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Donald R. Kill for the degree of Master of Science in Poultry Science presented on December 15, 1989

Title: Reproductive Performance of Dwarf Breeder Pullets Fed Yellow Peas (Pisum sativum L. var. Miranda)

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An experiment was conducted to determine the suitability of a new variety of yellow pea *(Pisum sativum L.*, var. Miranda) as a feed ingredient in broiler breeder diets. Two-hundred twenty-five I S A Vedette dwarf broiler breeder pullets were fed either a corn-soy (CS) or corn-pea (CP) diet from day of age to 46 weeks of age . Diets were formulated to be isonitrogenous and isocaloric and were supplemented with D,L-methionine. Treatment groups were reared in adjacent floor pens from day of age to 22 WOA. Following selection based upon uniformity of body weight, Thirty-two pullets from each dietary treatment were placed in individual cages and photostimulated.

With the initiation of lay, the following variables were measured: hen-day egg production, egg weight, fertility and hatchability of fertilized eggs. Body weight gain was controlled by restricted feeding, as had been done prior to initiation of lay. No differences were observed ($p>.05$) in the reproductive parameters measured. Mortality was negligible in either treatment group. This work demonstrates

that the Miranda variety of field pea, which can be grown in the Willamette Valley, can be used as an alternative feed ingredient for dwarf broiler breeder pullets.

Reproductive Performance of Dwarf Breeder Pullets Fed Yellow Peas *(Pisum sativum L.* var. Miranda)

By

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To Jill: My kindered spirit

There has been no period in my life
more fruitful and at the same time more
painful. We have shared the pain and
we will share the fruit.

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CHAPTER I

INTRODUCTION

Development of alternative grain and feed sources for use in poultry diets is essential to the Pacific Northwest because the region lacks the climatic condition necessary for growing corn and soybeans, the two primary feed ingredients used in poultry diets. Choosing the correct alternative feed ingredient depends upon availability, palatability, acceptability, industry testing and ultimately economics. The following are some of the alternative feeds that have been cited recently in the journal, Poultry Science.

Hatchery Waste	Lactifern	Earthworm Coke Protein
Citrus Pulp	Sprouted Barley	Shark By-Products
Maize Bran	Rice Bran	Corn Fermentation Soluables
Sea Weed	Sorghum	Shrimp By-Products
Citrinin	Cottonseed Meal	Leaf Protein of Hardwood Trees
Hog Hair Meal	Activated Sludge	Leaf Protein of Pulse Crops

(Alternative feedstuffs continued)

Sunflower Meal	Blood Waste	Cassava Leaf Meal
Rapeseed Meal	Wheat	Dried Poultry Waste
Banana Chips	Pigeon Peas	Ammoniated Mustard Meal
Brazilian Elochea	Canola Meal	Palm Kernal Cake
Catfish By-Products Meal	Jimson Weed	Poultry Offal Meal
Triticale	Safflower	Canola Meal

Some of these alternative feed ingredients are traditional components of animal or human diets while others are food industry by-products. The common pea *(Pisum sativum)* is a traditional human food that has had limited use in animal agriculture. Pea production is well-suited to the climate of the Pacific Northwest of the United States and shows great potential as an alternative feed for laying hens and turkeys. Therefore, the purpose of this research is to test the efficacy of feeding the Miranda variety of field pea to dwarf broiler breeder pullets.

CHAPTER II

REVIEW OF LITERATURE

A. HISTORY

The origin of dry peas can be traced to Central Asia where estimated dates of the first domestication vary from 9000-5000 B.C. (U.S. Dry Pea and Lentil Council, 1988). Peas were cultivated by the ancient Greek and Roman cultures, which introduced the crop throughout their empires. The famous voyage of Christopher Columbus in 1492 brought peas to the North American continent (Makasheva, 1983). It is believed that peas were originally eaten in the mature or dry form but in recent centuries the immature form has achieved great status (Janick *et al.*, 1974).

B. TAXONOMY

Pisum sativum, a diploid (2n = 14), is the familiar "Green Pea", "Common Pea", or "Garden Pea". *Pisum sativum,* belongs taxonomically to the family Leguminosae, subfamily Pipilionoides, and tribe Vicieae (Kupicha, 1981). There are many species and subspecies based on phenotypic differences that are mentioned in the literature. The current trend is to view *Pisum* as a monospecific group because of its mutual crossability and fertility (U.S.D.A., 1983).

C. CHEMICAL COMPOSITION OF PEAS

The composition of peas is varied and can be affected by agronomic practices. Peas contain between 9 and 15% (w/w) water, 18 and 35% (w/w) protein, 24 and 60% (w/w) carbohydrate, 0.6 and 1.5% (w/w) lipids, 2 and 10% (w/w) cellulose, and 2 to 4% (w/w) minerals (Makasheva, 1983). Soil nitrogen, moisture conditions, cultivation practices, and cultivar differences account for the wide range in chemical make-up (Ali-Khan and Young, 1973; McLean *et al.,* 1974).

1. Protein

Peas, like other legumes, have a symbiotic relationship with nitrogen fixing bacteria. Because of this, peas are able to accumulate two to three times more protein than other cereals.

Variations in nitrogen, protein, and the amino acid profile of peas have been attributed to cultivar or genotype (Bajaj et al., 1971; Ali-Khan and Youngs, 1973; Pandey and Gritton, 1975; Holt and Sosulski, 1979), environment or location (Holt and Soluski, 1979), cultivar x location interaction (Ali-Khans and Youngs (1973), maturity of the plant (Pandey and Gritton, 1975), presence or absence of nitrogen fixing bacteria (McLean *et al.*, 1974), and nitrogen and phosphorus fertilization (Sosulski *et al.*, 1974). Bajaj *et al.* (1971) reported no correlation between protein content and protein quality. Holt and Soluski (1979) as well as Evans and

Boulter (1980) reported a negative correlation between sulfur amino acid content and pea seed protein.

In determining the protein content of peas, Holt and Soluski (1979) recommended using a 5.25 nitrogen to protein (N:P) factor rather than the normally accepted 6.25 N:P ratio. Pandy and Gritton (1975) state that about 10% of N is non-protein nitrogen and that the Kjeldahl method of estimating protein is not applicable for peas.

2. Carbohydrates

Pea seeds have a total carbohydrate content that ranges between 60 and 67% (Cerning-Beroard and Filiatre, 1976). Starches comprise 20 to 50% of the carbohydrates, sugars another 4 to 10% with hemicellulose, cellulose, pectins and pentoses comprising the remainder (Makasheva, 1983). The principal starch constituents in peas are in the form of amylopectin or amylose (Baily and Boulter, 1971; Makasheva, 1983). Verbascose, starchyose, sucrose, and raffinose are predominant sugars with arabinose being present in certain pea varieties (Cerning-Beroard and Filiatre, 1976).

3. Fat

Peas contain from 1 to 1.3% fat (U.S. Dry Pea and Lentil Council, 1988). Triglycerides represent approximately 90% of the total lipids and linoleic acid constitutes 50% of the total fatty acids (Grosjean, 1985).

4. Vitamins and Minerals

The National Research Council (1984) itemized the vitamin content for field peas (*Pisum sativum*) as the following:

Vitamin	Concentration (mg. per kg)
Biotin	0.18
Folic Acid	0.40
Pantothenic Acid	10.00
Riboflavin	2.30
Choline	642.00
Niacin	34.00
Pyridoxine	1.00
Thiamin	7.50
Tocopherol	3.00

Phosphorus and calcium constitute 79% of the total minerals in dry peas, with iron, sulfur, magnesium, copper, silicon, chlorine, sodium, and zinc comprising the bulk of the remaining 21%.

5. Antinutritional Factors

a. Protease Inhibitors

Legumes and all common cereal grains contain trypsin inhibitors (Cheeke and Shull, 1985). The role of these inhibitors in the plant may be to restrict the activity of insect and bacterial proteases. Unfortunately, these trypsin inhibitors can affect animal performance when raw beans are included in diets. The effect of trypsin inhibitors on monogastric nutrition is well documented. The antinutritional effect is limited to raw peas, i.e. heat treated peas have no adverse effect. Field peas (*Pisum sativum*) have been reported to contain one-tenth of the trypsin inhibitory activity (TIA) of soybeans which contain from 2.5 to 13 TIA per gram (Grosjean, 1985; Weder, 1981). Chymotrypsin inhibitors have also been found in field peas (*Pisum sativum*). The inhibitory activity ranges from 8 to 15 chymotrypsin-inhibiting activity (CTIA) per gram.

b. <u>Hemagglutinins (Lectins)</u>

Lectins are proteins or glycoproteins present in plants and invertebrate animals. These molecules bind specifically to glycoproteins or other carbohydrate groups on cell surfaces (Lehninger, 1982, Bohinski, 1983). The presence of lectins in animal diets can cause various adverse effects such as reduced growth, diarrhea, decreased nutrient absorption and an increased incidence of bacterial infections (Cheeke and Shull, 1985). Most legume seeds, including peas (*Pisum sativum*), contain heat-labile lectins.

Lectins are capable of agglutinating a variety of cell types (Jaffe, 1980; Toms, 1981). This ability is expressed as hemagglutinating activity (HU) per gram of seed or plant material. Activity measurements are standardized through the use of rabbit erythrocytes. In green peas (*Pisum sativum*), the HU activity has been measured to be about 80 units per gram while beans such as *Phaseolus vulgaris* contain between

8000 and 155,000 HU (de Muelenaere, 1965). Davidson (1980) found that hemagglutinin activity is low in peas as compared to kidney beans and that dry heating of peas for 50 seconds at 165 C lowered the HU activity further. In a subsequent report, Davidson (1981) noted that soaking peas (*Pisum arvense)* prior to boiling did not destroy the HU activity.

c. Tannins

Tannins are another plant substance that have the ability to precipitate digested proteins, bind with digestive enzymes, which inhibits their action, and have an astringent action upon mucous membranes. Such effects can have adverse nutritional consequences (Cheeke and Shull, 1985). Peas contain between .06 and .35% tannins depending on the variety (Griffiths, 1983). The quantitative effects of pea tannins in poultry diets have not been demonstrated conclusively.

D. NUTRITIONAL EVALUATION OF PEAS IN POULTRY

1. Growing Chicks and Broilers

Various studies have been done describing the performance of chickens fed diets containing field peas. Petersen *et al.* (1944) concluded that Alaska field peas, when fed to growing chicks and used as the sole source of protein, were unable to support chick growth because the pea diets were deficient in methionine. Subsequent studies have confirmed these findings (Bolin *et al.*, 1946; Moran et *al.*, 1968; Goatcher and McGinnis, 1972; Reddy *et al.* 1979). Petersen *et al.* (1944) established the level of supplemental methionine necessary for chick growth to be .25% (w/w). Bolin *et al.* (1946) fed various protein supplements in an effort to complement the protein quality of ground Alaskan field peas. Casein, fish meal, dried milk, rendering plant meat meal, packing plant meat meal, oats, wheat, alfalfa, and corn all failed to support optimum growth. An increased response in growth was observed with the addition of .25% methionine to any diet.

Kienholz *et al.* (1962) fed a diet containing 93.4% Alaskan peas (*Pisum sativum*) by weight and concluded that autoclaving peas with steam improved the growth of chicks when compared to diets containing raw peas. The addition of 56, 280, and 560 ppm zinc to the pea diets also improved the growth of chicks fed the non-autoclaved peas. These researchers concluded that peas contained two antinutritional agents inactivated by steam autoclaving. They suspected that one of these factors interfered with zinc utilization.

Moran *et al.*(1968) used dry field peas (*Pisum sativum*) as the sole source of protein in 22.5% crude protein starter diets. They noted that raw, autoclaved and steam-pelleted field peas supplemented with methionine neither supported growth nor feed utilization as well as the control soybean diet when fed to chicks from one to three weeks of age. Autoclaving with dry heat or steam pelleting of peas improved the overall digestibility and nitrogen to protein utilization; however, dry heating reduced the pea's metabolizable energy. Moran *et al.* (1968) concluded that the use of peas in broiler diets, regardless of treatment, should be restricted to levels of 35% or less.

Goatcher and McGinnis (1972) significantly improved growth when antibiotics (50 ppm penicillin) were added to diets containing 53.5% raw ground Alaskan peas (*Pisum sativum*) with supplemental methionine. The improved growth was comparable to a mixed protein control diet. The addition of either methionine or penicillin to the pea diets separately, failed to improve growth. Also, neither total protein efficiency nor feed to gain ratio were influenced by the penicillin. Goatcher and McGinnis (1972) concluded that antibiotics either improved digestibility (absorption of nutrients by altering populations of intestinal microorganisms) or that the antibiotic inhibited an enzyme which may have been involved in growth inhibition.

Reddy *et al.* (1979) evaluated forty-four lines of raw peas in chick diets. Three lines of peas had high concentrations of methionine as determined by chemical analysis but did not significantly improve chick growth. Supplementing the diets with .2% (w/w) D,L-methionine improved growth and the protein efficiency ratio in all lines of peas. In fact some lines of peas, when supplemented with methionine, resulted in chick performance comparable to those fed from soybean meal. Reddy *et al.* (1979) concluded that those lines of peas that yielded poor performance may have contained antinutritional agents or unavailable protein.

Kulkarni (1987) fed broiler chicks diets containing raw and autoclaved field peas (*Pisum sativum* L. var. Miranda) with and without supplemental methionine. Diets containing 25% peas did not affect performance; however, when diets contained 50% unsupplemented peas, depressed growth was observed. When these diets were supplemented with methionine or choline, equivalent performance to corn-soy diets was achieved. Autoclaving peas had no effect on broiler growth.

2. Layers

Moran *et al*. (1968) fed raw and steam-pelleted field peas (*Pisum sativum*) to laying hens. Peas were incorporated at 15 and 30% of the diets and were supplemented with 0.05% D,L-methionine. Egg production and egg weights were unaffected by treatment while feed utilization was slightly lower. Steam-pelleting improved feed utilization at both dietary levels of peas evaluated.

Lindgren (1975) used three different varieties of dry cooked peas (*Pisum sativum*) in layer rations and found that egg production was not affected. However, Lindgren (1975) observed a negative correlation between tannin content of the pea variety and protein digestibility.

Davidson (1980) fed field peas (*Pisum sativum*) to laying hens, these peas were either raw or were dry heated with infrared radiation. Diets containing raw peas depressed egg production by one-half when compared with a fishmeal control diet. Heating or adding methionine to the raw pea diet increased egg production. However, only when peas were heated and methionine added was full egg production achieved. Egg weight was improved with the addition of methionine to the raw pea diet but was less than that observed with the control diet. Heating the peas had no effect on egg weight. Davidson *et al.* (1981) fed forage peas (*Pisum arvense*) to laying hens. These peas were either raw or soaked and boiled. Davidson (1981) found forage peas to be low in methionine, like field peas. Even though supplemental methionine improved the performance of layers fed raw peas, performance was poorer than that observed with a fishmeal control diet. Heat treatment of peas neither affected egg weight nor egg production. Therefore, Davidson *et al.* (1981) inferred the presence of an heat stable antinutritional factor. Ivusic (1989) demonstrated that field peas (*Pisum sativum* L. var. Miranda) could replace up to 100% of the soybean meal protein in practical laying rations without affecting performance.

3. Turkeys

Savage and Nakaue (1987) evaluated the reproductive performance of turkey breeder hens fed a corn-yellow pea diet containing the Miranda variety of field pea (*Pisum sativum* L.). These researchers showed that 100% of the soybean meal in the diet could be replaced by field peas with no adverse effects on reproductive performance. Hen day egg production and feed utilization were significantly ($P<.05$) improved for hens fed the pea diet. Savage *et al.* (1986) fed the Miranda field pea to market turkeys at 25 and 55% of starter and finisher diets, respectively, and observed no detrimental effect on growth, feed utilization, or cooked meat quality.

E. DWARF (dw) BROILER BREEDERS

The sex-linked dwarf (dw) gene in dwarf broiler breeder pullet is pleiotropic to many morphological and physiological characters. For example the dwarf gene affects skeletal development by restricting the growth of long bones (Hutt, 1959) and reduces body weight. Mature breeder pullets are approximately 70% of the size of the standard broiler breeder pullet. This difference in size provides the potential for reducing the cost of producing broiler hatching eggs because of increased feed efficiency (Bernier and Arscott, 1971; Waldroup and Hazen, 1976). Dwarf breeder pullets have also been shown to perform well in cages and caged layers may be artificially inseminated (Strain and Piloski, 1975; Lin *et al.*, 1979; Leeson and Summers, 1985). While artificial insemination is labor intensive, it affords the exclusive use of select sires.

A limitation of the dwarf gene in breeder pullets is the reduction of egg size and resulting small chick at hatch (Whiting and Pesti, 1983). The influence of the initial low chick weight on growth rate of the fowl is well documented. However, when egg weight is expressed as a percentage of body weight, dwarfs lay larger eggs than their normal counterparts (Jaap, 1971; Polkinghorne and Harvey 1980; Proudfoot, 1982; Smith, 1984).

The dietary requirements and management of the dwarf breeder pullet are inconclusive. Typically, the practice of restricting nutrient intake of broiler breeder hens begins at 14 days of age. A similar management practice cannot be applied to the dwarf broiler breeder pullet. Leclercq and Blum (1971, 1975) demonstrated that the reduced performance induced by early feed restriction is tied to the *dw* gene and recommended that feed restriction of dwarf broilers be delayed. After six weeks of age the *dw* pullets can be feed restricted as much as *DW* hens. During the laying period, *dw* pullets consume 10-36% less feed per dozen eggs. Apart from egg size, reproductive performance appears to be unaffected by feed restriction.

CHAPTER III

REPRODUCTIVE PERFORMANCE OF DWARF BREEDER PULLETS FED YELLOW PEAS *(PISUM SATIVUM L. VAR. MIRANDA)*[1]

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ABSTRACT

An experiment was conducted to determine the suitability of a new variety of yellow pea *(Pisum sativum L.,* var. Miranda) as a feed ingredient for dwarf broiler breeder pullets. Two-hundred twenty-five I S A Vedette dwarf broiler breeder pullets were fed either corn-soy (CS) or corn-pea (CP) diets from day of age to 46 weeks of age. Diets were isonitrogenous, isocaloric and supplemented with D,L-methionine. Treatment groups were reared in adjacent floor pens from day of age to 22 weeks of age. At this age 32 pullets from each dietary treatment were selected, based on uniformity of body weight and placed in individual cages. Pullets were photostimulated by increasing the daily photoperiod from 8 to 14 hours of light.

Following initiation of lay, the following variables were measured: hen-day egg production, egg weight, fertility and hatchability of fertilized eggs. Body weight gain was controlled by restricted feeding as had been done prior to the initiation of lay. No differences were observed ($p>.05$) between the two groups for the reproductive variables measured. Mortality was negligible in either treatment group. This work demonstrates that the Miranda variety of field pea, which can be grown in the Pacific Northwest of the United States, can be used as an alternative feed ingredient for dwarf broiler breeder pullets.

INTRODUCTION

Poultry production in the Pacific Northwest requires its principal feed components, corn and soybean meal, to be transported from the Midwest. Consequently, production costs due to feed are greater in the Pacific Northwest. Development of locally grown alternative feeds could reduce feed costs, as well as regional dependency on imported grains. The yellow pea *Pisum sativum* L. also known as the field pea, can be grown in the Pacific Northwest. However, the literature regarding inclusion of peas in poultry diets is both limited and contradictory. Peterson et al. (1944) fed leghorn cockerels a diet that contained 54.5% (w/w) raw ground peas and was supplemented with methionine (RGP + M) Growth of these chicks was comparable to that of chicks fed an unspecified control diet. In contrast, Moran et al. (1968) fed broiler starter diets containing 35 and 65% RGP + M and observed a depressed rate of growth and reduced feed:gain ratio when compared to a corn-soy control diet. In the same report, the authors formulated egg type hen rations containing 15 and 30% RGP + M and noted that egg production and egg weights were not different from those of hens fed a soybean meal control diet. Anderson (1979) fed egg-type hens a 30% pea meal diet supplemented with methionine and observed similar results. However, the pea diet caused decreased shell thickness.

A promising new cultivar of field pea (*Pisum sativum* L. Variety Miranda) has been introduced into the Pacific Northwest. Savage et al. (1986) demonstrated satisfactory growth rate and feed utilization in market turkeys fed diets containing 25 to 55% RGP + M. Ivusic (1989) concluded that the Miranda variety of field pea can replace 100% of the soybean meal protein in layer rations without affecting performance. This report describes an experiment in which dwarf broiler breeder pullets were fed a diet containing the Miranda variety of yellow pea and pullet reproductive performance was determined.

MATERIALS AND METHODS

Two hundred and twenty five day old I S A Vedette dwarf breeder pullets were wing banded and randomly assigned to one of two dietary treatment groups, a conventional corn-soy (CS) control or corn-yellow pea (CP). Both CS and CP diets were isonitrogenous, isocaloric, and prepared to the breeders recommendations,[1] (Table III. 1). The CP diets were prepared by grinding whole peas prior to mixing with other feed ingredients. Treatment groups were reared in adjacent pens containing wood shavings for litter. The daily photoperiod from day-old to 22 weeks of age (WOA) was 8L:16D. All birds were weighed weekly, mean body weights compared to the breeder's recommended standards, and the feed for the subsequent ages adjusted per the breeder's recommendations. The feeding program consisted of a 17% crude protein starter diet fed ad libitum for the first 5 weeks. This diet was then provided on an every-other-day basis until pullets were 8 weeks of age. From 9 to 27 WOA, all birds were fed 15.4% crude protein developer rations.

At 22 WOA, 32 pullets were selected from each treatment on the basis of comparable body weights. These birds were housed in individual cages (30.5 x 45.7 x 35.6 cm) within a windowless, positive pressure environmentally controlled house. The pullets were shifted to a 14L:10D daily

1 I S A Vedette Management Program, 1985

photoperiod. Water was provided during eight 15-minute periods at 2 hour intervals during the light period. Pullets were kept on the every-other-day feeding schedule and were weighed biweekly. At 25 WOA, feed was provided on a daily basis. At 28 WOA, dietary protein was increased to 16% and maintained at this level until the termination of the study (46 WOA).

Individual egg production was recorded daily. Egg weights were determined at 32, 36, 40 and 44 WOA. Hens were artificially inseminated at 35, 37, 41 and 45 WOA with 0.05 ml of pooled broiler breeder male semen. Eggs were collected for 4 consecutive days after the second day following insemination. Hen-day egg production, egg weight, fertility, and hatchability of fertilized eggs, were analyzed by analysis of variance (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The effect of feeding a diet containing yellow peas on dwarf broiler breeder performance is shown in Table III.2. No treatment effects ($p>.05$) were observed in hen-day egg production, egg weight, fertility or hatchability of fertilized eggs. Therefore the Miranda field pea appears to be a suitable substitute for soybean meal as a protein source in balanced rations fed to dwarf broiler breeder pullets.

The results of this study complement the work of Ivusic (1989) as well as Savage and Nakaue (1987). These researchers demonstrated that diets containing yellow peas had no detrimental effects on the egg production traits of leghorns or turkey breeder hens, respectively. These findings are of special interest in that other varieties of field peas have been reported to have undetermined nutritional deficits, which have limited the utilization of such peas in poultry diets. It appears that the Miranda variety of yellow pea can adequately support egg production.

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Table III.1 Composition of the dwarf breeder pullet diets from 0 to 46 weeks of age (WOA)

Ingredients	Starter(0-8 WOA)		Developer(9-27 WOA)		Breeder(28-46 WOA)	
	CS	C-YP	CS	C-YP	CS	C-YP
Corn, yellow	46.10		49.00	30.80	61.21	12.40
Yellow pea		85.00		60.00		66.09
Soybean meal, 47.5% CP	23.20		12.50		20.36	
Barley, Pacific Coast	25.00		25.00		7.00	5.00
Alfalfa meal, dehy. 17% CP	2.50		2.50		2.50	2.50
Deflourinated phosphate 32% Ca; 18% P	2.12	1.90	.50	1.75	1.90	1.97
Limestone flour	.48	.55	.05	.60	3.25	3.39
Oystershell flour					3.25	3.37
D,L Methionine, 98%	.05	.40	.05	.25	.03	.28
Salt, iodized	.30	.25	.25	.25	.25	.25
Vitamin premix[1]	.20	.25	.15	.25	.20	.20
Trace mineral premix[2]	.05	.05	.05	.05	.05	.05
Safflower oil						1.00
Animal fat, stabilized		6.00				3.50
Meat and bone meal, 50%			5.00			
Sand, silicate (#70 grade)		5.60	4.95	6.05		
Calculated analysis						
Crude protein, %	17.7	18.0	15.4	15.4	16.2	15.9
Met. Energy, kcal/kg	2822	2833	2761	2763	2802	2798
Calcium, %	1.00	.87	.86	.83	3.20	3.28
Available phosphorus, %	.50	.45	.48	.42	.45	.47
Lysine, %	.89	.93	.74	.72	.78	.78
Methionine, %	.33	.46	.29	.35	.30	.36
Methionine + cystine, %	.64	.70	.56	.57	.58	.58

[1] Supplied per kilogram of C-S starter feed: vitamin A, 3300 IU; vitamin D, 1100 ICU; riboflavin, 3.3 mg; d-pantothenic acid, 5.5 mg; niacin, 22 mg; choline, 191 mg; vitamin B_{12}, 5.5 mcg; vitamin E, 1.1 IU; vitamin K, .55 mg; folacin, .15 mg.

[2] Supplies per kilogram of feed: calcium, 97.5 mg; manganese, 60 mg; iron, 20 mg; iodine, 1.2 mg; zinc, 27.5 mg; cobalt, .02 mg; copper, 2 mg.

Table III.2 The effects of corn-soy and corn-pea diets on dwarf broiler breeder pullet body weight gain, hen day egg production, mean egg weight, fertility, and hatchability of fertilized eggs[1]

DIETARY TREATMENT	BODY WEIGHT[2] GAIN	HEN DAY EGG PRODUCTION[3]	EGG WEIGHT[4]	FERTILITY[5]	HATCHABILITY OF FERTILIZED EGGS[5]
	(kg)	(%)	(g)	(%)	(%)
Corn-Soy	.578 ± .104	62.90 ± .96	62.05 ± 2.77	93.36 ± 8.75	96.74 ± 6.22
Corn-Pea	.556 ± .061	62.80 ± 1.31	61.76 ± 3.22	89.48 ± 11.14	95.97 ± 6.56

1 Means ± SEM.

2 22 to 45 weeks of age (WOA).

3 25 to 45 WOA.

4 Measured at 32, 36, 40 and 44 WOA.

5 Measure at 35, 37, 41, and 45 WOA.

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CHAPTER IV

GENERAL DISCUSSION

Field peas *(Pisum sativum L.)* show great promise as an alternative feed for poultry diets in the Pacific Northwest. The present work demonstrates that the Miranda variety of field pea, which can be grown locally in the Willamette Valley, can support dwarf broiler breeder growth and reproduction.

Three considerations must be taken into account when field peas are fed to poultry: 1) the type of bird, 2) the pea variety, and 3) least cost diet formulation. Broiler breeders, laying hens, market turkeys and turkey breeder hens have performed well when fed diets containing field peas. In contrast, broilers have performed poorly. The presence of growth inhibiting substances or low protein availability may selectively affect broilers because of their rapid growth rate. Slinger *et al*. (1964) demonstrated that chickens and turkeys utilize the same feedstuffs in a dissimilar manner, suggesting that a species difference may exist in digestion.

Different breeding lines of field peas vary in protein availability, amino acid profile, metabolizable energy and content of antinutritional agents. Obtaining a thoroughly tested variety of field pea with well defined parameters is paramount. When the cost of a kilogram of utilizable protein from field peas is comparable to or less than that of utilizable protein from soybean meal, peas can be economically incorporated in selected poultry diets.

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APPENDICES

APPENDIX 1

THE EFFECTS OF CORN-SOY OR CORN-PEA DIETS ON DWARF BROILER BREEDER PULLET MEAN EGG WEIGHT BETWEEN 25 AND 45 WEEKS OF AGE

The following appendix gives mean egg weights over the experimental period. Mean egg weights are provided for 32, 36, 40 and 44 weeks of age in Table A1.1.

Table A1.1 Egg weights from dwarf broiler breeder pullets fed either a corn-soy or corn pea diet

Dietary Treatment	Replicate	Egg Weight (g)[1] by Week of Age[2]			
		32	36	40	44
Corn-Soy	1	59.8 ± 1.2	60.8 ± 1.2	63.9 ± 1.0	64.9 ± 1.2
	2	58.9 ± 0.8	61.3 ± 0.6	62.4 ± 1.0	64.3 ± 1.0
Corn-Pea	1	58.0 ± 1.1	60.5 ± 1.2	62.8 ± 0.7	65.5 ± 0.9
	2	58.1 ± 0.6	60.3 ± 0.7	63.1 ± 0.7	65.7 ± 0.3

[1] Grand mean ± SEM.

[2] A significant ($P < .001$) effect of time was observed.

APPENDIX 2

COMPARISON OF CORN-SOY AND CORN-PEA DIETS ON EGG PRODUCTION, EGG WEIGHT, FERTILITY AND HATCHABILITY OF FERTILIZED EGGS IN DWARF BROILER BREEDER PULLETS BETWEEN 22 AND 45 WEEKS OF AGE

This appendix provides analysis of variance tables for egg weight, hen-day egg production, fertility and hatchability of fertilized eggs.

Table A2.1 Analysis of variance for egg weights at 32, 36, 40 and 44 weeks of age of dwarf broiler breeder pullets fed either a corn-soy or corn-pea diet

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio	Significance Level
Diets	1.300	1	1.300	.412	NS
Periods	371.924	3	123.975	39.332	<.001
Interaction	11.285	3	3.762	1.194	NS
Residual Error	176.518	56	3.152		
Total	561.026	63			

NS = P > .05

Table A2.2 Analysis of variance for hen-day egg production of dwarf broiler breeder pullets between 25 and 45 weeks of age and fed either a corn-soy or corn pea diet

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio	Significance Level
Diets	.0287	1	.0287	.001	NS
Residual	1987.9757	62	32.0641		
Total	1988.0043	63			

NS = P > .05

Table A2.3 Analysis of variance for fertility[1] of dwarf broiler breeder pullets measured at 35, 37, 41, and 45 weeks of age fed either a corn-soy or corn pea diet

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio	Significance Level
Main Effects	796.76	6	132.79	.923	NS
Group[2]	456.24	3	152.08	1.057	NS
Set[3]	340.52	3	113.51	.789	NS
Residual	8204.40	57	143.93		
Total	9001.17	63			

1 The arc sine transformations of percentages of fertilized eggs were analyzed.

2 Defined as 16 pullets housed in consecutive cages within a single bank of cages and fed a common diet.

3 Defined as a point in time at which eggs were incubated. Eggs were set when pullets were 35, 37, 41, and 45 weeks of age.

NS = P > .05

Table A2.4 Analysis of variance for hatchability of fertilized eggs measured at 35, 37, 41, and 45 weeks of age

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio	Significance Level
Group[1]	624.87	3	208.29	1.655	NS
Residual	5535.96	44	125.82		
Total	6160.83	47			

[1] Defined as 16 pullets housed in consecutive cages within a single bank of cages and fed a common diet.

NS = P > .05