REVIEW OF LITERATURE

Productive energy, as determined by Fraps and frequently referred to in American literature, is a modified net energy determination but recent studies have shown the values to be very unreliable and their use is not recommended. Metabolizable energy which has a relatively constant value in poultry and is relatively easy to determine, is the energy value of feeds for poultry (Anonymous, 1959). Morrison (1959) stated that metabolizable energy can be determined more easily than productive energy values.

The literature concerning the effects of different dietary energy levels in the nutrition of laying hens is still limited; however, the majority of the work has shown that energy level of the laying ration influences egg production. Ewing (1963) reported that Hauser and co-workers were among the first to show that rations low in fiber content supported a higher rate of egg production than similar rations high in fiber content, while Singsen et al. were others who found that rations high in energy value have higher efficiency than rations low in energy value. High energy diets tend to improve egg size and feed utilization efficiency, and within limits they
decrease the cost per unit of energy and reduce handling costs because of their decreased bulk (Anonymous, 1972).

Hill et al. (1956) reported that during winter the highest rate of production was obtained from the flock fed a high energy ration and the lowest was on a low energy ration. During autumn, spring and summer egg production was not affected by the energy level of the ration.

McIntyre and Aitken (1957) found that when they fed laying hens with high energy rations which supplied about 900 kcal of productive energy per lb and low energy rations which supplied slightly over 700 Kcal per lb in the first period and then in the second 840 Kcal per lb; the energy content of the ration had no effect on egg production.

Pepper et al. (1959) also found that egg production was not affected by the energy content of the ration, nor was feed efficiency. The energy content of the rations in the trial were 916, 929, 944 and 973 Kcal of productive energy per lb for the high energy ration, and 872, 874, 877, 879 kcal of productive energy per lb for the low energy rations. Petersen et al. (1960) reported that the low energy ration in crumbled form which supplied 650 kcal of productive energy per lb maintained as good egg production as high energy ration which supplied 910 kcal of productive energy per lb in the form of mash or crumbles.
In the work of McIntyre and Aitken (1957), it was shown that feed consumption per bird and per dozen eggs was significantly lower on a high energy ration. There was an increase of 11 percent in feed consumption per 100 kcal decrease in productive energy. Bolton (1958) stated that feed intake was regulated by the energy content of the ration. MacDaniel et al. (1959) reported that feed required per dozen eggs decreased as the energy of the ration increased. Petersen et al. (1960) found that feed consumption was more when the ration had low energy, it was also more when the ration was crumbled. Hughes (1967) stated that the reduction in feed intake has been estimated at 6% for each six degrees F. temperature rise. Shutze (1959) reported that feed intake is influenced by body weight, stage of production, environmental temperature, housing/cage or floor pens, energy content of diet and strain of bird. Phelps (1970) stated that layers with different genetic backgrounds require rations individually tailored to their laying potential and physical characteristics. Small bodied Leghorns need rations with a fairly high nutrient density to compensate for their small appetites, but such rations would be wastefully over-consumed by big-bodied brown-egg layers. Though the layer's feed intake tends to decrease as the energy level of the diet is increased, their ability to adjust feed consumption to maintain a constant daily intake of energy is limited and overconsumption occur (Anonymous, 1972). According
to Krautmann (1972) nearly all of the increased feed intake associated with lower temperature is due to greater energy needs to keep the bird warm. If the temperature at about 27°C can be maintained most of the time, considerable amounts of feed can be saved.

Wilson (1948) and Wilson et al. (1957) found that an increase of environmental temperature caused an increase in water consumption. Fox (1951) reported that the White Leghorn breed drank more water in hot weather than the Rhode Island Red and New Hampshire breeds. Jull (1949) stated that a hen in first year production which laid 180 - 240 eggs consumed 130 - 180 lb of water. It took about 9 lb of water to produce a dozen eggs. Tyler (1958) reported that the pattern of eating and drinking differed widely among individuals, but the individuals did not differ from day to day. There was a highly significant positive correlation between total intake of water and water excreted in eggs and feces. Water intake did not seem to be related to dry matter intake under the condition of the trial, but was significantly related to temperature. The amount of water drunk per gram of feed consumed ranged from 2.1 - 2.6 milli-liters for all ages with exception of the 32 week-old laying hens, where the amount was 3.6 ml per gram of feed. This increase in water consumption was believed to be due to the water lost in the egg (Medway and Kare, 1959).
Winter and Funk (1956) stated that there is a relation between the energy need and the percentage of protein needed in a ration for poultry. Olson et al. (1961) found that the best diet for laying hens was that with 14 percent protein and ratio of kcal metabolizable energy per lb to percentage of protein of 94 : 1.

McDaniels et al. (1957) showed that in various strains of layers combined efficiency of feed conversion was improved in increasing the energy of the ration; with 17 percent protein the increase of efficiency for an increase of 88 kcal of productive energy was 0.59 lb feed per dozen egg produced. With 18 percent protein the figure was 0.39 lb. For an increase of one percent protein, feed required per dozen decreased 0.1 lb. Miller et al. (1957) found that there was no improvement of egg production by giving 5 protein levels from 12.5 to 20.9 percent with 3 levels of energy in which the ratio of productive energy to protein in the rations varies from 31 to 86. As the energy content of the ration increased, less feed was required per dozen eggs when the protein level was over 14 percent. By feeding rations containing 16 or 17 percent protein with productive energy 937, 970 or kcal per lb, to six groups of six month old laying Single Comb White Leghorn pullets Prince et al. (1957) also showed that the level of either protein or energy didn't significantly affect rate of egg production.
Feed consumption per dozen eggs produced decreased as the energy value of the diet increased. The overall improvement of feed efficiency with increase of energy was 14.8 percent. Hochreich et al. (1958) fed rations containing 15.7, 17.0 or 18.35 percent protein, each without or with 6.6 percent stabilised yellow grease added, and with productive energy values of the unsupplemented rations at 974, 958 and 1049 kcal per lb. Egg yield was not affected by adding fat at any level of protein but was significantly higher when protein level was higher. By feeding various diets containing 15, 20 and 25 percent which supplied 750 or 960 kcal of productive energy, McDaniel et al. (1959), did not observe an effect on egg production, but feed required per dozen eggs decreased as the energy of the ration increased. Roblee et al. (1959) fed groups of turkey breeding hens during the hatching season on one of 6 rations supplying 70, 79 or 88 therms of productive energy per 100 lb, and either 15 or 17% protein. Rate of egg production and fertility and hatchability of eggs were not affected by energy or protein levels of the rations. As the energy content of the ration increased there was roughly proportional increase of intake of energy with both levels of protein; it suggested that breeding turkeys, unlike chickens, don’t eat primarily to satisfy their energy requirement. Increase of intake of productive energy did not give a
proportionate decrease of amount of feed per dozen eggs produced. The finding of Frank and Waibel (1960) showed that efficiency for egg production on 12.4 and 14.9 percent protein was greater on high energy diets containing 984 to 1250 kcal of productive energy per lb.

In the work of Graham (1934), the protein intake was 12.9 percent when laying hens were fed 18 percent protein laying mash plus corn and oats. Some birds laid well on a diet containing 12 to 13 percent protein and the others required 14 to 15 percent. Heiman et al. (1936) found that by adding fish meal to the diet containing 13 percent all-plant-protein for Single Comb White Leghorn pullets, the marginal protein level for weight maintenance and egg production was 14 percent. Heuser (1936) stated that the optimum dietary protein for laying hens was 16 percent.

The optimum level of protein in the diet of laying White Leghorns as reported by Heywang et al. (1955) was 15 percent during both hot weather and relatively cool and moderate weather. Shutze (1969) reported that optimum egg weight and egg production can be obtained on protein levels ranging from 13 to 18 percent. He also stated that other studies indicate a constant 15 to 16 percent protein feed is adequate through the laying cycle. For supporting egg production, if hens are eating between 105 and 110 g per day, 15 percent protein with 0.28 percent methionine is adequate; however if hens are only eating 85 to 90 g
For Krautmann (1972), nearly all of the increased protein with 0.34 to 0.36 percent protein associated with lower temperatures is due to increased needs to keep the bird warm. If the temperatures are maintained, most of the increased protein requirement might also be reduced if a lower level of protein diet could be used for laying hens. Wilson (1948) and Wilson (1949) reported that methionine was the only amino acid deficient in a simple corn-soybean meal diet for the growth of chicks to six weeks of age, and cystine was the only amino acid deficient in a simple corn-cottonseed meal diet for growth of chicks to six weeks of age. Both vitamin B₁₂ and methionine were necessary for a maximum growth response of chicks fed a corn-soybean meal diet. In the work of Leong and McGinnis (1952), the level of methionine required for supporting egg production, body weight gain and egg size was approximately 0.28 percent in the presence of 0.25 percent cystine. The findings of Fitsimmons et al. (1963) showed that White Leghorn hens fed a diet containing 80% of ground yellow corn as the only protein bearing ingredient rapidly declined in body weight and egg production, and produced smaller eggs. By supplementing the diet with amino acids to bring the dietary total to 1.25 x the minimum requirement estimates of Johnson and Fisher 1958 or with 7.68% of an isolated soybean protein bringing total dietary pro-
tein to 13.1%, normal production was obtained. Heywang et al. (1963) found that a level of 0.41 – 0.44 percent methionine plus cystine per therm metabolizable energy per lb. was adequate for egg production under the condition of their studies. Scott et al. (1969) stated that the amino acid requirement may differ depending upon the balance of other essential amino acids in the protein being fed. The requirements of lysine, methionine or methionine and cystine of laying hens are 0.5 percent, 0.53 percent, 0.28 percent and 0.25 percent respectively (N. R. C., 1971).

Calcium and phosphorus are the minerals needed by laying hens at the highest levels. Norris et al. (1934) demonstrated that 1.5 percent dietary calcium was not sufficient for good egg production, while 1.65 percent was just adequate and 1.80 percent was found to be optimum. Evans et al. (1944) reported that hens receiving 3.0 percent calcium in the diet gave more satisfactory results than receiving higher or lower levels when egg shell thickness was used as the criterion. But a level of 2.5 percent calcium also resulted in as satisfactory production as one of 3.0 percent. Production and egg shell quality were considerably decreased when dietary calcium level was reduced to 1.0 percent. Mitchell and McClure (1937) assumed that for 50 percent production and 50 percent utilization of dietary calcium, 2.74 percent dietary calcium would be enough. Although the laying diets should contain about
2.3 percent calcium and 0.8 percent phosphorus, the requirements will vary within wide limits depending on the rate of egg production (Winter and Funk, 1956). Moistert (1960) reported that for optimum egg shell quality hens in batteries required 2.5 to 3.5 percent Ca in an all mash diet. Bergdoll (1968) stated that with certain strains of birds housed in cages and laying at rates of 80 to 90 percent, the calcium requirement would be around 3.75 percent of the total ration. He also said that birds in cages seem to have a higher requirement for calcium than do floor layers.

Summers et al. (1970) stated that the percentage of protein and calcium in a ration should vary according to the energy content of the ration. It is due to the fact that the hen eats mainly to satisfy its energy requirement. The calcium requirement of laying hens that are subjected to a temperature of 32°C (90°F) or more for several weeks is 3.0 to 3.5 percent (N. R. C., 1971).

Massengale and Platt (1930) found that with a level of 0.5 percent phosphorus in the diet fed to laying hens, as good production as could be obtained with higher levels of phosphorus. In the work of Morris et al. (1934), 0.5 percent phosphorus was found to be insufficient for maintaining normal egg production, while 0.75 percent appeared to be adequate. Miller and Bearse (1934) reported that feeding 0.8 percent dietary phosphorus resulted in
higher egg production than diets containing either more or less of this nutrient. Mitchell and McClure (1937) stated that a level of 0.32 percent phosphorus should be sufficient for a level of 50 percent production if half of the phosphorus in the diet is utilized. The findings of Titus et al. (1937) showed that there were no significant differences in production of laying hens fed 0.9 and 1.2 percent dietary phosphorus. Titus (1939) recommended that 1.0 percent of phosphorus should be included in the complete diet. Nowotarski and Bird (1943) found that the amount of phosphorus required for maximum growth and for prevention of rickets was greater than 0.5 percent and that vitamin D reduced the amount of minerals needed for best results. O'Rourke et al. (1955) reported that not more than 0.43 percent of dietary phosphorus was needed to maintain egg production at a normal level. On the basis of Nutrient Requirements of Poultry published by National Research Council 1971, the dietary phosphorus requirement of starting chickens, growing chickens, laying hens and breeding hens are 0.7 percent, 0.4 percent, 0.6 percent and 0.6 percent respectively.

In Indonesia fish meal is an available animal protein source for poultry. Bradion and Hill (1953) reported that fish meal contains an unknown growth factor or factors. Lubis (1963) stated that in Indonesia fish meal generally consists of dried small fish. It contains
about 53.3 percent crude protein. Waring (1969) stated that fish meal was an excellent source of protein and moderate source of energy. Its nutritive value was better than that of meat and bone meal. The statements of Scott et al. (1969) supported the conclusion that fish meal is an excellent source of protein for poultry because it contains adequate quantities of all essential amino acids required by chickens, and is an especially good source of lysine and methionine.

It has been shown that raw soybeans in the laying diet can be well tolerated by laying hens. Fisher and Johnson (1958) reported that supplementation of fifteen percent raw soybean protein with either a mixture of essential amino acids known to be well balanced or with egg albumen overcomes all the growth depressing activity of raw meal. Saxena et al. (1961) found that raw soybean meal when used as the sole source of dietary protein for chicks and poults, resulted in a significant growth inhibition and reduced feed efficiency. Udikartaprawira (1965) found that chicks would grow and utilize feed efficiently if a minimum of 8 percent fish meal was used to replace an equal amount of raw soybean meal in a corn soya bean diet.

Cicillo (1926) found that it may be advantageous to use
20 to 30 percent copra meal in the laying diets. The level of 30 percent copra meal appeared to be the limit. Mahadevan et al. (1957) reported that a ration containing 20 percent coconut meal, 45 percent cereal, 9 percent fish meal, 21 percent rice bran, 2 percent gingseng cake and 3 percent coupea, when adequately supplemented with vitamins and minerals provided the best balance of nutrients for economic egg production. Thomas and Scott (1962) were in agreement that fish meal and meat scraps were good supplements for copra meal in chick diets and fish meal, blood meal and torula yeast adequately supplemented the copra meal in laying ration. Good growth and feed conversion were obtained with diets containing 40% copra meal. A Cornell study indicated that a level of 40 percent of coconut oil meal could be used very successfully for both broilers and layers if the amino acids were balanced by addition of methionine and lysine or fish meal, and if fat was added to provide sufficient energy in the high coconut oil meal ration (Scott et al., 1969). Creswel and Brooks (1971) stated that the protein in coconut meal had an apparent digestibility of 50.7%. Digestibility coefficient for nitrogen free extract, ether extract and crude fiber were high in diets containing coconut meal; as a result the digestible energy content was high, 3.6 kcal per gram of feed.
According to Winter and Funk (1956), breeding, feeding, housing, diseases, and maybe other factors influence egg quality at time of production. Gowe (1956) conducted an experiment with seven strains of White Leghorns kept in batteries and floor pens. He found that egg weight was significantly different between strains and between locations. Thorton et al. (1957) reported that the supplementation of a combination of lysine and DL-methionine had a beneficial effect on egg weight with 10 and 15 percent protein but was not effective with 11 percent protein. Miller et al. (1957) fed laying hens with rations containing 12.5 to 13 percent protein and supplying 871 - 987 kcal of productive energy per pound, and found that egg weight was not affected by the energy levels used when animal protein was included in the ration. McIntyre and Aitken (1957) reported that the energy content of the ration had no effect on egg weight, specific gravity of eggs, and quality of white or incidence of blood and meat spots. In their trial, they used Barred Plymouth Rocks, White Leghorns and crossbreds. Hochreich et al. (1958) reported that protein levels did not affect egg weight, shell thickness, and the quality of albumen. Within each protein level, added fat increased egg weight but reduced shell thickness. The protein levels used in this experiment were 15.7; 17.0 and 18.35 percent. Berg and Bearse (1958) reported that
White Leghorn pullets at 28 weeks of age which had had the high protein, high energy ration to 20 weeks laid heavier eggs, but this tendency disappeared as the season advanced. Griminger and Scott (1954) fed four groups of White Leghorn pullets with four kinds of all-mash rations which differed only in the type of cereal grains employed. They found that different grains (corn, oats, wheat and mixed) did not influence egg weight, shell thickness and the standing-up quality of the egg white. The average Haugh units in the above order were 76.6; 76.5; 75.4; 76.0. Thorton et al. (1956) reported that internal egg quality as measured by Haugh units and shell thickness was not affected by the different levels of protein. In this trial they used four different all-vegetable basal rations containing 11, 13, 15 and 17% protein; each of these basal rations was supplemented with different levels of amino acids. Pepper et al. (1959) found that the quality of fresh eggs or eggs held for 14 days at 55° measured in Haugh units was not affected by either the energy content of the ration or the system of feeding. Pepper et al. (1959) found that the energy level of diets used in the growing period did not exert a consistent effect on the Haugh unit values of fresh or held eggs. Harter (1960) conducted a series of experiments to test the effect of variation in dietary treatment on the albumen quality of eggs measured with Haugh units. It
was found that there was a negative correlation between egg quality and rate of egg production.

Mueller (1959) conducted an experiment with 4 groups of White Leghorn laying pullets kept on a practical all mash ration containing 2.34 percent Ca, under the following conditions of temperature and relative humidity: 85°F and 70 percent R.H.; 55°F and 70 percent R.H.; 85°F and 25 percent R.H. and uncontrolled temperature and R.H.

He found that average shell thicknesses, including shell membrane, in the above order were 0.373, 0.400, 0.384 and 0.392 mm respectively, and all differed significantly.

Winter and Funk (1955) stated that laying hen performance in cages is slightly better than on the floor. Gore (1956) reported that laying mortality was significantly higher in pens than in batteries, and there were significant differences between strains in each location.

Egg production estimated on the basis of hen-housed and hen-day production differed significantly between strains and between location. MacIntyre and Aitken (1959) found that caged birds laid fewer and heavier eggs than birds on the same diet in floor pens and consumed less feed.

Birds in batteries are usually less active than those on the floor and, consequently, require less energy. Cage birds therefore tend to gain more weight, which is primarily fat, in contrast with birds fed the same feed in floor houses (Jensen, 1972).
Card (1962) stated that to use built-up litter may simplify the feeding problem. This is due to the fact that in the floor litter, the chicken can pick-up some products of intestinal synthesis. Snyder (1963) reported that according to the comparison of the performance of birds kept under six different systems of housing, the best performance (70% production with a 4.2 - pound feed conversion) was obtained from birds kept on the conventional floor litter system. Rate of production of colony cage layers was 6% less than the floor system and the performance of single-bird-per-cage layers was just a little less than the floor birds. Michalson (1964) said that egg production tended to be lower in cage houses than in floor houses. It is largely due to the result of cage fatigue and a higher mortality in cage houses. Feed conversion also tended to be lower in cages. Phelps (1971) stated that layers in cages produced more blood spots than birds on deep litter. Blood spots within the eggs might be due, at least partly, to modern intensive management. March and Biely (1962) subjected White Leghorn pullets to three dietary regimens under which the birds received 2.5, 7.5, and 12.5 percent of fat from the time of hatching until they were 3 years old. During the laying period, the birds were housed under the Cage system. They found the mortality from liver derangement was approximately doubled when either 7.5 or 12.5 percent of fat was fed but no
other outward effects on mortality rate were noted.

According to Phelps (1970b), the optimal floor space allowance per bird and ideal number of birds per cage can vary independently of laying strain involved, the environmental conditions, and the economic climate currently prevailing. The minimum requirement of feed trough space and floor space under a cage system for pullets of around 1800 - 2000 g in weight at point-of-lay appear to be 10 cm and 465 cm² per hen respectively (Peach, 1972).

Phelps (1970b) stated that with 90 sq. inches (30 cm²) of floor and 5 inches (12.7 cms) of trough provided for 2, 3 and 4 hens per cage, egg number did not differ significantly between those colony sizes. The hen housed production from 6 - bird cages was 5 eggs fewer than the average of the smaller colonies. With layers more densely stocked at 68 to 72 sq. inches (439 to 454 cm²) and 3 3/4 to 4 inches (9.5 to 10 cms) of floor space and feed trough, there was a consistent decline in egg output with each increase in colony size.