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In recent years, small poultry producers have been interested in finding an alternative for corn and soybean for a variety of reasons. Health concerns related to either naturally occurring isoflavones (phytoestrogens) or their genetically modified organism (GMO) status are the primary considerations behind this trend. Secondly, the recent high prices of corn and soy and unavailability of these two ingredients locally are other reasons to identify alternative feed ingredients. For these reasons, three experiments were performed to identify the feasibility of including locally grown alternative feed ingredients in turkey rations. The first experiment assessed the inclusion of up to 30% wheat, 10% lentils, and 10% chickpea to replace all of the corn and a part of soybean in turkey diets to eight weeks of age. The wheat based diet was supplemented with Alpha Gal™ 180P enzymes at level 0.4 1bs/ton. Day old turkey poults were randomly assigned to one of the diets and body weight, feed consumption, and mortality were recorded at two, four, six and, eight weeks of age. Body weights of turkey poults fed wheat based diets with and without enzymes outperformed ($p = 0.04$) the body weights of turkey poults fed the corn-soy based control diet. No significant ($p > 0.05$) differences were observed between the body weights of turkey poults fed diets with or without enzymes. There was no significant difference between the feed conversion ratios of the three groups. Feeding wheat-based diets

improved growth rates in turkey poults compared with corn-soy based control diet but did not affect feed conversion. Adding AlphaGal™ 180p to wheat-based diets did not improve growth rates or feed conversion in turkey poults. Experiment two compared the growth rates and feed conversions of turkeys fed a corn based –soy free, and, a wheat based (corn-soy free) to the control (corn-soy based) diets. Day old turkey poults were randomly assigned to one of the diets. Body weight, feed consumption, and mortality were determined at two, four, six and, eight weeks of age. The final body weights of poults fed the control diet were significantly higher than those fed a corn based-soy free or a wheat based (corn-soy free) diets ($P = 0.001$). There were no statistical differences between body weights (3.1kg) of birds fed a corn based-soy free diet and body weights (3.2kg) of birds fed a wheat based (corn-soy free) diet. The feed efficiency was not different between treatments. Excluding soybean from the diets decreased growth rates in turkey poults but did not affect feed conversion. It also increased mortality and cannibalism. Experiment three compared the growth rates and feed efficiency of turkey poults fed wheat based diets containing different level of methionine (control 0.5%, organic 0.15%, and, no supplemental methionine 0%) for six weeks. There were no significant differences between the mean body weights of birds fed a wheat based diet supplemented with 0.5% methionine (control) and the mean body weights of birds fed a wheat based diet supplemented with 0.15 % methionine (organic), while turkey poults fed a ration containing 0% supplemental methionine had significantly ($P < .05$) lower bodyweight when compared to the organic (0.15% met) and control (0.5% met) diets. No significant differences were noticed between the feed conversion ratios between the diets. Decreasing the dietary methionine supplementation to 0.15% in the organic diets used in this trial did not affect turkey poults' body weight or feed conversion when compared with those fed the control diet. Excluding supplemental methionine from the diet decreased growth rates but did not affect feed conversion.

Locally Grown Alternative Feed Ingredients in Turkey Diets

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Kurdman Mohammed Ali Sulaiman, Author

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CHAPTER 1
INTRODUCTION

Poultry feeds are referred to as complete feeds, because they contain all the nutrients necessary for growth, production, reproduction and health of the birds. Energy sources constitute the largest component of poultry diets, followed by protein sources. The most common energy source used is corn, which is high in starch, palatable, and highly digestible for poultry. Soybean meal is a common plant protein source, which contain about 44- 48% crude protein. The protein in soybean provides the building blocks for muscles, organs, feathers, and eggs. For decades, these two ingredients have been the primary feed ingredients in poultry diets. The combination of these two ingredients is considered the gold standard.

In recent years, small flock producers have been interested in finding alternatives for these two ingredients for a variety of reasons. Health concerns are the primary consideration behind this trend to seek alternatives to corn and soy. Today, most soy and corn produced in the US are genetically modified organisms (GMO). The genetics of these ingredients have been altered by using various genetic engineering techniques, developed in 1980's and 1990's, which allows gene transfer from one organism into another, thereby conferring resistance to various herbicides, pests, and/or diseases, resulting in higher crop yield (Key et al., 2008; Kruft, 2001; Swanson, 2013). In recent years the worldwide cultivation of these genetically modified plants has increased with GMO soy worldwide at 77% of all that is produced (GMO compass, 2010), while in the United States the level is 93% (USDA, 2013). In addition, corn grown in the United States, is 85% GMO (USDA, 2013).

The subject of GMOs is highly controversial. Some studies have been published, dealing with health implications and safety issues associated with GMO foods in the human diet. Some of these studies concluded that there were no unexpected harm or risk associated with the consumption of foods derived from GMO crops (Aeschbacher et al., 2005; Taylor et al., 2003; Taylor et al., 2007; Cromwell et al., 2002; Jennings et al., 2003), while others have raised some concerns (Nordlee et al., 1996; Vecchio et al., 2009; Leu, 2012; Seralini et al., 2012).

Furthermore, there are other health concerns implicating soybean; such as breast cancer, due to its high content of phytoestrogens, compounds that are found in plants that function as estrogen. There is much conflicting data about consumption of soy products and their effect on breast cancer. Some studies indicated that consuming high amount of soy products reduce the risk of breast cancer (Wu et al., 2002; Lee et al., 1991), while others seem to show that higher exposure to phytoesestrogens over a lifetime increases the risk of breast cancer (McMichael-Philips et al., 1998; Hsieh et al., 1998). With all the uncertainty surrounding soy products some small producers have a heightened desire to find alternatives to using soy in poultry diets.

The recent high price of corn and soy is another consideration behind the trend to seek alternatives to corn and soy. Historically, feed costs have represented 70-75% of the cost of poultry production, which plays a major role in determining the profitability of a poultry enterprise. With the use of corn in ethanol, demand for corn has increased. In 2011, about 27.5% of U.S corn was used in ethanol production (NCGA, 2012 World of corn), and as a result, the price of corn has risen sharply in recent years.

Unavailability of the ingredients that are grown locally also leads producers to find alternatives that can be found from local sources. If corn and soy are not cultivated locally, producers must import them from other parts of the country or from overseas, which in turn tend to increase the cost of production, thus further reducing profits. Additionally, there are some consumers who consider themselves “Localvores”, those interested in eating only locally produced foods which is based on distance traveled, often to reduce the “carbon footprint” resulting from the import of feedstuffs from some distance.

Alternative ingredients in poultry diets include cereal grains, such as wheat, oats, and barley; legume grains, such as peas, lentils, chickpeas, and dry beans; as well as other non-cereal grain alternatives such as canola and camelina. Cereal gains are often used as alternatives for corn because of their high starch content resulting in high energy, while legumes are mostly used as substitutes for soybean. Legume seeds are rich in protein; have more than twice the protein as most cereal grains and are also a good dietary energy source.

While these alternatives appear to have all necessary ingredients for poultry to thrive when fed in properly formulated diets, there are some important considerations to take into account when using these alternative ingredients, such as nutritional value, palatability, protein quality, and anti- nutritional factors. Knowledge of the nutritional composition (such as, dry matter, protein, energy, vitamins and minerals, and anti-nutritional factors) of any dietary ingredient before formulating them in to poultry diets is critical in order to match the available nutrients with the bird's needs, and to reduce the addition of problem compounds. Protein quality, the concentration of amino acids in the ingredients, when formulating poultry diets is particularly important due to the typically limiting amino acids such as lysine and methionine. Legume grains tend to have limited methionine content, the amino acid that often limiting for proper growth and production. A sufficient amount of these essential amino acids is required to support optimum bird performance.

Anti- nutritional factors are naturally occurring compounds found in many feed ingredients that can negatively affect digestion so must be taken in to account when non-traditional feed ingredients are used in poultry diets. Cereal grains such as wheat and barley contain non starch polysaccharides (NSPs) which cannot be well digested by poultry, as they lack the necessary enzymes in their gastrointestinal tract.The predominant NSP in wheat is arabinoxylans, while in barley, β-glucans are the predominant NSPs (Odetallah et al., 2002). Supplementing diets with synthetic NSP hydrolyzing enzymes has been shown to aid digestion, improving nutrient utilization, and bird performance (Boguhn and Rodehutscord, 2010)

Legume grains also include a variety of anti-nutritional factors that affect the growth and performance of poultry. Examples of these include: tannins, oligosaccharides, and enzyme inhibitors. Some processing techniques including: soaking and aqueous heating, autoclaving, dry toasting, dehulling, germination, and extrusion can partially or completely eliminate the adverse effect of some of the anti-nutritional factors found in grain legumes.

To test the alternative feed ingredients in turkey diets, three experiments were performed to identify the feasibility of including locally grown alternative feed ingredients in turkey rations. Experiments assessed the inclusion of the combination of different ingredients, including wheat, lentils, chickpea, and field peas, to replace corn and/or soybean in turkey diets. The wheat based diet was supplemented with Alpha Gal™ 180P enzymes at level 0.4 1bs/ton. The objectives of these experiments were to determine whether alternative dietary grains can be used to sustain maximum productivity compared to typical corn/soy-based turkey diets and to evaluate the effect of adding AlphaGal™ 180p to wheat-based diets on growth and feed efficiency of turkeys.

CHAPTER 2
LITERATURE REVIEW

Health concerns of corn and soy

Most of the corn and soy cultivated in the US are genetically modified organisms (GMO) (USDA, 2013). The subject of GMOs in food is highly controversial and provokes intense debate. Many studies have been published, dealing with potential health implications associated with GMO food crops. Some of these studies have concluded that there is no unexpected harm or risk associated with the consumption of food derived from GMO crops (Aeschbacher et al., 2005; Taylor et al., 2003; Taylor et al., 2007; Cromwell et al., 2002; Jennings et al., 2003), others with the opposite results (Nordlee et al., 1996; Vecchio et al., 2009; Leu, 2012; Seralini et al., 2012).

In a study on broilers and layers fed 60% conventional or GMO corn, researchers indicated that there were no significant differences between the body weight gain, daily feed intake, and feed conversion ratio of broiler and layers fed diets formulated with conventional or GMO corn. They also reported that the nutrient composition of the meat in terms of DM, CP, and fat were not different between the two feeding groups (Aeschbacher et al., 2005). Taylor et al., (2003) recorded the same results in their research on broilers fed GMO corn, non-transgenic control, and commercial corn. They reported that broilers fed GMO corn had the same body weight, feed conversion, carcass yield, and meat composition as non-transgenic control and commercial corn.

In a study on growing-finishing swine fed diets supplemented with either GMO soybean meal or conventional soybeans researchers indicated that the composition and the nutritional value of GMO soybean was equivalent to that of conventional soybean and the performance of swine was not affected by diets containing GMO soybean (Cromwell et al., 2002).

In another study on "Determining whether transgenic and endogenous plant DNA and transgenic protein are detectable in muscle from swine fed Roundup Ready soybean meal" researchers concluded that no portions of transgenic DNA or immunoreactive fragments of transgenic protein were detected in the loin muscle samples from pigs fed a diet containing GMO soybean meal (Jennings et al., 2003).

Furthermore, in a study on dairy cows fed rations mixed with GMO corn silage, it was found that the nutritive value, fermentation characteristics, mineral composition, and amino acids content of GMO corn silage were similar to those of non-GMO corn silage. The same study indicated that there was no difference between the production and the composition of milk derived from cows fed diets contained either GMO or non-GMO corn silage, and no transgenic DNA was detected in milk samples (Phipps et al., 2005). However, other studies have shown contradictory results and raised some health concerns, such as food allergies and transferring the gene inserted to the GMO crops to the DNA of the bacteria living in the human and animal gastrointestinal tracts (Nordlee et al., 1996; Aris and Leblanc, 2011; Tudisco et al., 2010).

One of the main health concerns regarding to GMOs crops, which contain an engineered protein, is food allergies. True food allergies are an immunological response and occur in about 2% of the adult population and 5-8% of young children (Herman, 2003). Introducing a bacterial gene into plants has the possibility of creating a new allergen or cause an allergic reaction in susceptible individuals (Verma et al., 2011). In a study on "Identification of a Brazil-nut allergen in transgenic soybean", researchers found that soybean modified with a gene from the Brazil nut can react with the blood antibodies taken from people who are allergic to Brazil nuts (Nordlee et al., 1996); this suggests that the transgenic soybean can produces allergic reactions in people that are already allergic to Brazil nuts.

Several controversial animal studies indicated health risks associated with GMO food consumption including, infant mortality, growth, reproductive, hepatic, and pancreatic effects (Vecchio et al., 2009; Leu, 2012; Smith, 2009; Seralini et al., 2012). When Vecchio et al., (2009) supplemented GM soybean to the male rat diets, they found that the structure of their testicles was altered and the development of sperm cells was also affected by GMO soy (Leu, 2012), which in turn reduced fertility.GM soy also changed the color of male rat testicles from pink to dark blue (Smith, 2009).

Because of the potential health risks of GMO feeds found in some animal studies and because some GMO foods have been determined by some not to have been properly tested for human consumption, in 2009 American Academy of Environmental Medicine called on "Physicians to educate their patients, the medical community, and the public to avoid GM foods when possible and provide educational materials concerning GM foods and health risks" (American Academy of Environmental Medicine, 2009).

The most ominous finding of GMO soybean by some is that, the gene inserted into GMO soybean may survive processing and could be transferred to the DNA of bacteria living in the human digestive tract (Netherwood et al., 2004). Canadian researchers indicated that a certain pesticide toxin (Cry1Ab) from GMO crops was detected in maternal and fetal blood samples. In a study on 30 pregnant women and 39 nonpregnant women, researchers collected blood samples to determine their exposure to Cry1Ab toxin from GMO crops. Cry1Ab toxin was found in 93% of maternal blood samples, 80% of fetal blood samples, and in 69% of nonpregnant women blood samples (Aris and Leblanc, 2011). In another study on pregnant goats fed diet supplemented with GMO soy bean, researchers indicated that a small transgenic DNA fragments were detected in milk samples of goats as well as in the blood samples and organs of their kids (Tudisco et al., 2010).

Finally, there are other health concerns, such as breast cancer, which some consider related to soy consumption, due to its high content of phytoestrogens. “Soy and soy products are the major source of isoflavones, a particular class of phytoestrogen that interacts with endogenous estrogen signaling pathways” (Cederroth et al., 2012). Again, the research here has conflicting results which are unclear about the consumption of soy. It is still unclear whether phytoestrogens from soy affect a women’s breast cancer risk. Reduced risk of breast cancer in women consuming high levels of soy was reported by Lee et al., (1991). This finding was supported by Wu et al., (2002), who demonstrated that high soy intake in childhood was associated with reduced breast cancer risk. However, other studies have shown contradictory results. A study on women with benign or malignant breast cancer, who received a diet with or without soy containing 45 mg isoflavones for two weeks, had higher proliferation rates of breast cancer cells (McMichael Philips et al., 1998). In another study, researchers demonstrated that diet supplemented with genistein, a phytoestrogen, stimulated mammary gland and tumor growth (Hsieh et al., 1998).

Henneman (2010) says “Whether phytoestrogens inhibit or stimulate cancer cells depends at a minimum on 1) the specific phytoestrogen compound, 2) its concentration in the blood, 3) whether cancer is yet present, and if so, the stage and other pathology of the tumor and 4) the general hormonal environment in the person at the time of exposure – both age and menopausal status clearly matter". He concluded that because of the contradictory results of studies, it remains unclear whether phytoestrogen inhibit or stimulate cancer cells.

Alternative Feed Ingredients

Wheat

Wheat is the world's most important cereal crop in terms of both acreage cultivated and the amount of grain produced. According to an FAO report, production of wheat in 2013 reached 704 million metric tons, a 6.8 percent increase over previous year's reduction and represents the highest level in history (FAO, 2013). As production increases the price decreases. "International prices of wheat declined slightly in June 2013 with the onset of the annual harvests in the Northern Hemisphere. By contrast, maize prices increased, supported by continued tight global supplies" (Crop Prospects and Food Situation, 2013). In the U.S. wheat is usually considered a source of human food rather than an ingredient for poultry and livestock feeds.

The nutritional value of the wheat places it in a position of importance among the few crop species grown as an essential food source. Wheat as a whole grain, with the exception of the outer husk, contains all the elements necessary for growth (Lincoln, 2009). Although the energy content of wheat is lower than that of corn, it is higher in other nutrients, including protein, phosphorus, calcium, and many amino acids, such as methionine, lysine, phenylalanine, cystine and arginine. (National Research Council, 1994) The protein content of wheat varies from 11 to 19%, based on type of wheat, variety, and test weight (Sullivan & Gleaves, 1977). Wheat stores energy in the form of starch. The amount of starch contained in the wheat grain is between 60-75% of the total dry weight of the grain, (Šramkováa et al., 2009), while lipids are present only in small amounts.

Wheat is quite palatable to poultry, being used rather than corn, in poultry rations in different parts of the world, including Canada, Australia and Europe. Up to 80% of finishing poultry diets in United Kingdom are formulated with wheat. However, the relatively low and variable energy values of wheat compared to corn have limited its use in commercial turkey and broiler diets (Santos et al., 2004).

Non starch polysaccharides (NSP) are the primary factor associated with variation in dietary metabolizable energy content in grains (Odetallah et al., 2002). Wheat contains 5% to 8% NSPs. Soluble non starch polysaccharides cannot be digested and utilized by monogastric animals, due to the absence of the necessary enzymes in the gastrointestinal tract (Tuoying, 2005). NSP have adverse effects on the utilization of nutrients, thus inclusion of wheat is limited in turkey diets (Odetallah et al., 2002). Choct and Annison (1992) reported that the presence of NSPs in wheat based diets increase viscosity in the small intestine and decreased contact between digestive enzymes and substrates, thus reducing nutrient absorption, and negatively effecting birds performance (Wang et al., 2005). When a high level of viscous occurs in the small intestine, increased fermentation occurs in the small intestine, which is known to be detrimental to the performance and well-being of poultry (Choct et al., 1996). It was reported by Choct and Annison (1992) that high levels of NSPs in poultry diets depress the digestibility of protein and starch in the ileum, causing sticky droppings. Moisture content of the excreta is 10% higher in birds fed diets rich in NSPs compared to birds fed corn based diets (Santos et al., 2004). This increased diarrhea is associated with wet litter, which in turn causes leg problems and enteric diseases.

Many studies indicate that appropriate enzyme supplementation to wheat based diets is an effective way to eliminate the negative effects high levels of NSPs (Santos et al., 2004;

Odetallah et al., 2002; Wang et al., 2005; Esmaeilipour et al., 2011; Boguhn and Rodehutscord, 2010). Adding enzymes can improve growth performance and feed conversion ratio in broilers. The enzyme Xylanase and dietary fat effect the digestion of nutrients and feed transit in different parts of digestive tract by their interaction with the intestine which leads to differences in body weight (Danicke et al., 1999). Enzyme supplementation reduced the size of both the GI tract and pancreas (Jaroni et al., 1999). It also results in an increase in the total volatile fatty acids in the ceca (Wang et al., 2005) and decreased digesta viscosity (Jia et al., 2008). Esteve-Garcia (1997) demonstrated that adding Xylanase to wheat based diets reduced the incidence of vent pasting. Reduced mortality, improved feather condition, and reduced the incidence of cannibalism and feather picking in turkeys fed a wheat based diet (Odetallah et al., 2002).

When enzymes are added to poultry diets, the bird's age can affect how well they will utilize these enzymes. In their research on turkeys fed wheat based diets, Santos et al., (2004) used two different kinds of enzymes, Endoxylanase and Phospholipase. They found that phospholipase supplementation had a greater effect on growth performance and energy utilization during the starting phase, while Endoxylanase was more effective when supplemented to growing and finishing diets; however, a natural blend of enzymes had an intermediate effect, regardless of turkey age. This could be due to the immature gut ecosystem of young birds, while older birds have a mature and resistant gut, with the greater capacity for lipid digestion (Santos et al., 2004). Evidence of this phenomenon is supported by Buguhn and Rodehutscord, (2010), who indicated that enzymes have more effect on body weight and FCR during the finishing-growing phase. The amount of enzymes added to the diet is also important. Wang (2005) reported that the optimum enzyme supplementation is 200 mg/kg.

There are some other considerations when using wheat in poultry rations. First is the physical form in which the wheat is fed. Finely ground wheat usually become sticky when it is wet, and will stick to the beak of birds and cause beak impaction, which in turn reduces feed intake (Sullivan et al., 1977). The amount of finely ground wheat recommended, especially in young birds' ration, is no more than 5 to 10%. Usually, coarsely ground, rolled or a whole grain is more desirable and can replace up to one-half to as much as 100% of the corn in chick, pullet, layer and turkey rations (Sullivan et al., 1977). Engberg et al., (2004), reported that feeding whole wheat to broilers improves gizzard function, which in turn prevents pathogenic bacteria from entering the intestinal tracts.

The second consideration is pigmentation. Wheat does not include the pigment (hydroxyl carotenoids) responsible for the yellow color of the egg yolk, skin, and shanks (Sullivan et al., 1977). Corn gluten meal or dehydrated alfalfa can be used if the yellow color is desired.

Lentils

Lentils (*Lens culinaris*), which is believed to have originated in central Asia, are relatively tolerant to drought and are grown throughout the world (Akibode and Maredia., 2011). Lentils are an important legume crop and play an important role in human and animal feeding as well as soil improvement. It is a cheap source of protein in the diets of the citizens of developing countries who cannot afford animal protein for balanced nutrition. It can also replace a part of soy bean meal in animal diets. The important lentil growing countries of the world are India, Canada, Turkey, Bangladesh, Iran, USA, China, Nepal and Syria (Cokkizing & Shtaya., 2013).

There are many different cultivars available, each with unique properties. Lentils are low in fat, a good source of protein, and an excellent source of dietary fiber and complex carbohydrates. The protein content of lentils is between 23.9 to 25%, with a fat content of about 4.3%, carbohydrate level of 55%, and crude fiber level of 4.7%. It is also a good source of vitamins and minerals (Akmal Khan et al., 1987).The major amino acid content of lentils is glutamic acid, aspartic acid, leucin, lysine, proline, and arginine. The amino acid with the lowest content is methionine.

Lentils are mostly used for human consumption. There is little research about formulating lentils into animal's diets. For poultry, 10% lentils formulated into diets is considered a maximum level percent suggested, unless lentils are decorticated (to remove the bark, husk, or outer covering). Addition of lentils to layer diets has had limited success, due to the protein quality and low levels of sulfur-containing amino acids (Mavromichals, 2013).

Chickpeas

Chickpea or Garbanzo bean (*Cicer arietinum)* is another important grain legume in world agriculture. It is widely consumed by humans, due to the high nutritional value and especially, high protein content. It is also used as a good source of protein in animal diets and can replace some of the soybean used in formulated diets. The protein content of chickpeas ranges from 18-24% DM, the starch content is 45-54% DM, with the amount of soluble carbohydrate at 2-9% DM, and the fiber content of 3-8% DM, which is similar to that of field peas (6.4%DM), or fava bean (8.3%DM), but lower than that of yellow lupine (*lupinus luteus)* (17.8%DM), or white lupine (*lupinus albus*) (11.9%DM) (Ribeiro and Melo, 1990). The lysine content of chickpeas is 1.49% however; sulfur amino acids are low, in addition to, valine, threonine and tryptophan (Chavan et al., 1989). Chickpea is also a good source of dietary minerals, such as calcium, magnesium, iron, phosphorus and potassium.

Chickpeas contain a variety of anti-nutritional factors, such as protease and amylase inhibitors, lectins, polyphenols and oligosaccharides. However, chickpeas contain small amounts of trypsin and chymotrypsin inhibitors compared with other legumes. Chavan et al., (1989) reported that the anti-nutritional factor contents of chickpeas is similar to that of soybeans (Bampids et al., 2009).These anti nutritional factors inhibit the digestibility of protein and starch, and also reduces the bioavailability of some essential minerals (Sharma et al., 2013) ,which affect animal health and growth (Singh, 1988). It is also reported that these anti-nutritional factors cause organ hypertrophy in monogastrics (Bampids et al., 2009).

Proximate analysis of chickpea varies with cultivars, soil, and environment conditions. Karadavut and Genc (2012) studied the proximate analysis of several chickpea cultivars and determined that moisture, dry matter, ash, nitrogen, crude protein, water soluble protein, total carbohydrates, crude fiber and crude fat contents varied between cultivars. Variability was explained between 82.7 and 90.5% according to cultivars. This finding is supported by Sharma et al., (2013) who also found high variation of nutritional composition among nine chickpea cultivars.

Inclusion of chickpea into the rations of poultry has been studied with a general consensus for maximum inclusion of 10% (Algam et al., 2013; Torki & Karimi, 2007; Algam et al., 2012). It was reported by Torki and Karimi (2007) that partial replacement of soybean meal with 10% chickpeas in broiler diets had no detrimental effect on body weight gain, feed intake, and feed conversion ratio. Algam et al., (2012) reported similar results as Torki and Karimi when they used raw chickpea in broiler diets at levels of 5%, 10%, and 15%. Birds fed 10% and 15% of chickpea showed the same performance as control (0% chickpea), relative to body weight gain, feed conversion ratio, and slaughter weight, dressing percentage and protein efficiency.

While, birds fed diets containing 5% chickpeas were significantly lower in weight gain, carcass weight and feed conversion ratio compared to the control. When increasing the chickpea level to 30% of the diet negatively affected the weight of some digestive organs. It resulted in an increase in relative pancreas and liver weights, and relative lengths of duodenum, jejunum and ceca (Brenes, 2008). Use of extruded chickpea can lower the weight of pancreas and improve weight gain, apparent ileal digestibility of crude protein, and apparent excreta digestibility of crude fat (Brenes, 2008).This finding is supported by Christodoulou et al., (2006a) who demonstrated that replacement of soybean meal with extruded chickpeas, at inclusion levels up to 200 kg/t, in diets of broiler turkeys resulted in similar performance.

Field pea

Field pea (*Pisum sativum*) it is another important edible legume seed for human and animal nutrition. Leguminous seeds such as peas are a major source of alternative dietary proteins for monogastric animals in Europe (Gabriel et al., 2008). Inclusion of pea to poultry diets can provide a considerable proportion of dietary protein and energy. Peas are rich, not only in protein and starch, but also in other nutrients such as fiber, vitamins and minerals (Harmankaya et al., 2010). The protein content ranges from 22.85 to 26.16% DM, starch 40.9% DM, soluble carbohydrate 8.8%DM, crude fiber 7.1% DM, and fat 1.32%DM (Rodrigues et al., 2012). Field peas have high concentrations of lysine averaging 1.67%, but relatively low contents of methionine and cysteine (Hickling, 2003).

Pea seeds, like other legumes, contain number of anti-nutritional factors, such as, protease inhibitors, tannins, alkaloids, lectins, phytic acid, saponins and oligosaccharides. These ANFs effect bird performance, reduce growth rate and also cause pancreatic hypertrophy (Hickling, 2003). The concentrations of these anti-nutritional factors differ widely among different varieties of peas (Vidal-Valverde et al., 2003). Heat treatment, such us autoclaving, and pelleting generally improve the digestibility of starch and protein in peas (Castell et al., 1996).

There is also variation in nutrient content of different pea cultivars. In research on 18 different pea cultivars for concentrations of nutritional compounds and anti-nutritional factors, it was found that the color of the pea is an indicator of different nutritional value (Vidal-Valverde et al., 2003). Peas with light green seed had the highest lysine contents, and those with dark green seed were the richest in vitamins B1 and B2. Peas with brown seed had the highest concentration of inositol hexaphosphate, while they were the lowest in verbascose and sucrose contents. Vidal-Valverde et al., (2003) also reported that the size of the pea has an effect on its nutritional value. They found that smaller peas had the highest content of protein nitrogen, vitamins B1 and B2, verbascose and inositol pentaphosphate. Medium sized peas had the lowest content of verbascose, a-galactoside and vitamin B2. The largest peas had the lowest inositol content of pentaphosphate.

The amount of pea that can be used in broiler diets is between 10-35% (Igbasan & Guenter, 1996; Diaz,et al., 2006; McNeill et al., 2004; Antoine, 2009), while in layer and turkey diets, peas can be used at level between 25-50% (Fru-Nji et al., 2007; Perez-Maldonado et al., 1999; Savage et al.,1986). Diaz et al., (2006) demonstrated that the inclusion of peas at 35% in broiler diets did not affect body weight gain or feed intake, while eviscerated carcass yield was reduced. This finding was different from McNeill et al., (2004), who observed that the feed intake and body weight of broilers fed diets formulated with field peas included at levels 10% to 20%. They reported that the feed intake and the weight gain were reduced by inclusion of 20%

pea meal in the diet. Sensory testing suggested that inclusion of field pea meal up to 20% in broiler diets had no negative effects on meat characteristics (McNeill et al., 2004).

In laying hens, Fru-Nji et al., (2007) used five different levels, 10% to 50%, of field peas in the diet as a replacement of soybean. They reported that increasing levels of peas up to 50% did not significantly effect on egg production, egg size, or egg quality, while feed consumption increased and body weight gain decreased. Research done on market turkeys, Savage et al., (1986) found that there were no significant differences in feed efficiency, growth rate and meat quality from including peas at levels 25% in the starter feed and 55% in the finisher feed.

CHAPTER 3

MATERIALS AND METHODS

Three experiments were conducted at the Oregon State University poultry center. Experiment 1 and 2 were conducted using the same set of nine pens, while experiment 3 used nine pens in a different building on the same farm.

Experiment One

Birds

Nicholas 500 day-old poults (N=144) were obtained from a local commercial hatchery. The poults were randomly assigned to one of nine pens with each replicate of three dietary treatment group consisted of 16 poults.

Environmental Design

The research facility was an insulated enclosed building with cement floors. Wood shavings were used as bedding. When required, pens were top dressed with additional wood shavings during the experiment. The pens each measured 3.9 m. by 3 m. Heat was provided by two 250 watt infrared bulbs and ventilation was provided by exhaust fans under both timer and thermostat control. The temperature of the pens was kept between 26-21°C during the experiment. At three weeks of age, one infrared light bulb was disconnected in each pen with only one remaining as a heat source. Fluorescent lighting was provided 24 hours per day.

Treatments

All diets were prepared approximately one week before the beginning of the experiment. The dietary formulation was based on the recommendation of NRC (1994). All poults were fed mash feeds *ad libitum* throughout the duration of the experiment. All feeds were weighed and recorded prior to distribution to each pen and supplied by hanging tube feeders. The three experimental diets including a corn-soybean control, wheat-based diet, and a wheat-based diet plus enzymes at level 0.4 1b/ton. The wheat-based diets contained soy as well as ground lentils and garbanzo bean screenings. All of the poults had a constant access to drinking water by typical nipple drinkers for the first four weeks with additional gallon drinkers after two weeks. After the fourth week, the nipple drinkers and gallon jugs were replaced with hanging bell drinkers.

Measurements and Samples

The experimental diets are shown in Table 1. During the experiment poults were weighed individually at two, four, six, and eight weeks of age. Mortality and culled birds were recorded and their weights were used during the calculation of feed consumption data. Bodyweights were subjected to one way analysis of variance (ANOVA) testing, using the R-studio software package for windows. Treatments were compared using the Least Significant Difference (LSD) test. The chosen level of significance was $P \leq 0.05$. Feed conversion rates were calculated and compared on a per pen basis with means separated using Duncan's Multiple Range test.

Enzymes

The enzyme used in this study was AlphaGal™ 180P, a powdered enzyme which was described by the manufacturer as "containing a source of alpha-galactosidase derived from Saccharomyces cerevisiae and carbohydrases derived from Bacillus subtilis, Aspergillus niger and Trichoderma longibrachiatrum. Alpha-galactosidase is an exo-activity which catalyses the hydrolysis of alpha 1, 6 linked galactose moieties present in polysaccharides, oligosaccharides, galactomannans and galactolipids. The selected carbohydrases hydrolyze 1, 4-B-D glycosidic linkages and various other non-starch polysaccharides.It contains activity of alpha-galactosidase of minimum 8 pNPG units, and Xylanase of minimum 300 Xylanase units (XYL) per gram of product" (Kerry group, Tralee, Ireland). AlphaGal^{TM} 180P was applied at level 0.4 1bs/t, as recommended by the manufacture. The product was premixed with a small amount of feed before being mixed into the diet.

Experiment Two

Birds

Two hundred Nicholas 500 turkey eggs were obtained from a local commercial hatchery. Eggs were hatched at the OSU hatchery under typical incubation conditions. After hatching, poults (N=118) were randomly assigned to one of nine pens. Each replicate consisted of 13 poults at the beginning of the trial.

Environmental Design

This experiment was conducted in the same system as experiment one with one modification; the use of only one 250 watt infrared heat lamp in each pen due to the warmer ambient temperatures. The temperature of the pens was kept between 25-21°C during the experiment. Fluorescent lighting was provided 24 hours per day.

Treatments

All diets were prepared approximately one week before the beginning of the experiment. The dietary formulation was based on the recommendation of NRC (1994). All poults were fed mash feeds *ad libitum* throughout the duration of the experiment. All feeds were weighed and recorded prior to distribution to each pen and supplied by hanging tube feeder. The three experimental diets were a corn-soybean meal control, corn based –soy free, and, wheat based (corn-soy free). The birds had constant access to drinking water. Nipple drinkers and fountain drinkers (1 gallon) were used during the first four weeks. At the fifth week, nipple drinkers were replaced with bell drinkers.

Measurements and Samples

The experimental diets are shown in Table 2. During the experiment poults were weighed individually at two, four, six, and eight weeks of age. Mortality and culled birds were recorded and their weights were used during the calculation of feed consumption data. Bodyweights were subjected to one way analysis of variance (ANOVA) testing, using the R-studio software package for windows. Treatments were compared using the Least Significant Difference (LSD) test. The chosen level of significance was $P \leq 0.05$. Feed conversion rates were calculated and compared on a per pen basis with means separated using Duncan's Multiple Range test

Experiment Three

Nicholas 500 day-old poults (N=90) were obtained from the same local commercial hatchery as in experiments one and two. The poults were randomly assigned to one of nine pens. Each replicate consisted of 10 poults.

Environmental Design

The research facility in this experiment was curtain-sided un insulated house with cement floors and cinder block walls. The pens measured 4.88 m. by 2.44 m. Wood shavings were used as bedding. When required, pens were top dressed with additional wood shavings during the experiment. Each pen had one 250 watt infrared bulb for heat. Ventilation was provided by natural air movement through curtain sides. The temperature of the pens was between 23-21°C during the experiment. Fluorescent ambient lighting was provided 24 hours per day.

Treatments

All diets were prepared approximately one week before the beginning of the experiment. The dietary formulation was based on the recommendation of NRC (1994). All poults were fed mash feeds *ad libitum* throughout the duration of the experiment. All feeds were weighed and recorded prior to distribution to each pen and supplied by hanging tube feeders. The three experiment diets included the same wheat based no soy diet divided into three equal parts and either supplemented with 0.5% methionine (control), 0.15% methionine (organic), and no added methionine. The birds had constant access to drinking water. Nipple drinkers were used for the first 4 weeks. After two weeks, each pen was supplied with an additional fountain (one gallon) drinker. At the fifth week, nipple drinkers were replaced with bell drinkers.

Measurements and Samples

Diets are presented in Table 3. During the experiment, poults were weighed individually at two, four, and six weeks of age. Mortality and culled birds were recorded, and their weights were used to adjust the feed consumption data. Bodyweights were subjected to an analysis of variance (ANOVA) testing, using the R-studio software package for windows. Treatments were compared using the Least Significant Difference test. The chosen level of significance was $P \leq 0.05$. Feed conversion rates were calculated and compared on a per pen basis with means separated using Duncan's Multiple Range test.

All experiments were conducted with the approval of the Oregon State University Institutional Animal Care and Use Committee to assure humane treatment of the poults.

CHAPTER 4
RESULTS AND DISCUSSION

Experiment One

Body weights are presented in Tables 4-7. At two weeks of age no significant treatment effects were observed in body weights between poults fed the wheat based diet and the wheat based diet supplemented with enzymes (P = 0.24) or in poults fed the wheat based diet supplemented with enzyme and the control diet (P = 0.18) (Table 4). Similar results were recorded by Boguhn and Rodehutscord (2010). However, body weights were higher in poults fed the wheat based diet compared with those receiving the control diet (P = 0.01). Note: due to mixing error, the first two weeks of feed the birds had lower that optimum vitamin/mineral levels which would have resulted in poorer than expect performance

At four weeks of age, similar body weight results were recorded as that of week two. No significant differences on body weight were found between birds fed a wheat based diet with or without enzymes (P = 0.25) or between poults fed the control diet and those fed the wheat based diet supplemented with enzymes (P = 0.11) (Table.5). These results support Odetallah et al. (2002) who reported that at 28 days of age no significant effects on male turkey body weight were observed in wheat based diet supplemented with enzymes in comparison to a wheat based diet without enzymes. Finally, body weights of poults fed the wheat based diet were higher when compared to those fed the control diet (P = 0.006).

On weeks six, and eight of age, there were no statistical differences between the mean body weights of birds fed the wheat based diet, whether supplemented with enzymes or not, while both outperformed the control diet with a mean body weight of 2.2 kg for wheat based diet, and 2.15kg for wheat based diet supplemented with enzymes, compared to 2.0 kg for the control group on week 6 of age (Table 6). At eight weeks of age the mean body weights of birds fed the wheat based diet, wheat based diet supplemented with enzymes, and the control diet were: 3.97kg, 3.96kg, and 3.7kg respectively (Table 7).

From day one to eight weeks of age, no significant differences on body weights were observed between birds fed the wheat based diet and a wheat based diet supplemented with AlphaGal™ 180P enzymes. These results support Boguhn and Rodehutscord (2010) who studied the effect of non-starch polysaccharides hydrolyzing enzymes on turkey performance during various ages from one to 22 weeks of age. They reported that body weights were only significantly different at the oldest age when supplemental enzymes were fed. They concluded that enzymes supplementation is especially effective in older birds. This finding was supported by Odetallah, et al. (2002) who reported that the effect of enzymes in turkey diets is age dependent.

It is also important to supplement a sufficient amount of enzymes to the diets with a high xylanase activity. Santos et al. (2004) in a study on turkeys that were fed a wheat based diet, applied a commercial enzyme Lyxasan Forte® (Endoxylanase activity 56000EXU/g), in two different levels (50g/ton and 100g/ton). They found that the 100gm dosage was more effective than 50gm dosage. In this study AlphaGal™ 180P enzyme was supplemented to the diet at a level of 181g/ton. The activity of xylanase in this enzyme was 300XYL/ g of the product, which was insufficient to eliminate the adverse effect of NSPs in the diets.

In this study the final body weights of birds fed wheat based diets supplemented with or without enzymes were significantly higher than birds fed the control diet. However, this does not indicate that the wheat based diets are better than the control diet because the final body weights of the birds fed the control diet (3.7kg) on week 8 of age (Table 7) were below the commercial standard of (3.85kg), this may have been due to a possible low vitamin premix level (0.25%) in all diets due to an unfortunate mixing error during the first two weeks of the experiment. However, since all diets received the same level of vitamins, the lower body weights of the control birds is not completely understood, especially since the control diet had a protein level that was more than percentage points higher than the experimental diet.

Another possibility is that, the use of wheat, chickpea, and lentils together as alternatives in turkey diets may have had a positive effect on the eight weeks body weights (3.97 kg), and was higher than the expected commercial standard weight (3.85kg). It may be that with or without enzyme supplementation, a mixture of several alternative ingredients can be used to sustain maximum productivity compared to typical corn-soy diets. Finally, sex was determined using the secondary sex characteristic of snood, dewlap, and, caruncle development; and the color of necks and faces. The percent of male turkeys for the control, the wheat based diet, and the wheat based diet supplemented with enzymes were 39%, 39%, and 42% respectively, the lower proportion of males in the control group may have had an additional effect on final body weight differences.

Weights of dead birds and culled birds were included in the calculation of feed conversions and are reported in Table 15. No significant differences were found between the treatments. Dietary enzyme supplementation did not have any positive effect on feed conversion ratio.

Experiment Two

Body weights are presented in Tables 8-11. Final body weights of poults fed the control diet were significantly higher ($p = 0.0001$) than those fed a corn based-soy free or a wheat based (corn-soy free) diets (Table 11). Similar bodyweight depression in broilers was also reported by

Payvastagan et al. (2012) when 20% canola meal was added to the diets as a replacement of soybean. These results support the finding of Hameed et al. (2002) who found inclusion of canola meal up to 15% in the Japanese quail diets negatively affected their body weight gain. While, Sarcicek et al. (2005) reported that canola meal can be used as a replacement of soybean meal at level of 25% in quail rations without having any detrimental effect on their body weights, but inclusion ratios above 25% can cause negative effects on growth rates and yield characteristics.

In this study, there was no significant difference between the mean body weight (3.1kg) of birds fed the corn based-soy free diet and mean body weights (3.2 kg) of birds fed a wheat based (Corn-soy free) diet at eight weeks of age. It was also found that the percent mortality of the birds fed soy free diets was twice as high as poults receiving the control diet. Most of the mortality occurred in the first two weeks of the experiment. The incidence of cannibalism (3 cases) was also noted in the corn based-soy free diet at eight weeks of age. This indicates that excluding soy alone or in the combination with corn from diets of turkey poults can have a negative effect on poult performance.

The calculated feed conversions for this experiment are found in Table 16. The conversion of feed to gain in this experiment was not significantly different between the diets with the corn based (soy free), wheat based (corn-soy free) and control (corn-soy based) diet with conversions 1.84, 1.83, and, 1.76 respectively. Results from this experiment are not in agreement with Payvastaganet al. (2012) who reported 20% inclusion of canola meal as a replacement of soybean meal in broiler chicken diets significantly impaired the feed conversion ratio.

Experiment Three

Body weights are presented in Tables 12-14. Final body weights of poults fed diet containing 0% methionine were significantly (P < .05) lower than bodyweights of poults fed diet containing organic level of methionine (0.15% met) and the control (0.5% met) diet (Table 14). There were no significant differences between the mean body weights of birds fed the wheat based diet supplemented with 0.5% methionine (control) and the mean body weights of birds fed the wheat based diet supplemented with 0.15 % methionine (organic). This indicates that in diets used in this study the recommended level of methionine (31bs/t) supplementation in current organic turkey diets by USDA (0.15%) is adequate to provide proper growth of organically grown turkeys.

Weights of dead and culled birds were included in the calculation of feed conversions and are reported in Table 17. Poults fed diet supplemented with 0.5 % met (1.93) outperformed the poults fed the diet supplemented with 0.15% met (2.13) and methionine free diet (2.19), while this difference was not significant between the treatments.

The main consideration for reducing methionine level in poultry diet is based on US Department of Agriculture (USDA) rules for reducing synthetic methionine level in organic poultry production. The rule became effective on October 1, 2012.

Methionine is an essential amino acid required in the diets of the poultry. Birds must obtain this amino acid from the diets because they are unable to synthesize it (Saengkerdsub et al., 2013). This amino acid is usually limited in typical poultry diets and must to be added for optimal productivity. Methionine enhances the overall growth, production, and feed conversion ratio (Narayanswamy and Bhagwat, 2010). It is also important for protein synthesis and regulation of cell division (Kalbande et al., 2009).

Currently, methionine is produced by chemical processes or hydrolyzing proteins (Saengkerdsub et al., 2013). The National Organic Standards Board determined that a totally natural substitute of methionine is not available in sufficient quantities to meet the requirements of poultry producers; therefore they proposed a rule to permit organic producers to use synthetic methionine in specific amounts in organic poultry production. Before October 1, 2012 the synthetic level of methionine allowed by US Department of Agriculture (USDA) in organic poultry production was four pounds per ton of feed for laying chickens; five pounds per ton of feed for broiler chickens; and six pounds per ton of feed for turkeys and other poultry (World Poultry, 2012). On September 19, 2012, the National Organic Program published a final rule extending the allowance for synthetic methionine in organic poultry production but in lower levels. After October 1, 2012, the limited amounts of synthetic methionine being used for laying and broiler chickens is two pounds per ton of feed and for turkeys and all other poultry is three pounds per ton of feed (Federal Register, 2012).

Conclusion

From the current research, it can be concluded that alternative feed ingredient such as wheat, chickpea, and lentils can be used as a mixture to replace all of the corn and a portion of the soybean meal in turkey diets without sacrificing performance. These ingredients sustained maximum productivity compared to typical corn/soy diets. The effect of the mixture of these three ingredients was positive on the final body weights (3.97 kg) at eight weeks of age, and was similar to the expected weights for the commercial standard (3.85 kg). Adding AlphaGal^{TM} 180P enzyme to the wheat based diet did not improve body weights or feed conversion of turkey poults. Xylanase activity (300 XYL/gram) of this enzyme was insufficient to eliminate the adverse effect of NSPs in the diets.

When soybean was completely removed from the diets, body weight was negatively affected. Alternative feed ingredients such as lentils, field peas, chickpea, and canola can partially replace soybean meal in the diets which is desirable for some small producers of organic turkeys, however, soy free diet, based with either corn or wheat, while not resulting in significantly different weights when compared together, did not support adequate growth when compared to typical corn-soy diets. In addition, excluding soybean from the diets did not affect feed conversion. It was also found that the percent mortality was twice as high in soy free diets when compared to the control diet. Some cannibalism (3 cases) was also noted in the corn based-soy free diet. These results suggest that soybean meal is important and difficult ingredient to replace in turkey diets. More research is needed to identify more substitute combinations of ingredients that will support proper growth and production in turkeys.

Finally, reducing methionine level of 0.15% in organic diets did not affect turkey poults body weight or feed conversion when compared to the control diet. However, the mean body weights of turkey poults fed diets with no methionine supplementation were lower in comparison to the mean body weights of poults fed diets with 0.15% or 0.5% methionine. Excluding supplemental methionine from the diet did not affect feed conversion ratios. This indicates that the USDA recommended level of synthetic methionine (3 pounds per ton) in the organic turkey diets used in this research can provide their maintenance requirement without sacrificing growth and feed conversion. However, other diets may not prove to be successful with this low level of methionine.

Table 1: Experimental diets for turkey poults.

Ingredient	Starter Diet (0-6 wks of age) %		Grower diet (6-8 wks of age) %	
	Control	Wheat based	Control	Wheat based
Corn	40.0	-	52.15	-
Wheat	-	30.0	-	39.35
Soybean Meal (44% CP)	54.0	43.25	38.0	26.0
Lentils	-	10.0	-	12.0
Garbanzo bean screenings	-	10.0	-	12.0
Soybean oil	1.5	2.0	5.0	5.0
Dicalcium Phosphate	2.0	2.0	2.0	2.0
Limestone	1.5	1.5	1.5	1.5
DL-Methionine	0.5	0.5	0.5	0.5
Common Salt	0.25	0.25	0.25	0.25
Vitamin-mineral premix*	0.25	0.25	0.5	0.5
L-lysine	-	0.25	0.10	0.5
Threonine	-	-	-	0.4
Calculated Nutrient Composition				
ME (kcal/kg, DM basis)	2,810	2,820	3,140	3,150
Crude protein (%)	27.57	27.1	21.69	21.53
Crude fiber (%)	2.99	2.41	2.63	1.96
Calcium (%)	1.15	1.15	1.11	1.11
Methionine (%)	0.92	0.84	0.84	0.77
Lysine (%)	1.70	1.72	1.33	1.59
Available phosphorus (%)	0.17	0.21	0.14	0.18

*Vitamin-mineral premix supplied per kg. of diet: vitamin A, 2,200,000 I.U.; vitamin D, 374,000 I.U.; vitamin E, 4,400 I.U.; menadione, 292.6 mg.; riboflavin, 1,760 mg.; pantothenic acid, 2,720 mg.; niacin 8,800 mg.; vitamin B12, 6.6 mg.; vitamin B6, 506 mg.; folic acid, 264 mg.; thiamine, 308 mg.; choline, 81,840 mg.; biotin, 79.2 mg.; calcium min, 7.5%; calcium max, 8.4%; Sulfur, 4.5%; cobalt, 290.4 ppm.; copper, 4840 ppm.; iodine, 123.2 ppm.; iron, 2.18%.; manganese, 2.38%; selenium, 264 ppm.; zinc, 3.96%.

AlphaGal™ 180P enzymes were supplemented to the diet at level 0.4 1bs/t.

Table 2: Ration Formulation of All Diets Tested in Experiment 2.

Ingredient	Starter-grower Diet (0-8 wks of age) %		
	Control	Corn based	Wheat based
Corn	44.70	33.7	-
Wheat	-	-	36.4
Soybean Meal -44%	42.70	-	-
Lentils	-	6.0	5.0
Field peas	-	6.0	5.0
Canola meal	-	34.0	31.2
Corn gluten meal	-	5.0	6.0
Menhaden meal	5.0	7.0	6.0
Soybean oil	1.5	-	-
Corn oil	-	4.0	5.0
Dicalcium Phosphorus	3.0	1.0	1.30
Limestone	1.5	1.5	2.0
DL-Methionine	0.5	0.5	0.5
Common salt	0.35	0.35	0.35
Vitamin –mineral premix*	0.75	0.75	0.75
L-lysine	-	0.2	0.5
Calculated Nutrient Composition			
ME (kcal/kg, DM basis)	2,830	2,900	2,900
Crude protein (%)	26.03	26.51	26.06
Crude fiber (%)	2.69	4.63	4.46
Calcium (%)	1.59	1.39	1.59
Methionine (%)	0.95	1.0	0.98
Lysine (%)	1.62	1.64	1.75
Available phosphorus (%)	0.89	0.59	0.61

*Vitamin-mineral premix supplied per kg. of diet: vitamin A, 2,200,000 I.U.; vitamin D, 374,000 I.U.; vitamin E, 4,400 I.U.; menadione, 292.6 mg.; riboflavin, 1,760 mg.; pantothenic acid, 2,720 mg.; niacin 8,800 mg.; vitamin B12, 6.6 mg.; vitamin B6, 506 mg.; folic acid, 264 mg.; thiamine, 308 mg.; choline, 81,840 mg.; biotin, 79.2 mg.; calcium min, 7.5%; calcium max, 8.4%; Sulfur, 4.5%; cobalt, 290.4 ppm.; copper, 4840 ppm.; iodine, 123.2 ppm.; iron, 2.18%.; manganese, 2.38%; selenium, 264 ppm.; zinc, 3.96%.

Table 3: Ration Formulation of the Diet Tested in Experiment 3.

Ingredient	Starter Diet (0-6 wks of age) %		
	Control (0.5 % met)	Organic (0.15% met)	No met
Wheat	36.4	36.4	36.4
Canola meal	31.2	31.2	31.2
Corn gluten meal	6.0	6.0	6.0
Lentils	5.0	5.0	5.0
Field peas	5.0	5.0	5.0
Menhaden meal	6.0	6.0	6.0
Corn oil	5.0	5.0	5.0
Limestone	2.0	2.0	2.0
DL-Methionine	0.5	0.15	0.0
Common salt	0.35	0.35	0.35
Vitamin-mineral premix*	0.75	0.75	0.75
L-lysine	0.5	0.5	0.5
Dicalcium phosphorus	1.3	1.3	1.3
Calculated Nutrient Composition			
ME (kcal/kg, DM basis)	2,900	2,900	2,900
Analysis crude protein (%)	26.7	26.7	26.7
Crude fiber (%)	4.46	4.46	4.46
Calcium (%)	1.59	1.59	1.59
Methionine (%)	0.98	0.98	0.98
Lysine (%)	1.75	1.75	1.75
Available phosphorus (%)	0.61	0.61	0.61

*Vitamin-mineral premix supplied per kg. of diet: vitamin A, 2,200,000 I.U.; vitamin D, 374,000 I.U.; vitamin E, 4,400 I.U.; menadione, 292.6 mg.; riboflavin, 1,760 mg.; pantothenic acid, 2,720 mg.; niacin 8,800 mg.; vitamin B12, 6.6 mg.; vitamin B6, 506 mg.; folic acid, 264 mg.; thiamine, 308 mg.; choline, 81,840 mg.; biotin, 79.2 mg.; calcium min, 7.5%; calcium max, 8.4%; Sulfur, 4.5%; cobalt, 290.4 ppm.; copper, 4840 ppm.; iodine, 123.2 ppm.; iron, 2.18%.; manganese, 2.38%; selenium, 264 ppm.; zinc, 3.96%.

Experiment 1

Table 4: Effect of feeding wheat-based diets supplemented with AlphaGal™ 180P enzyme (0.4 lbs/t feed) on body weights (kg) of turkey poults (n= 144) at 2 wks of age expressed as replicate and overall means (Experiment 1).

Treatment	Replicate (n =16 per replicate & group)			Overall
	1	2	3	X ± SEM
Wheat based	0.30	0.27	0.27	0.28 ± 0.015[a]
Wheat based + Enzyme	0.25	0.29	0.28	0.27 ± 0.016[ab]
Control*	0.27	0.25	0.25	0.26 ± 0.011[b]

[ab] Treatment means with different superscripts are significantly different (P < .05).

*Birds in the control group did not perform as a standard because of the low level, due to mixing error, of vitamins in all diets in the first two weeks of the experiment.

Table 5: Effect of feeding wheat-based diets supplemented with AlphaGal™ 180P enzyme (0.4 lbs/t feed) on body weights (kg) of turkey poults (n = 144) at 4 wks of age expressed as replicate and overall means (Experiment 1).

Treatment	Replicate (n =16 per replicate & group)			Overall
	1	2	3	X ± SEM
Wheat based	0.96	0.89	0.91	0.92 ± .055[a]
Wheat based +Enzyme	0.82	0.94	0.87	0.87± .062 [ab]
Control*	0.88	0.74	0.81	0.81 ± .057 [b]

[ab] Treatment means with different superscripts are significantly different (P < .05).

*Birds in the control group did not perform as a standard because of the low level, due to mixing error, of vitamins in all diets in the first two weeks of the experiment.

Table 6: Effect of feeding wheat-based diets supplemented with AlphaGal™ 180P enzyme (0.4 lbs/t feed) on body weights (kg) of turkey poults (n= 144) at 6 wks of age expressed as replicate and overall means (Experiment 1).

Treatment	Replicate (n =16 per replicate & group)			Overall
	1	2	3	X± SEM
Wheat based	2.31	2.11	2.2	2.20 ± .103[a]
Wheat based+ Enzyme	2.10	2.22	2.1	2.14 ± .108[a]
Control*	2.24	1.84	1.91	2.00 ± .108[b]

[ab] Treatment means with different superscripts are significantly different ($P < .05$).

*Birds in the control group did not perform as standard because of the low level, due to mixing error, of vitamins in all diets in the first two weeks of the experiment.

Table 7: Effect of feeding wheat-based diets supplemented with AlphaGal™ 180P enzyme (0.4 lbs/t feed) on body weights (kg) of turkey poults (n= 144) at 8 wks of age expressed as replicate and overall means (Experiment 1).

Treatment	Replicate (n =16 per replicate & group)			Overall
	1	2	3	X ± SEM
Wheat based	4.00	3.90	4.03	3.97 ± .170[a]
Wheat based + Enzyme	3.86	4.02	4.00	3.96 ± .159[a]
Control*	4.12	3.50	3.45	3.70 ± .182[b]

[ab] Treatment means with different superscripts are significantly different ($P < .05$).

*Birds in the control group did not perform as standard because of the low level, due to mixing error, of vitamins in all diets in the first two weeks of the experiment.

Experiment 2

Table 8: Effect of excluding soy alone or in combination with corn from diets for turkey poults (n =118) on their body weights (kg) at 2 wks of age expressed as replicate and overall means (Experiment 2).

Treatment	Replicate (n =13 per replicate & group)			Overall
	1	2	3	X ± SEM
Control (Corn/soy)	0.31	0.30	0.35	0.32 ± .019[a]
Corn based (Corn/No soy)	0.23	0.22	0.20	0.22 ± .019[b]
Wheat-based (No corn/No soy)	0.25	0.21	0.25	0.24 ± .020[b]

[ab] Treatment means with different superscripts are significantly different ($P < .05$).

Table 9: Effect of excluding soy alone or in combination with corn from diets for turkey poults (n =118) on their body weights (kg) at 4 wks of age expressed as replicate and overall means (Experiment 2).

Treatment	Replicates (n =13 per replicate & group)			Overall
	1	2	3	X± SEM
Control (Corn/soy)	1.05	1.00	1.11	1.05 ± .060[a]
Corn based (No soy)	0.77	0.72	0.69	0.73 ± .064[b]
Wheat based (No corn/No soy)	0.83	0.69	0.79	0.77 ± .066[b]

[ab] Treatment means with different superscripts are significantly different ($P < .05$).

Table 10: Effect of excluding soy alone or in combination with corn from diets for turkey poults (n =118) on their body weights (kg) at 6 wks of age expressed as replicate and overall means (Experiment 2).

Treatment	Replicate(n =13 per replicate & group)			Overall
	1	2	3	X ± SEM
Control (Corn/soy)	2.41	2.23	2.40	2.34 ± .119[a]
Corn based (No soy)	1.67	1.67	1.66	1.66 ± .153[b]
Wheat based (No corn/No soy)	1.93	1.72	1.83	1.82 ± .140[b]

[ab] Treatment means with different superscripts are significantly different ($P < .05$).

Table 11: Effect of excluding soy alone or in combination with corn from diets for turkey poults (n =118) on their body weights (kg) at 8 wks of age expressed as replicate and overall means (Experiment 2).

Treatment	Replicate (n =13 per replicate & group)			Overall
	1	2	3	X ± SEM
Control (Corn/soy)	4.15	3.84	4.25	4.08 ± .184[a]
Corn based (Corn/No soy)	3.00	3.21	2.95	3.10 ± .272[b]
Wheat based (No corn/No soy)	3.31	3.19	3.17	3.22 ± .216[b]

[ab] Treatment means with different superscripts are significantly different ($P < .05$).

Experiment Three

Table 12: Effect of methionine supplementation (No met: 0%; organic: 0.15%; control 0.5%) to wheat-based diets on body weights (kg) of turkey poults (n = 90) at 2 wks of age expressed as replicate and overall means (Experiment 3).

Treatment	Replicate (n =10 per replicate & group)			Overall
	1	2	3	X ± SEM
Control (0.5% met)	0.24	0.22	0.23	0.23 ± .012[a]
Organic (0.15% met)	0.19	0.24	0.23	0.22 ± .012[a]
No methionine (0% met)	0.20	0.19	0.18	0.19 ± .010[b]

[ab] Treatment means with different superscripts are significantly different ($P < .05$).

Table 13: Effect of methionine supplementation (No met: 0%; organic: 0.15%; control 0.5%) to wheat-based diets on body weights (kg) of turkey poults (n = 90) at 4 wks of age expressed as replicate and overall means (Experiment 3).

Treatment	Replicate (n =10 per replicate & group)			Overall
	1	2	3	X± SEM
Control (0.5% met)	0.61	0.59	0.66	0.62 ± .040[a]
Organic (0.15% met)	0.58	0.59	0.64	0.60 ± .040[a]
No methionine (0% met)	0.56	0.48	0.53	0.52 ± .030[b]

[ab] Treatment means with different superscripts are significantly different ($P < .05$).

Table 14: Effect of methionine supplementation (No met: 0%; organic: 0.15%; control 0.5%) to wheat-based diets on body weights (kg) of turkey poults (n = 90) at 6 wks of age expressed as replicate and overall means (Experiment 3).

Treatment	Replicate (n =10 per replicate & group)			Overall
	1	2	3	X± SEM
Control (0.5% met)	1.40	1.41	1.46	1.42 ± .075[a]
Organic (0.15% met)	1.36	1.40	1.51	1.42 ± .101[a]
No methionine (0 % met)	1.27	1.13	1.19	1.20 ± .066[b]

[ab] Treatment means with different superscripts are significantly different ($P < .05$).

Table15: Effect of feeding wheat-based diets supplemented with AlphaGal™ 180P enzyme (0.4 lbs/t feed) on feed conversion of turkey poults (n = 144) from day 0 to 8 wks of age expressed as replicate and overall means (Experiment 1).

Treatment	Replicate (n =16 per replicate & group)			Overall
	1	2	3	Mean
Control	2.19	1.76	1.80	1.91
Wheat based + Enzyme	2.01	1.94	1.84	1.93
Wheat based	1.92	1.79	1.72	1.81

Table 16: Effect of excluding soy alone or in combination with corn from diets for turkey poults (n = 118) on their feed conversion from day 0 to 8 wks of age expressed as replicate and overall means (Experiment 2).

Treatment	Replicate (n =13 per replicate & group)			Overall
	1	2	3	Mean
Control (Corn/soy)	1.78	1.71	1.8	1.76
Corn based (Corn/No soy)	2.81*	1.87	1.81	1.84
Wheat based (No corn/No soy)	1.85	1.77	1.89	1.83

*Treatment was excluded from the statistical analysis because the total amount of feed added to the pen was not consumed by the birds, but an amount of it was spilled by them every day by digging.

Table 17: Effect of methionine supplementation (No met: 0%; organic: 0.15%; control 0.5%) to wheat-based diets on feed conversion of turkey poults (n = 90) from day 0 to 6 wks of age expressed as replicate and overall means (Experiment 3).

Treatment	Replicate (n =10 per replicate & group)			Overall
	1	2	3	Mean
Control (0.5% met)	2.26	2.08	2.23	2.19[a]
Organic (0.15% met)	1.94	2.09	2.37	2.13[a]
No methionine (0% met)	1.92	1.84	2.04	1.93[a]

Treatment means with the same superscripts are not significantly different (P > .05).

Literature Cited

Aeschbacher, K., Messikommer, R., Meile, L., & Wenk, C. (2005). Bt176 corn in poultry nutrition: physiological characteristics and fate of recombinant plant DNA in chickens. *Poult. Sci*, *84*(3), 385–394.

Akibode, S., & Maredia, M. (2011). Global and regional trends in production, trade and consumption of food legume crops. *Draft Report.*

Akmal Khan, M., Rana, I. A., Ullah, I., & Jaffery, S. (1987). Physicochemical characters and nutrient composition of some improved lines of lentils grown in Pakistan. *Journal of Food Composition and Analysis*, *1*(1), 65–70.

Algam, T. A., Atti, K. A. A., Dousa, B. M., Elawad, S. M., & Elmanan, B. A. (2013). Effect of dietary raw chickpea (Cicer arietinum L.) seeds replacement groundnut meal, sesame meal on broiler performance and blood constituents. *Online Journal of Animal and Feed Research (OJAFR)*, *3*(2), 91–95.

Algam, T. A., Atti, K. A. A., Dousa, B. M., Elawad, S. M., & Elseed, A. F. (2012). Effect of dietary raw chick pea (Cicer arietinum L.) seeds on broiler performance and blood constituents. *International Journal of Poult. Sci.*, *11*(4), 294–297.

American Academy of Environmental Medicine. (2009). Genetically modified foods. Retrieved from http://www.aaemonline.org/gmopost.html.

Antoine, S.-C. (2009). Legume grains (Phaseolus vulgaris and Pisum sativum) of the Pacific Northwest as an alternative broiler feedstuff. MS Thesis, Oregon State University.

Aris, A., & Leblanc, S. (2011). Maternal and fetal exposure to pesticides associated to genetically modified foods in Eastern Townships of Quebec, Canada. *Reproductive Toxicology*, *31*(4), 528–533.

Bampids, V., Christodoulou, V., Nistore, E., Skapetas, B., & Nistor, G. (2009). The use of chickpea (Cicer arietinum) in poultry diets: A review. *Lucrări ştiinţifice Zootehnie şi Biotehnologi,* 42(1).

Boguhn, J., & Rodehutscord, M. (2010). Effects of nonstarch polysaccharide-hydrolyzing enzymes on performance and amino acid digestibility in turkeys. *Poult. Sci.*, *89*(3), 505–513.

Brenes, A., Viveros, A., Centeno, C., Arija, I., & Marzo, F. (2008). Nutritional value of raw and extruded chickpeas (Cicer arietinum L.) for growing chickens. *Spanish Journal of Agricultural Research*, *6*(4), 537–545.

Castell, A. G., Guenter, W., & Igbasan, F. A. (1996a). Nutritive value of peas for nonruminant diets. *Animal Feed Science and Technology*, *60*(3), 209–227.

Cederroth, C. R., Zimmermann, C., & Nef, S. (2012). Soy, phytoestrogens and their impact on reproductive health. *Molecular and Cellular Endocrinology*, *355*(2), 192–200.

Chavan, J.K., Kadam, S.S. and Salunkhe, D.K. (1989) Chickpea, in *Handbook of World Food Legumes,* Vol. I, (eds. D.K. Salunkhe and S.S. Kadam), CRC Press, Boca Raton, FL.

Choct, M., & Annison, G. (1992). The inhibition of nutrient digestion by wheat pentosans. *Br. J. Nutr*, *67*(1), 123–32.

Choct, M., Hughes, R. J., Wang, J., Bedford, M. R., Morgan, A. J., & Annison, G. (1996). Increased small intestinal fermentation is partly responsible for the anti-nutritive activity of non-starch polysaccharides in chickens. *Br. poult. Sci.*, *37*(3), 609–621.

Christodoulou, V., Bampidis, V. A., Hucko, B., & Mudrik, Z. (2006a). The use of extruded chickpeas in diets of broiler turkeys. *Czech Journal of Animal Science, 51*(9), 416.

Christodoulou, V., Bampidis, V. A., Hucko, B., Iliadis, C., & Mud rik, Z. (2006b). Nutritional value of chickpeas in rations of broiler chickens. *Arch.Geflügelk*, *70*(3), 112–118.

Cokkizgin, A., & Shtaya, M. J. (2013). Lentil: Origin, cultivation techniques, utilization and advances in transformation. *Agriculture Science*, 1(1), 55–62.

Cromwell, G. L., Lindemann, M. D., Randolph, J. H., Parker, G. R., Coffey, R. D., Laurent, K. M., Hartnell, G. F. (2002). Soybean meal from roundup ready or conventional soybeans in diets for growing-finishing swine. *Journal of Animal Science*, *80*(3), 708–715.

Crop Prospects and Food Situation. (2013). Retrieved from http://reliefweb.int/report/world/crop-prospects-and-food-situation-no-2-july-2013.

Danicke, S., Vahjen, W., Simon, O., & Jeroch, H. (1999). Effects of dietary fat type and xylanase supplementation to rye-based broiler diets on selected bacterial groups adhering to the intestinal epithelium. on transit time of feed, and on nutrient digestibility. *Poult. Sci.*, *78*(9), 1292–1299.

Diaz, D., Morlacchini, M., Masoero, F., Moschini, M., Fusconi, G., & Piva, G. (2006). Pea seeds (Pisum sativum), faba beans (Vicia fabavar. minor) and lupin seeds (Lupinus albus var. multitalia) as protein sources in broiler diets: effect of extrusion on growth performance. *Italian Journal of Animal Science*, *5*(1), 43–54.

Engberg, R. M., Hedemann, M. S., Steenfeldt, S., & Jensen, B. B. (2004). Influence of whole wheat and xylanase on broiler performance and microbial composition and activity in the digestive tract. *Poult. Sci.*, *83*(6), 925–938.

Esmaeilipour, O., Shivazad, M., Moravej, H., Aminzadeh, S., Rezaian, M., & van Krimpen, M. M. (2011). Effects of xylanase and citric acid on the performance, nutrient retention, and characteristics of gastrointestinal tract of broilers fed low-phosphorus wheat-based diets. *Poult. Sci.*, *90*(9), 1975–1982.

Esteve-Garcia, E., Brufau, J., Perez-Vendrell, A., Miquel, A., & Duven, K. (1997). Bioefficacy of enzyme preparations containing beta-glucanase and xylanase activities in broiler diets based on barley or wheat, in combination with flavomycin. *Poult. Sci.*, *76*(12), 1728–1737.

Federal Register. (2012). Rules and Regulation. 77(182). Retrived from http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5100580

Food and Agriculture Organization of the United Nations. (2013). World cereal production set to reach historic high in 2013. Retrieved from http://www.fao.org/news/story/en/item/179967/.

Fru-Nji, F., Niess, E., & Pfeffer, E. (2007). Effect of graded replacement of soybean meal by faba beans (Vicia faba L.) or field peas (Pisum sativum L.) in rations for laying hens on egg production and quality. *The Journal of Poult. Sci.*, *44*(1), 34–41.

Gabriel, I., Lessire, M., Juin, H., Burstin, J., Duc, G., Quillien, L., Sève, B. (2008). Variation in seed protein digestion of different pea (Pisum sativum L.) genotypes by cecectomized broiler chickens: 1. Endogenous amino acid losses, true digestibility and in vitro hydrolysis of proteins. *Livestock Science*, *113*(2-3), 251–261.

GMO Compass. (2010). Genetically modified plants:Global cultivation area. Retrieved from http://www.gmo-compass.org /eng/agri_biotechnology/gmo_planting/342 genetically_modified_soybean_global_area_under_cultivation.html.

Hameed, S., Ahmad, N., & Rabbani, M. (2002). Effect of replacing dietary levels of soybean meal with canola meal in Japanese quail. *International Journal of Agriculture and Biology*, *4*(3), 389–391.

Harmankaya, M., Özcan, M. M., Kardas, S., & Ceyhan, E. (2010). Protein and mineral contents of pea (Pisum sativum L.) Genotypes grown in central Anatolian region of Turkey. *South Western Journal of Horticulture, Biology and Environment*, *1*(2), 159–165.

Henneman, M. L. (2010). Should breast cancer patients eat or avoid phytoestrogens? Retrieved from http://bioblog.biotunes.org/bioblog/2010/04/16/should-breast-cancer-patients-eat-or-avoid-phytoestrogens/.

Herman, E. M. (2003). Genetically modified soybeans and food allergies. *Journal of Experimental Botany*, *54*(386), 1317–1319. doi:10.1093/jxb/erg164

Hickling, D. (2003). Canadian feed peas industry guide. *Pulse Canada Publ., Winnipeg, Manitoba, Canada*. Retrieved from http://wcfin.ca/Portals/0/Pea%20Guide%202003.pdf.

Hsieh, C.-Y., Santell, R. C., Haslam, S. Z., & Helferich, W. G. (1998). Estrogenic effects of genistein on the growth of estrogen receptor-positive human breast cancer (MCF-7) cells in vitro and in vivo. *Cancer Research*, *58*(17), 3833–3838.

Igbasan, F. A., & Guenter, W. (1996). The evaluation and enhancement of the nutritive value of yellow-, green-and brown-seeded pea cultivars for unpelleted diets given to broiler chickens. *Animal Feed Science and Technology*, *63*(1), 9–24.

Jaroni, D., Scheideler, S. E., Beck, M. M., & Wyatt, C. (1999). The effect of dietary wheat middlings and enzyme supplementation II: Apparent nutrient digestibility, digestive tract size, gut viscosity, and gut morphology in two strains of leghorn hens. *Poult. Sci.*, *78*(12), 1664–1674.

Jennings, J. C., Kolwyck, D. C., Kays, S. B., Whetsell, A. J., Surber, J. B., Cromwell, G. L., Glenn, K. C. (2003). Determining whether transgenic and endogenous plant DNA and transgenic protein are detectable in muscle from swine fed Roundup Ready soybean meal. *Journal of Animal Science*, *81*(6), 1447–1455.

Jia, W., Slominski, B. A., Bruce, H. L., Blank, G., Crow, G., & Jones, O. (2008). Effects of diet type and enzyme addition on growth performance and gut health of broiler chickens during subclinical Clostridium perfringens challenge. *Poult. Sci.*, *88*(1), 132–140.

Kalbande, V. H., Ravikanth, K., Maini, S., & Rekhe, D. S. (2009). Methionine supplementation options in poultry. *Int. J. Poult. Sci*, *8*, 588–591.

Karadavut, U., & Genc, A. (2012). Statistical Evaluation of Chemical Components Acording to Some Chickpea (Cicer arietinum L.) Cultivars. *Journal of Selcuk University Natural and Applied Science*, 1(2).

Key, S., Ma, J. K.-C., & Drake, P. M. (2008). Genetically modified plants and human health. *Journal of the Royal Society of Medicine*, *101*(6), 290–298.

Kruft, D. (2001). Impacts of Genetically-Modified Crops and Seeds on Farmers. Retrieved from http://law.psu.edu/_file/aglaw/Impacts_of_Genetically_Modified.pdf.

Lee, H. P., Lee, J., Gourley, L., Duffy, S. W., Day, N. E., & Estève, J. (1991). Dietary effects on breast-cancer risk in Singapore. *The Lancet*, *337*(8751), 1197–1200.

Leu, A. (2012). GMO Safety Issues based on Science. Retrieved from http://www.ofa.org.au/pages/GMO-Safety-Issues-based-on-Science.html.

Lincoln, M. J. (2009). *Mrs. Lincoln's Boston cook book: What to do and what not to do in cooking*. Apple wood Books's Store. Retrieved from http://books.google.com/books?hl=en&lr =&id=V2BT3Y17JIoC&oi=fnd&pg=PA1&dq=Mrs.+Lincoln%27s+Boston+Cook+Book&ots=1 zSAbEF3jg&sig=DAxYHqt3tVQlw3NtsymJW6VSdds.

Mavromichalis, I. (2013). Alternative animal feed protein sources: faba beans, lentils. Retrieved from http://www.wattagnet.com/Alternative_animal_feed_protein_sources__faba_beans,_lentils.html.

McMichael-Phillips, D. F., Harding, C., Morton, M., Roberts, S. A., Howell, A., Potten, C. S., & Bundred, N. J. (1998). Effects of soy-protein supplementation on epithelial proliferation in the histologically normal human breast. *The American Journal of Clinical Nutrition*, *68*(6), 1431S–1435S.

McNeill, L., Bernard, K., & MacLeod, M. G. (2004). Food intake, growth rate, food conversion and food choice in broilers fed on diets high in rapeseed meal and pea meal, with observations on sensory evaluation of the resulting poultry meat. *Br. Poult. Sci.*, *45*(4), 519–523.

Narayanswamy, H., & Bhagwat, V. (2010). Evaluating the efficacy of methionine supplementation options in commercial broiler chickens. Retrieved from http://www.himalayahealthcare.com/pdf_files/ahp/him_methio001.pdf

National Corn Growers Association. (2012). World of Corn. Retrieved from www.ncga.com.

National Research Council. (1994). Nutrient Requirements of Poultry. 9th revised edition. National Academy Press, Washington, DC.

Netherwood, T., Martín-Orúe, S. M., O'Donnell, A. G., Gockling, S., Graham, J., Mathers, J. C., & Gilbert, H. J. (2004). Assessing the survival of transgenic plant DNA in the human gastrointestinal tract. *Nature Biotechnology*, *22*(2), 204–209.

Nordlee, J. A., Taylor, S. L., Townsend, J. A., Thomas, L. A., & Bush, R. K. (1996). Identification of a Brazil-nut allergen in transgenic soybeans. *New England Journal of Medicine*, *334*(11), 688–692.

Odetallah, N. H., Parks, C. W., & Ferket, P. R. (2002). Effect of wheat enzyme preparation on the performance characteristics of tom turkeys fed wheat-based rations. *Poult. Sci.*, *81*(7), 987–994.

Payvastagan, S., Farhoomand, P., Shahrooze, R., Delfani, N., & Talatapeh1, A. (2012). The effects of different levels of canola meal and copper on performance, susceptibility to ascites and plasma enzyme activities in broiler chickens. *Annals of Biological Research*, *3*(11), 5252–5258.

Perez-Maldonado, R. A., Mannion, P. F., & Farrell, D. J. (1999). Optimum inclusion of field peas, faba beans, chick peas and sweet lupins in poultry diets. I. Chemical composition and layer experiments. *British Poult. Sci.*, *40*(5), 667–673.

Phipps, R. H., Jones, A. K., Tingey, A. P., & Abeyasekera, S. (2005). Effect of corn silage from an herbicide-tolerant genetically modified variety on milk production and absence of transgenic DNA in milk. *Journal of Dairy Science*, *88*(8), 2870–2878.

Ribeiro, R., & Melo, I. M. (1990). Composition and nutritive value of chickpea. *Options Méditerranéennes-Série Séminaires*, *9*, 107–111.

Rodrigues, A. M., Reis, C. M. G., & Rodrigues, P. J. (2012). NutritioNal assessment of different field pea genotypes (Pisum sativum l.). *Agricultur Academy in Bulgaria*. Retrieved from http://repositorio.ipcb.pt/handle/10400.11/1745.

Saengkerdsub, S., O’Bryan, C. A., Crandall, P. G., & Ricke, S. C. (2013). Possibility for Probiotic Sources of Methionine for Organic Poultry Nutritional Supplementation: An Early Review. *J Prob Health*, *1*(103), 2.

Salunkhe, D. K., & Kadam, S. S. (1989). *Handbook of world food legumes: nutritional chemistry, processing technology, and utilization. Volume 1.* CRC Press, Inc. Retrieved from http://www.cabdirect.org/abstracts/19901453366.html.

Santos Jr, A. A., Ferket, P. R., Grime, J. L., & Edens, F. W. (2004). Dietary supplementation of endoxylanase and phospholipase for turkeys fed wheat-based rations. *Int. J. Poult. Sci*, *3*(1), 20–32.

Sarcicek, B. Z., Klc, U., & Garipoglu, A. V. (2005). Replacing soybean meal (SBM) by canola meal (CM): The effects of multi-enzyme and phytase supplementation on the performance of growing and laying quails. *Asian Australian Journal of Animal Sciences*, *18*(10), 1457.

Savage, T. F., Nakaue, H. S., Holmes, Z. A., & Taylor, T. M. (1986). Feeding value of yellow peas (Pisum sativum L. Variety Miranda) in market turkeys and sensory evaluation of carcasses. *Poult. Sci.*, *65*(7), 1383–1390.

Séralini, G.-E., Clair, E., Mesnage, R., Gress, S., Defarge, N., Malatesta, M., de Vendômois, J. S. (2012). Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize. *Food and Chemical Toxicology*, *50*(11), 4221–4231.

Sharma, S., Yadav,, N., Singh, A., & Kumar, R. (2013). Nutritional and antinutritional profile of newly developed chickpea (Cicer arietinum L) varieties. *International Food Research Journal*, *20*(2), 805–820.

Singh, U. (1988). Antinutritional factors of chickpea and pigeonpea and their removal by processing. *Plant Foods for Human Nutrition*, *38*(3), 251–261.

Smith, J. M., & Hogue, M. (2009). American Academy of Environmental Medicine Calls for Immediate Moratorium on All Genetically Modified Foods. Retrieved from http://www.nutris.net/_documents/aktuality_GM_plodiny.doc.

Sramková, Z., Gregová, E., & \vSturdík, E. (2009). Chemical composition and nutritional quality of wheat grain. *Acta Chimica Slovaca*, *2*(1), 115–138.

Sullivan, T. W., & Gleaves, E. W. (1977). G77-386 Wheat in Poultry Rations. *Historical Materials from University of Nebraska-Lincoln Extension.* paper1295.

Swanson, N. (2013). Genetically Modified Organisms and the deterioration of health in the United States. Retrieved from http://people.csail.mit.edu/seneff/glyphosate/NancySwanson.pdf.

Taylor, M. L., Hartnell, G. F., Riordan, S. G., Nemeth, M. A., Karunanandaa, K., George, B., & Astwood, J. D. (2003). Comparison of broiler performance when fed diets containing grain from roundup ready (NK603), yieldgard x roundup ready (MON810 x NK603), non-transgenic control, or commercial corn. *Poult. Sci.*, *82*(3), 443–453.

Taylor, M., Lucas, D., Nemeth, M., Davis, S., & Hartnell, G. (2007). Comparison of broiler performance and carcass parameters when fed diets containing combined trait insect-protected and glyphosate-tolerant corn (MON 89034$\times$ NK603), control, or conventional reference corn. *Poult. sci*, *86*(9), 1988–1994.

Torki, M., Karimi, A. (2007). Evaluation of dietary replacement of soybean meal by chickpea supplemented by enzymes on performance of broiler chicks. *16th European Symposium on Poultry Nutrition*.

Tudisco, R., Mastellone, V., Cutrignelli, M. I., Lombardi, P., Bovera, F., Mirabella, N., Infascelli, F. (2010). Fate of transgenic DNA and evaluation of metabolic effects in goats fed genetically modified soybean and in their offsprings. *Animal: an International Journal of Animal Bioscience*, *4*(10), 1662.

Tuoying, A. (2005). Exogenous enzymes and organic acids in the nutrition of broiler chicks: effects on growth performance and in vitro and in vivo digestion. Ph.D. Thesis, University of Kentucky.

United States Department of Agriculture. (2013). Adoption of Genetically Engineered Crops in the U.S. Retrieved from http://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us/recent-trends-in-ge-adoption.aspx#.UoAoduJjHW0

Vecchio, L., Cisterna, B., Malatesta, M., Martin, T. E., & Biggiogera, M. (2009). Ultrastructural analysis of testes from mice fed on genetically modified soybean. *European Journal of Histochemistry*, *48*(4), 449–454.

Verma, C., Nanda, S., Singh, R. K., Singh, R. B., & Mishra, S. (2011). A review on impacts of genetically modified food on human health. *Nutr. Journal*, *4*, 3–11.

Vidal-Valverde, C., Frias, J., Hernandez, A., Martin-Alvarez, P. J., Sierra, I., Rodriguez, C.,Vicente, G. (2003). Assessment of nutritional compounds and antinutritional factors in pea (Pisum sativum) seeds. *Journal of the Science of Food and Agriculture*, *83*(4), 298–306.

Wang, Z. R., Qiao, S. Y., Lu, W. Q., & Li, D. F. (2005a). Effects of enzyme supplementation on performance, nutrient digestibility, gastrointestinal morphology, and volatile fatty acid profiles in the hindgut of broilers fed wheat-based diets. *Poult. Sci*, *84*(6), 875–881.

World poultry. (2012). Methionine rule affects organic poultry farmers. Retrieved from http://www.worldpoultry.net/Broilers/Markets--Trade/2012/2/Methionine-rule-affects-organic-poultry-farmers-WP009979W/.

Wu, A. H., Wan, P., Hankin, J., Tseng, C.-C., Mimi, C. Y., & Pike, M. C. (2002). Adolescent and adult soy intake and risk of breast cancer in Asian-Americans. *Carcinogenesis*, *23*(9), 1491–1496.