Extrusion Characteristics, Palatability, and Health Implications of Pea Fractions in Dog Food

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Abstract

Trends in the pet food industry follow those of the human food industry. There are growing product launches with claims that position pet food products to have functional attributes that contribute to the health and wellness of pets. Pulse crops, such as peas, have a number of marketable attributes. They are high in protein and fibre, non-genetically modified, gluten free, have a low glycemic index and require less energy to grow than other crops resulting in lower greenhouse gas emissions. All of these attributes have the potential to contribute to pet food product claims. Peas are available to manufacturers of pet food and snacks in several fractionated forms including protein, starch and fibre. One research study determined that incorporating pea fractions individually or in combinations of up to 15% of the final formulation resulted in an extruded product with a stable and predictable density and specific mechanical energy. Palatability results for the protein and starch fraction diets were comparable to the control product and consumption levels were higher for the 15% starch diet ($P<0.05$) as compared to the other diets. In summary, pea fractions have the potential to add value to final formulations and pea starch may be used to increase the palatability of pet food or snacks.

Introduction

The global pet food industry is valued at approximately $49 billion USD and increasing at a rate of greater than 5% per year (Linthicum, 2009). From April 2008 to April 2009, over 35% of all new pet food products originated out of North America, Italy and the U.K. each released 16% and Japan released 11% (Mintel, 2009). The Mintel Global New Product Database reports that 3,516 new pet food products were launched globally including 5,574 new claims in different product categories during the last 12 month period ending in April 2009. A listing of pet food product claim categories is included in Table 1. A further breakdown of Functional, Natural, Plus, Positioning and Suitable For claims is included in Appendix 1. These five claim categories comprise over 80% of all of the new products in the database.

Trends in product release claims tend to follow those of the human food industry as evidenced by comparing Tables 1 and 2. Pet food product claims (Table 1) tended to also follow the same trends as a percentage of total product releases (Table 2). These similarities in product release claims are likely due to the humanisation of the pet food industry as dictated by the customer. Pets are increasingly viewed not as animals but instead are thought of as members of the family and as such, pet owners purchase food products for their pets of the same quality as is normally afforded in the home.

Increased consumer environmental awareness has led to an evolving global trend in product releases with environmental claims. The food retail sector is changing to meet the public demand from the public for environmental performance. Although preliminary, most food companies have sustainability strategies or initiatives in place today, related primarily to energy savings. A few leading edge companies are looking back into their supply chains and asking about the sustainability of raw ingredients. As an example, carbon footprinting is gaining attention as consumers are becoming increasingly aware of the impact of the products they purchase on the global environment and in some cases are willing to pay more to protect the environment. Large multinational retail companies are also consciously relating the impact that their processes and products have on the environment and are mandating that the suppliers behave in a sustainable manner. This likely partially explains the increase in products launched with Ethical and Environmental claims (Table 2). This claim category may very well be the next area of opportunity for the pet food industry.

Table 1 – New Pet Food Product Claims and Changes

Claim Category	Number of Variants 2008-2009	Percent 2008-2009	Number of Variants 2007-2008	Percent 2007-2008	Percent Change
Functional - Pet	1,309	23.5	1,183	26.9	-3.4
Natural	1,205	21.6	862	19.6	+2.0
Plus	1,035	18.6	838	19.1	-0.5
Positioning	536	9.6	455	10.4	-0.8
Suitable for	382	6.9	266	6.1	+0.8
Minus	365	6.5	334	7.6	-1.1
Convenience	308	5.5	89	2.0	+3.5
Functional	215	3.9	223	5.1	-1.2
Ethical & environmental	185	3.3	134	3.1	+0.2

Table 2 – All Product Claims and Changes

Claim Category	Number of Variants 2008-2009	Percent 2008-2009	Number of Variants 2007-2008	Percent 2007-2008	Percent Change
Natural	29,923	21.2	33,412	22.1	-0.9
Suitable for	27,418	19.4	27,143	18.0	+1.4
Minus	22,410	15.9	27,839	18.4	-2.5
Convenience	17,165	12.2	15,656	10.4	+1.8
Positioning	16,441	11.6	18,641	12.3	-0.7
Ethical & environmental	7,622	5.4	4,456	3.0	+2.4
Plus	7,221	5.1	9,480	6.3	-1.2
Demographic	6,864	4.9	9,034	6.0	-1.1
Functional	4,799	3.4	4,205	2.8	+0.6
Functional - Pet	1,309	0.9	1,183	0.8	+0.1

Growing Health Concerns

A study completed in 2008 by the Association for Pet Obesity Prevention (APOP) found that 43% of dogs and 53% of cats are overweight and 10% of dogs and 19% of cats were classified as obese (Ward, 2008). This translates into 32 million dogs and 46 million cats in the United States alone that are either overweight or obese. Obesity is defined as an excess accumulation of adipose tissue in the body and is not only unsightly but may predispose pets to health issues such as orthopaedic disease, abnormalities in circulating lipid profiles, cardiorespiratory disease, urinary disorders, reproductive disorders, neoplasia (mammary tumours), dermatological diseases, and diabetes mellitus (German, 2006). Although there are some valid reasons for obesity in pets including hypothyroidism and hyperadrenocortism in dogs, pharmaceuticals, and rare genetic defects (in humans) the primary reason for the development of obesity is due to an imbalance between energy intake and energy expenditure (German, 2006). The type of diet fed (prepared vs homemade) does not appear to predispose pets to obesity (Edney and Smith, 1986). The price of pet food does have an effect as obese dogs are more likely to have been fed inexpensive rather than more expensive foods (Kienzle et al., 2000). There is also a human-pet interaction as overweight people tend to also have overweight pets (Kienzle et al., 1998). Traditionally many pet foods formulated for weight loss contain high levels of fibre which increases the bulkiness of the diet, reduces the caloric density, and decreases digestibility of the diet as well as contributing to satiety (Laflamme, 1997). However there has been concern that the feeding of excessive fibre may decrease nutrient digestibility and increase defecation (Burrows et al., 1982).

Diabetes mellitus occurs when the pancreas does not produce enough insulin. Insulin is required for the body to efficiently use sugars, fats and proteins. The disease is most prominent in middle age to older dogs and cats and more often in the female dogs and neutered male cats. It is estimated that the incidence of diabetes in dogs and cats ranges between 0.2 to 1% which is a substantial number of pets with the disease (Panciera et al., 1990). Many breeds of dogs are prone to diabetes including Samoyeds, Miniature Schnauzers, Miniature Poodles, Pugs, and Toy Poodles (Hess et al., 2000). Treating obesity in pets may also reduce the incidence of diabetes using low glycemic index (GI) and low calorie ingredients would be a valuable method to maintain animal health.

Clinical research has recently demonstrated that low GI diets in patients with type 2 diabetes that a low-glycemic index diet resulted in lower glycated haemoglobin A_{1c} (HbA_{1c}) (Jenkins et al., 2008). Glycated haemoglobin A_{1c} are normal haemoglobin to which a glucose molecule becomes added non-enzymatically. The percentage of this occurrence is dependent on the amount of time that the haemoglobin has been exposed to glucose in the blood stream and is used as an indicator of long term blood sugar management for studying diabetes. Pulses were an integral component of the diet used in this study and a low-glycemic index diet may be a useful strategy to improve glycemic control in patients with type-2 diabetes. The pet industry has the opportunity to include pulses in pet food aimed at treating pets with diabetes or manage obesity as a satiating ingredient due to its low glycemic index. Before the health attributes of pulses in canine diets can be investigated, the functionality of them as ingredients must be understood.

From the Latin ‘puls’ meaning thick soup or potage, pulses are the edible seeds of plants in the legume family such as pea, lentil, bean and chickpea. Peas are an excellent source of protein (23%) and energy content and as such are regarded as a multi-purpose ingredient (Hickling, 2003). Canada is the world’s largest grower and exporter of peas with over 4 million acres seeded each year producing over 3.5 million tonnes (Statistics Canada, 2009). Seed production for this crop does not use genetic modification therefore all pulse crops are non-GMO. They are naturally gluten free and as a legume they fix their own nitrogen from the atmosphere thereby reducing the necessity for synthetic fertilizer. Nitrogen is the most heavily used nutrient for plant growth and the main product used to make it is natural gas, a fossil fuel.

A project was completed by the Alberta Crop Industry Development Fund and partnered between Champion Petfoods Ltd., and Alberta Agriculture, Food and Rural Development to investigate the use of field pea and white flower faba bean in dog food diets (ACIDF, 2004). Four varieties of field pea and one zero-tannin faba bean variety were tested at three different inclusion rates. Palatability, digestibility and market acceptance tests were conducted on fifteen formulations. All pulses were dehulled and milled into coarse flour prior to extrusion processing. Pulse inclusion in the diet consisted of 12.5%, 25% and 50% of the diet. Canine trials were completed at the Ontario Nutri Labs Inc. for palatability, digestibility and animal performance. Palatability results from this trial work indicated that higher levels of pea inclusion (25 and 50%) were still palatable to dogs, 25% faba bean inclusion was preferred over 12.5% or 50% faba bean and there was no difference in palatability between field pea and faba bean at 12.5 percent inclusion levels. Faecal scores of all diets containing pulses were normal and the products extruded easily. Additional research describes a higher consumption ratio when including whole peas at a 15% level (Behnke, 2004).

Further processing of peas into fractions containing predominantly starch, protein or fibre are common. Although there are various methods of separating peas into fractions, air classification is the most common and inexpensive method. Interactions between fractions with respect to extrusion parameters including density, the specific mechanical energy of the equipment as well as palatability by dogs has not been investigated.

Materials and Methods

Pea protein and pea starch were obtained from Parrheim Foods and pea fibre was obtained from Best Cooking Pulses. Two levels of 7.5% and 15% of each of the starch, protein, and fibre fractions were tested in a mixture design experiment. In order to test the main effects and interactions of just the pea products, they were mixed as part of a finished diet. The diets were not reformulated to be isocaloric or isonitrogenous. A mixture designed experiment was used to determine the main effects and interactions for each of the outcomes, an outline of the diet combinations is presented in Table 5. A typical canine maintenance diet was formulated by Petfood Ingredient Inc. to be used as the diet by which to set the controls of the extruder as well as to proportion into the other diets. All diets were extruded at Wenger Manufacturing pilot plant in Sabetha Kansas through a Wenger X-85 Single Screw extruder with a 5/16 die size. Once the controls for speed, moisture or steam were established for the control diet, they were not modified for the other diets as they were extruded. A summary of the extruder settings is illustrated in Table 4. All diets were measured for product extruder discharge density (Density) immediately following extrusion with three samples per diet. The Specific Mechanical Energy (SME) was also measured and recorded three times over the run of each diet.

Palatability comparisons compared to control were completed only for diets 1, 2, and 3 at Kennelwood in Champaign, Illinois. Each test product was fed versus the control diet to a 20 dog panel for two consecutive days, providing 40 consumption comparisons. The bowl position was reversed to prevent 'left-right- bias'.

Extrusion measurements were analyzed by JMP software as a mixture design to test for main effects and interactions for Density and SME with statistical significance at $P<0.05$. Least squares means were used to determine statistical significance for the palatability of the diets tested with blocking on the Day of the animals during the trial period. A Tukey HSD test was used to determine statistical significance. Statistical analysis was completed in consultation with Forte Consulting Inc.

Table 3. Mixture Design Diet Combinations Containing Pea Fractions

Diet	Percent Control*	Pea Starch**	Pea Protein**	Pea Fibre***
Control	100	0	0	0
1	85	15	0	0
2	85	0	15	0
3	85	0	0	15
4	85	7.5	7.5	0
5	85	7.5	0	7.5
6	85	0	7.5	7.5

*Petfood Ingredient Inc., Standard Canine Maintenance Diet as Control
**Parrheim Foods, Saskatoon, Saskatchewan, Canada
***Best Cooking Pulses, Portage La Prairie, Manitoba, Canada

Table 4. Average Extruder Settings for Diet Runs

Parameter	Control	15% Starch	15% Protein	15% Fibre	Starch & Protein	Starch & Fibre	Protein & Fibre
Dry Recipe Rate	199	200	200	199	203	202	202
Feed Screw Speed	74	65	70	66	68	68	70
Preconditioner Speed	400	400	400	400	400	400	400
Preconditioner Discharge Temp.	68°C	67	67	71	70	72	68
Moisture Entering Extruder	23.3	23.1	22.3	22.2	22.6	22.3	22.8
Extruder Shaft Speed	420	420	420	420	420	420	420
Head/Pressure	460	533	400	450	437	450	500
Knife Drive Speed	1331	1317	1317	1317	1317	1317	1317

Results and Discussion

The extrusion results for Density and SME are illustrated in Figure 1. The main effects for the starch product, protein, and fibre were statistically significant at $P<0.01$ (Table 5) however there were no interactions between the products that were of statistical significance. The implications of this are that by changing the diet to include either one of the starch, protein or fibre products that the Density and SME of the equipment will change and will do so at a rate that is predictable. Combining these ingredients will change the overall Density or SME in direct accordance to each of the ingredients themselves. There is no additive effect for example by combining two of the ingredients and as the whole pea is made up of all three components, the change in these parameters by using whole peas can also be estimated. Figure 1 illustrates that Density increases nearly linearly with increasing amounts of the pea protein whereas adding pea starch decreases the Density of the product. There is a significant effect on Density by the fibre but the effect appears to be curvilinear with no apparent reason.

Extrusion equipment settings can also have an impact on these parameters but they were not included in the experimental design. Although it is well known that parameters such as the type of extruder (single or double barrel), screw speed, moisture content of the feed an barrel temperature are known to have affects on bulk density, water holding capacity and even digestibility of the end product these parameters were not included as variables in the work and instead were held as constant as possible as indicated in Table 4. The design was only to determine the effects of the ingredients themselves and look for interactions between ingredient components that may indicate potential additive effects or possibly problems. The results indicate that even up to 15% of the final diet can be any combination or singular use of any of the components. Having said this, during the experimental runs there was some surging of product that did occur particularly with the starch and the fibre fractions. Some additional steam was added with the diet containing 15% starch which helped with the surging and it was also recommended with the 15% fibre diet to increase the extruder speed or feed rate. This was not incorporated into the experiment to ensure a consistent methodology between batches. Although not documented within the experimental runs, the ability to correct surging of the product by modifying the extruder settings was easily accomplished by modifying the extruder settings after all data collection was complete.

Figure 1. Density and Specific Mechanical Energy Measurements for each of the Pea Fractions Combinations.

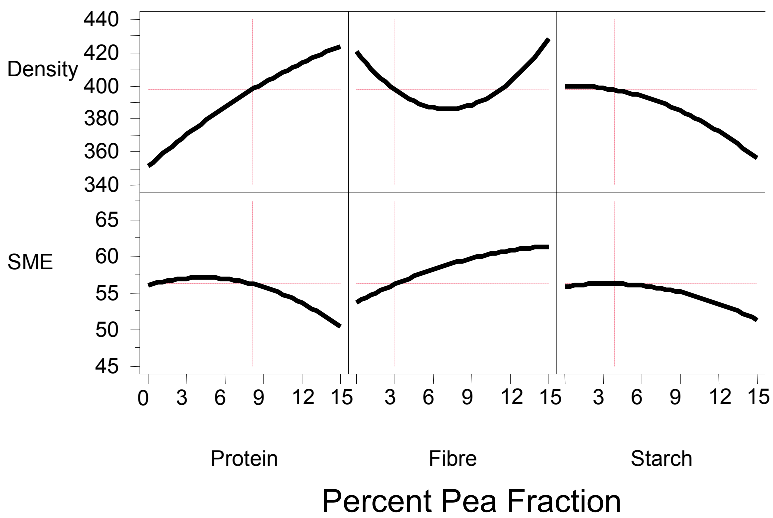
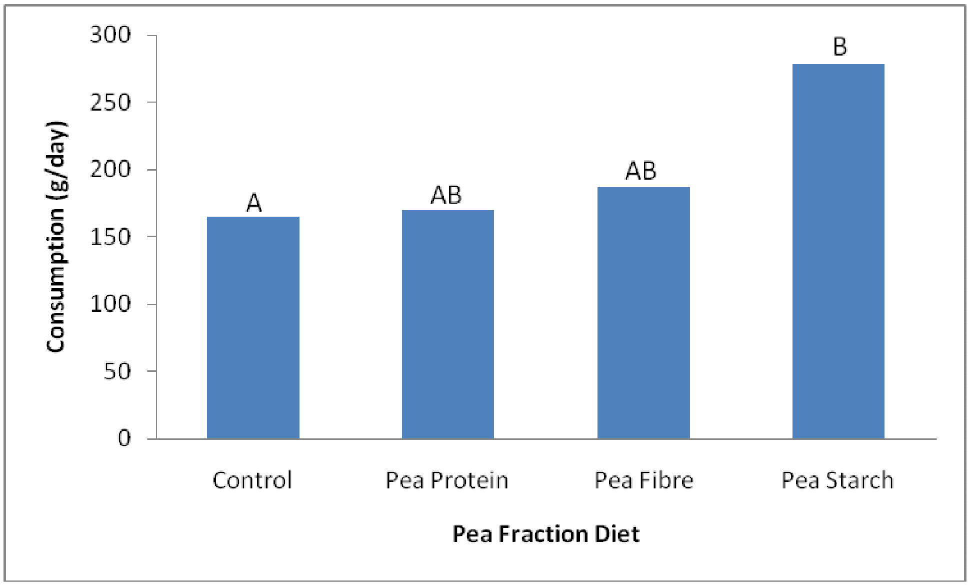


Table 5. Parameter Estimates and Probabilities for Component Variables and Interactions.

	Density		SME	
Parameter	**Estimate**	**Prob > F**	**Estimate**	**Prob > F**
Fibre	428.7	0.0004	50.3	0.0016
Protein	424.0	0.0005	61.3	0.0058
Starch	356.0	0.0019	51.3	0.0066
Fibre*Starch	-148.0	0.7547	12.7	0.8606
Protein*Fibre	-129.3	0.7847	14.0	0.8737
Protein*Starch	85.3	0.8569	1.3	0.9866

Palatability results are illustrated in Figure 2 for the diets 1,2 and 3 versus control. Although the results were blocked by Day, there was no statistical significance. Consumption of the fibre and protein diets was not statistically different from the control. These results indicate that up to 15% inclusion of any of the pea fractions into a dog food should not alter palatability of the final product and in the case of starch may actually accentuate it. The diet containing the pea starch had a significantly greater voluntary intake of the product. These results appear to be consistent with the work completed by Behnke (Benhke, 2004) that found that the inclusion of whole peas up to 15% of the final diet increased the consumption ratio of dogs and therefore it may be the starch component of the peas that is responsible for this. Pea starch on its own has the potential to serve as a palatability enhancer for products.

Figure 2. Daily Consumption and Statistical Significance of Pulse Fraction Diets.



*Different letters are significantly different at $P<0.05$.

Conclusion

The pet food industry is a dynamic and innovative market place with trends that are diverse and tend to mirror those of the human food industry. Current trends include Natural, Positioning, and Convenience and Functional attributes. Products are expected to contribute to the overall health and wellness of pets. An up and coming trend is the Ethical and Environmental claims on products. There is a growing emphasis in the human food industry towards a focus on the Carbon Footprint or reduction in greenhouse gas emissions released for the production of any food item. Pulse crops such as peas are potential ingredients for this industry as contribute to many of the trends that are of importance to the pet food industry. Pulses are a non-GMO crop, they are naturally gluten free, a good source of protein and fibre and have a low glycemic index which may have implications for the control of obesity and/or management of diabetes. The crops themselves have a low greenhouse gas emission per acre as they fix their own nitrogen from the atmosphere thereby reducing the necessity for synthetic fertilizer which is generated from the combustion of fossil fuels. For pet food manufacturers in North America there may be a greater advantage in the availability of these as a pet food ingredient as they are grown to a large extent in North America, primarily Canada.

Functional attributes of a product must be known to ensure that product quality and acceptance will be achieved by including them into a formulation. Previous research indicated that the inclusion of up to 15% of whole peas increased intake by dogs and up to 25% of faba bean was acceptable as well. Further processing of pulses, primarily peas, has the potential to offer more options in formulation as the fractions can offer higher levels of fibre, protein or starch depending on the requirement of the final product. All fractions up to 15% of the final formulation extrude well and changes in the density of the product and the SME required by the equipment can be estimated based on the percentage of each fraction that are added. Inclusion of pea fractions in the diet will not alter the palatability of the diets when used in canine formulations. The starch component increased intake in dogs and may be a suitable component for snacks as well as complete feed and may serve as a palatability enhancer.

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Appendix 1. Pet Food Claim Breakdown – April 2008 to April 2009.

Functional Claims

Claims	Number of Variants
Teeth & Tartar Prevention (Functional Pet)	609
Digestion & Urinary Tract (Functional Pet)	522
Skin & Coat (Functional Pet)	475
Vitamin/Mineral Fortified	449
Joints, Bones & Muscles (Functional Pet)	376
Immune System (Functional Pet)	368
No Additives/Preservatives	355
Premium	152
Other (Functional Pet)	145
High Protein	138

Natural Claims

Claims	Number of Variants
No Additives/Preservatives	897
All Natural	410
Low/No/Reduced Allergen	294
Vitamin/Mineral Fortified	282
Digestion & Urinary Tract (Functional Pet)	235
Organic	203
Skin & Coat (Functional Pet)	195
Premium	195
Teeth & Tartar Prevention (Functional Pet)	175
Immune System (Functional Pet)	168

Plus Claims

Claims	Number of Variants
Vitamin/Mineral Fortified	886
No Additives/Preservatives	292
Skin & Coat (Functional Pet)	244
High Protein	235
Teeth & Tartar Prevention (Functional Pet)	232
Joints, Bones & Muscles (Functional Pet)	222
Digestion & Urinary Tract (Functional Pet)	215
Immune System (Functional Pet)	182
Added Calcium	145
All Natural	135

Positioning Claims

Claims	Number of Variants
Premium	435
No Additives/Preservatives	155
Vitamin/Mineral Fortified	123
Teeth & Tartar Prevention (Functional Pet)	90
Digestion & Urinary Tract (Functional Pet)	89
All Natural	89
Skin & Coat (Functional Pet)	81
Joints, Bones & Muscles (Functional Pet)	50
Immune System (Functional Pet)	49
Low/No/Reduced Allergen	44

Suitable For Claims

Claims	Number of Variants
Low/No/Reduced Allergen	343
No Additives/Preservatives	245
Gluten-Free	150
All Natural	129
Vitamin/Mineral Fortified	99
Organic	72
Sugar (Low/No/Reduced)	54
Digestion & Urinary Tract (Functional Pet)	51
Teeth & Tartar Prevention (Functional Pet)	48
Premium	47