbohydrate from whole yellow pea flour in banana bread (100 %), biscotti (100 %) and pasta (30 %)	50 g carbohydrate from wholewheat flour in banana bread (100 %), biscotti (100 %) and pasta (100 %)	No change to normal background diet	Banana bread: 61·9 % reduction in IAUC Biscotti: 55·1 % reduction in IAUC Pasta: 43·1 % increase in IAUC
Seewi *et al.* (1999)[43]	Randomised, controlled clinical study	Ten healthy patients	1 d	30 g carbohydrate from pea starch dissolved in 500 ml cold tap water	30 g carbohydrate from maize starch preparations dissolved in 500 ml cold tap water	No change to normal background diet	Pea starch: 47 % reduction in post-meal glucose, 54 % reduction in serum insulin, and 37 % reduction in C-peptide responses
Cardiovascular health							
Sandström *et al.* (1994)[46]	Randomised, controlled cross-over clinical study	Eight healthy male patients	2-d treatment period with 2-week washout where patients consumed their habitual diets	7·4 g pea fibre product added to breakfast and 9·3 g pea fibre product added to the following lunch baked into bread	Low-fibre diet matched for energy content and macronutrient distribution	Diet matched for macronutrient distribution: 37 % energy from fat, 14 % from protein and 49 % from carbohydrate	Pea fibre: trend to lower postprandial TAG ($P<0.01$); no change in fasting lipid profile
Trinidad *et al.* (2010)[30]	Randomised, controlled clinical study	Twenty patients with moderately elevated cholesterol	Six, 2-week treatment periods, each separated by a 2-week washout	50 g carbohydrate from green peas, cowpeas, mung beans, pole sitao, chick-peas, groundnuts, pigeon peas or kidney beans	Individuals served as their own controls	No change to normal background diet (foods were recorded during the experimental period)	Pea product: no significant reduction in total or LDL-cholesterol levels
Gastrointestinal health							
Dahl *et al.* (2003)[50]	Controlled clinical study	114 elderly patients	4-week baseline followed by 6-week treatment period	4 g pea hull fibre added to foods	Foods without added fibre	Daily menu administered by long-term care institution for the elderly	Pea fibre: 7·5 % increase in bowel movement frequency
Flogan & Dahl (2010)[51]	Randomised, controlled cross-over clinical study	Thirteen paediatric patients with a history of constipation and/or abdominal pain in the past 12 months	3-week treatment, 3-week placebo period	5 g of inulin, two servings of study snacks with 1·4–3·4 g added pea hull fibre	5 g of maltodextrin and two servings of study snacks without added fibre	No change to normal background diet (3 d food intake records were taken for each 3-week period)	Pea fibre: 24 % increase in bowel movement frequency