UTILIZATION OF YOLK AS A FEED SOURCE IN NEWLY HATCHED CHICKS WITH AND WITHOUT VITELLIN

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(ABSTRACT)

Increasing feed efficiency and early body weight gain has always been a top priority in the poultry industry. This experiment was designed to study the effects of feed sources differing in energy and protein levels as well as yolk removal on behavior, feed efficiency, energy intake, body weight and GIT growth in newly hatched chicks.

Chicks in Experiment 1, Trial 1, were White Plymouth Rock chicks from the 40th generation of a line selected for high body weight, fed either freeze dried unincubated yolk (Diet Y) or mash (Diet M-A) from day 0 to day 5, after which all chicks were fed Diet M-A. Chicks in Experiment 1, Trial 2 were males from a commercial layer stock fed either a choice of residual yolk (yolk harvested from newly hatched chicks) and unincubated yolk (Diet Y), or mash (Diet M-A) alone from day 0 to day 6, after which all chicks were fed Diet M-A. In these experiments where chicks were offered yolk as a feed source for a period of time, body weight gain was significantly reduced and mortality increased. There was evidence that Diet Y chicks, consuming a high-lipid feed, experienced decreased appetite. There were no differences in body weight between the two diet groups in Trial 1 or Trial 2 on day 0, but during the days in which yolk was fed, Diet M-A chicks maintained a weight advantage over Diet Y chicks.

Chicks used in Experiment 2 were males from a commercial layer stock. Yolk sacs were surgically removed (Trt YR) from half of the chicks while the other half remained yolk-intact (Trt YI). From day 0 to day 6, all chicks were offered a choice of residual yolk (Diet Y) or mash (Diet M-A) and beginning on day 6, all chicks were fed Diet M-A. Throughout the experiment, the Trt YI chicks maintained their body weight advantage over the Trt YR chicks, but by day 13, the Trt YR chicks gained proportionately more body weight. Because of wastage, feed efficiency and energy intake values were not reported. The only difference in GIT data was the amount of chyme; its value was higher in the Trt YI chicks than in Trt YR chicks. Behavior results showed that Trt YI chicks stood more while Trt YR chicks rested more throughout the experiment.

Chicks used in Experiment 3 were males from a commercial layer stock. This experiment consisted of 4 groups: Trt YI chicks fed Diet M-E (mash feed high in energy and protein), Trt YI chicks fed Diet M-A (mash feed lower in energy and protein), Trt YR chicks fed Diet M-E and Trt YR chicks fed Diet M-A. Serial dissections on days 6, 13 and 20 allowed for better understanding of effects of diet and/or treatment on the growth of selected parts of the GIT. On days 13 and 20, there were no differences due to diet or treatment for GIT data except for the consistent difference due to diet for relative weight of the gizzard, whose value was higher in the Diet M-A chicks. Similar to results from Experiment 2, on day 13, Trt YR chicks fed Diet M-A gained more body weight than the Trt YI chicks fed the same diet. Also consistent with Experiment 2, of chicks fed Diet M-A, the Trt YI chicks stood more than the Trt YR chicks. Due to unusually large feed consumption values, feed efficiency and energy intake data were not reported.

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INTRODUCTION

As the demand for larger, meatier, and leaner chickens increases, so does the need for producers to maximize feed efficiency as well as to sustain growth to increase final body weight. Improving growth and feed efficiency will aid in ensuring that the consumers needs are met economically. In a quest to determine what initiates and/or influences growth and feed utilization, researchers have investigated the purpose of the yolk sac and its contents, as well as factors involving its absorption and digestion. Studies have also been conducted to determine what role behavior and selection of diet play in the absorption and digestion process of yolk in newly hatched chicks.

Current research hasn't answered all of the questions concerning increased weight gain at an early age through diet manipulation. This project was designed to answer questions about feed utilization and gastrointestinal tract (GIT) maturation in newly hatched chicks when providing two different types of yolk as the feed source: residual incubated yolk (yolk removed directly from chicks at hatch), and unincubated yolk (yolk removed from unfertilized, unincubated eggs). The chemical composition of the two types of yolk were determined and fed to newly hatched chicks that differed physiologically in growth and feed utilization so that different biological responses could be studied.

REVIEW OF LITERATURE

Genetic Stocks

Genetic stocks described in this review include: high weight (HW) and low weight (LW), high weight relaxed (HWR) and low weight relaxed (LWR), and high weight dwarf (HWD) and low weight dwarf (LWD) populations of chickens.

The HW and LW stocks consisted of White Plymouth Rock chickens divergently selected for high or low 8-week body weight. Within each line, parents of each generation were selected solely on the basis of 8-week body weight (Liu *et al*., 1994).

The HWR and LWR birds were sublines of the HW and LW populations respectively. They consisted of birds divergently selected for 8-week body weight for many generations, after which selection was relaxed and random mating was practiced. These lines were maintained by insemination of randomly chosen females with pooled semen of randomly chosen males (Liu *et al.,* 1994).

The HWD and LWD populations were created by mating dwarf males from an unrelated population with HW or LW normal females. With repeated backcrossing, 93.75% HWD and LWD progeny were produced. After this point, no further selection for body weight was practiced. Subsequent generations were reproduced in each of the two closed populations by randomly mating HWD males with HWD females, and LWD males with LWD females (Reddy and Siegel, 1977).

Role of the Yolk/Effects of Removal

As the avian embryo prepares for hatching, the yolk sac is internalized (Romanoff, 1960). The yolk sac enters the abdominal cavity just prior to hatch where it is a source of high density nutrition during the first few days after hatch (Nir *et al.,* 1988). Response to yolk sac removal with respect to growth, activity and food intake was influenced by genetic stock (Turro *et al.,* 1994). Removal of the yolk sac at hatch caused a decrease in growth in chicks selected for high body weight. By the seventh day after hatch, there was about a two-day delay in growth of the yolk-removed chicks compared to the yolk-intact chicks. In line LW, chicks whose yolk sacs were removed consumed more food than the intact chicks, indicating that they were probably compensating for the missing yolk. Turro *et al*. (1994) pointed out that the first three days after hatch are critical to the chick's development. In an experiment conducted with chicks of the same genetic backgrounds as those used by Turro *et al.* (1994), yolk-intact chicks consumed more feed and gained more weight than those without yolk sacs (Turro-Vincent *et al*., 1994). They suggested that the reason for this phenomenon was because the nutrients from the yolk were used to develop the GIT of the embryo, and because the yolks were removed, the chicks' GIT were not developed sufficiently to utilize exogenous food efficiently.

Yolk sac removal resulted in a depletion of fat reserves (Romanoff and Romanoff, 1967). To assess whether fat was essential for optimal growth during the neonatal period, Chamblee *et al*. (1992) removed the yolk sacs immediately after hatching, (before significant absorption had occurred) and fed the chicks one of three diets containing 3, 6 or 10% fat levels. Dietary fat had its greatest effect on growth after 10 days of age, suggesting that initiation of growth may be more dependent upon other nutrients such as amino acids, carbohydrates or simple sugars.

Although Turro *et al*. (1994) suggested that the contents of residual yolk might be transported directly into circulation because there were no noted changes in the high digestibility of the mash diet fed, Noy *et al*. (1996) reported otherwise. In an experiment where the pathways of yolk utilization were studied, they concluded that absorption as well as digestion occurred simultaneously. Although the yolk sac membrane appeared to be relatively permeable in both directions, movement of yolk to the intestine was followed via blue dextran (a dye), was seen moving in discrete pulses to the intestine and was later detected throughout the small intestine. These findings are consistent with those of Esteban *et al*. 1991, who used 0-2 day old Arbor Acre chicks of both sexes to study reabsorption of the yolk in newly hatched chicks. Through the use of radioactive solutions and dye, they found that the vitelline contents from the yolk sac were transported in two ways: 1) by transport across biological membranes and by the phagosome-lysomal system; 2) through the GIT via the lumen of the yolk stalk, followed by absorption by the intestinal wall.

Diet Regulation

Chickens can adjust food intake to compensate for deficiencies in their diet. Leeson and Summers (1978) used poults to study the effects of dietary self-selection. The birds were offered two diets simultaneously - one high energy/low protein, and one low energy/high protein. The NRC recommendation for turkeys to 4 weeks of age is 28% protein. Males and females adjusted their feed intake so that they consumed diets of 36% and 25% protein, respectively. Beyond 4 weeks of age, protein and energy consumption were both close to those recommended by NRC. Similarly, Huey *et al*. (1982) used HW, LW, HWD and LWD males to study dietary regulation. They allowed chicks from the four genetic stocks to select from two diets that differed in protein and energy content, and found that males from the HW and HWD lines selected the diet relatively high in protein while those from the LW and LWD lines tended to select the one relatively high in energy.

Using the same genetic stocks as Huey *et al*. (1982), Cherry and Siegel (1981) found that when chickens were fed a diet low in methionine, they ate more feed to compensate for the methionine that was lacking. In a similar experiment with chicks, Newman and Sands (1982) fed a L-lysine deficient diet, and found that the young birds voluntarily chose a diet higher in L-lysine content.

Hughes and Wood-Gush (1971) studied the appetite for calcium in commercial broiler chickens at approximately 7 weeks of age. They found that when the experimental group was fed a diet containing adequate amounts of all nutrients except calcium, compared to the control group given a complete balanced ration containing calcium, the calcium-deprived chickens exhibited a preference for calcium. Also studying an appetite for calcium, Holcombe *et al*. (1975) fed laying hens, differing in age by 30 weeks, two diets- one high in calcium, the other low in calcium. They observed that while the hens showed an immediate marked aversion to the high calcium diet, they successfully maintained egg production and egg weight.

Social Feeding Behavior

When studying social facilitation in domestic chicks, Tolman (1964) reported that from two groups of chicks, one raised in pairs, and the other in isolation, that the paired chicks ate more and gained more weight than the isolates. He also found that when he split the groups further into subgroups: isolation, visual contact (paired but separated by wire screen), and complete social contact, that complete social contact was necessary for social facilitation to occur. Tolman (1964) attributed the increased food intake behavior of the paired chicks to beak pecking, a phenomenon where a chick who is not eating is attracted to one who is, begins pecking at its beak, and ends up eating as well. The study also showed that simulating the movement of a chick's beak with a pencil will lead the chick to eat.

In a later paper by Tolman and Wilson (1965), it was hypothesized that emotionality was the cause of social facilitation. It was thought that the lack of a companion would cause a chick to become emotional, hence causing it not to eat. The hypothesis was not confirmed by the data in the experiment. Tolman and Wilson (1965) were also concerned with the feeding behavior of a chick if its companion was deprived of food. Their results showed that the amount of feeding behavior varied in chick "A" directly with the intensity with which "B" was deprived before they were combined.

When Savory (1975) studied social facilitation of feeding and its lasting effect on the growth of chicks, he reported that chicks 5 to 40 days of age were more efficient when housed 2 or 4 per pen than chicks housed in groups of 1 or 8. Conversely, chicks 40 to 80 days of age grouped 2 or 4 per pen converted their food less efficiently than did those housed in groups of 1 or 8. He explained these results as being a consequence of crowding and stress due to increased density levels. Savory was doubtful that social facilitation occurred in this experiment. In a study conducted by Kare *et al.* (1957) where the objective was to study taste in the fowl, results showed that the "positioning effect", where chicks chose one feed over another because of its location, was very prominent in their feeding behaviors.

<u>Taste and Choice Behavior</u>

A question that often arises is, do animals partake in the mechanisms of decision making with respect to taste and food intake? The answers are varied. Lindenmaier and Kare (1959) suggested that, because day-old chicks and three-month-old cockerels have on the average only 8 and 24 taste buds respectively, that taste buds are not the sole receptors of the sense of taste, and that chickens have more than a rudimentary sense of taste.

Kare *et al.*(1957) used flavor discrimination with water as the medium to further study the phenomenon of choice behavior and found that in some trials, depending on the flavors offered, over 2/3 of the chicks preferred the flavored water. On the other hand, in the trials where flavors like honey and strawberry were offered, the majority of the flavored solutions were rejected, indicating that there is a sense of taste in the chick.

In an experiment using lines HW and LW and reciprocal crosses between them to test taste preference for dextrose and quinine sulfate, Barbato *et al.* (1982) found that gustation was to some extent inherited. After a 18-hour deprivation of water, one of the two test solutions was offered along with water. The LW chickens had a lower threshold to the two solutions than HW chickens. The crosses were intermediate to the parental lines. The difference among genetic stocks was masked at higher and lower concentrations of dextrose and quinine sulfate. It was also noted that nonadditive genetic variation for hedonic sensitivity towards the two test components was apparent in the parental lines although it was in opposite directions (preference for dextrose and adversion to quinine sulfate).

Dawkins (1967) believed that color was very important in decision making in animals. He compared choices that chickens make with respect to color to that of the out come or "payoff" a gambler receives. The hypothesis was that there may have been some internal mechanism that determined the actual sequence of individual choices, and thus the phrase "Choice Threshold Model" was coined. Dawkins believed that there was a controlling mechanism i.e., a variable inside chickens, which he described as being something fluctuating in time, corresponding to the excitation (in this case the shape or color of feed). He suggested that when presented with options, if the variable exceeds the threshold of the stimulus then the animal makes a choice. But when the controlling mechanism is more than one threshold simultaneously, (the color of feed "A" is just as appealing as the shape of feed "B"), both or all options are equally likely to be chosen.

Digestive Enzymes and Organs

While studying the relative growth of internal organs of newly hatched cockerels of a light crossbred (New Hampshire x White Leghorns) and a heavy breed (White Rock), Dror *et al*. (1977) reported that relative weights of intestinal segments increased in the duodenum, and decreased in the colon. They also found that these increases were greater in the heavier stocks than in the lighter stocks. Relative weights of the duodenum and jejunum were higher in the light stocks than in the heavy stocks, with the reverse relationship being found in the ileum and caecum.

Nitsan *et al.* (1991a) suggested that adaptation to exogenous feed was closely linked with increased weight of the GIT and levels of digestive enzymes. Chicks reached maximal rate of gain on day 11 and feed efficiency (gain:food) peaked between 0 and 5 days of age, during which time the chick utilized exogenous food along with the internal yolk sac. The next peak in feed efficiency was between 5 and 10 days of age, when the relative body growth and relative weights of the pancreas and small intestine were maximal.

While comparing the development of the digestive organs and some digestive enzymes in broiler and egg-type chicks between 5 and 8 days of age, Nir *et al*. (1993) found a consistent increase in weights of the pancreas, small intestine, small intestinal contents and liver in broiler chicks, but in the egg-type chicks there was a reduction in growth rate of these organs. They also reported that the rate of development of the digestive enzymes in the pancreas and intestinal contents varied among breeds. They suggested that the total activities of the enzymes relative to body weight may be a limiting factor in broiler chicks while in egg-type chicks the total activities of the enzymes relative to body weight may exceed that needed to digest the amount of food consumed.

Studies reported by Nitsan *et al.* (1991b) examining digestive enzymes in the chick clearly showed that age and genetic background were influential factors. Three populations were used in this experiment: a broiler breeder male parent line and Lines HW and LW. Weights of the proventriculus, small intestine, liver and pancreas increased more rapidly than body weight shortly after hatch. There were also significant line-specific changes in the levels of digestive enzymes in the pancreas and contents of the small intestine between 3 and 5 days after hatch.

In a similar experiment using: HW, LW, HWR and LWR lines, O'Sullivan *et al.* (1992) reported that at similar body weights, there were no differences among lines for amylase, chymotrypsin and lipase in the pancreas and small intestinal chyme, while trypsin was lower in the LW and LWR than HW and HWR lines. A possible reason for this difference is hypophagic behavior (O'Sullivan *et al.*, 1992), that is less mechanical stimulation of the intestinal walls occurred in the LW and LWR chicks because they ate less, resulting in decreased stimulation of digestive enzyme synthesis. Nir and Nitsan (1979) compared intermittent and *ad libitum* feeding and found that synthesis and release of pancreatic enzymes depended on the amount of food delivered to the intestinal tract. The digestive enzyme activities also depended on presence of food in the small intestine.

Using heavy-bodied chicks with intermittent feeding, Pinchasov *et al*. (1992) found that activity of digestive enzymes in the pancreas as related to body weight decreased with age. Excessive amounts of chyme enhanced pancreatic secretion into the intestine, resulting in a marked increase in the relative activity of all enzymes in the intestine. Proteolytic enzymes (trypsin and chymotrypsin) in the pancreas of the feed-restricted chicks were similar to those of chicks fed *ad libitum*, suggesting that this hypersecretion was probably a result of hyperphagia in the restricted birds.

CHAPTER 1

EXPERIMENT 1, TRIALS 1 and 2: GROWTH, FEED EFFICIENCY AND GIT MATURATION OF CHICKS FED: 1)A MASH DIET COMPARED TO A YOLK DIET AND 2) A MASH DIET COMPARED TO A CHOICE OF DIETS.

OBJECTIVE

Experiment 1 was designed to answer questions about growth, feed efficiency, energy intake, GIT maturation and behavior in newly hatched chicks fed a mash diet or a yolk diet. The chicks in Trial #1 were given either a mash diet or a yolk diet, relatively high in energy. The chicks in Trial #2 were given either a mash diet, or a choice of two yolk diets, both relatively high in energy.

MATERIALS AND METHODS

Stocks, husbandry procedures, experimental procedures and feeds

Trial 1.

The chicks used in this experiment were White Plymouth Rocks from the 40th generation of a line selected for high 8-week body weight (Liu et al., 1994). On day 0, the chicks were removed from the hatcher, wingbanded and weighed to the nearest gram. Forty chicks were randomly assigned to 10 pens with 4 chicks per pen, and fed a starter diet in mash form (M) containing 20% CP and 2,685 kcal ME/kg. On day 1, chicks of 5 randomly chosen pens were fed unincubated yolk (UY - yolk removed from unincubated chicken eggs and freeze-dried), while the other chicks remained on Diet M. On day 5, the UY-fed chicks were fed mash again, and all chicks remained on mash until day 20.

Food, water and light were always available. The chicks were individually weighed to the nearest gram, on days 0, 3, 5, 13, and 20, and feed plus feeders were individually weighed on days 0, 1, 2, 3, 4, and 5. On day 3, the number of chicks eating, drinking, sitting, and standing at 0730, 0800, 1530, and 1600 hr was recorded. Behaviors were considered mutually exclusive and assigned in the order listed.

Trial 2.

The chicks used in this experiment were males from a commercial layer stock. On day 1, the chicks were received, wingbanded and weighed to the nearest gram. One hundred chicks were randomly assigned 5 per pen. Starting on day 1, four pens (20 chicks) were fed a diet in mash form (M) containing 20% CP and 2,685 kcal ME/kg, while the remaining 16 pens (80 chicks) were given a choice of residual yolk (RY - yolk removed directly from chicks at hatch) or Diet UY. In the pens in which the chicks were given a choice of yolks, location of feed dishes were alternated to avoid consumption of one type of yolk due to social facilitation or habituation to location. On day 6, the Diet Y chicks were fed Diet M and all chicks remained on Diet M until day 21.

Food, water and light were always available. Chicks were individually weighed to the nearest gram, on days 1, 4, 6, 14, and 21, and feed plus feeders were individually weighed on days 1, 2, 3, 4, 5, 6, 14, and 21. On days 4, 6, and 14, at 0730, 0800, 1530, and 1600 hr the number of chicks eating, drinking, resting, or standing was recorded. Behaviors were mutually exclusive and assigned in the order listed.

Organ Data

In both trials, on day 21, all chicks were killed and the small intestine (SI) dissected. Length of the SI was recorded to the nearest millimeter. Weight of the SI was obtained with and without chyme, to the nearest hundredth of a gram. Weight of the chyme was calculated by subtracting the weight of the empty SI from the full SI.

Statistical Analysis

For Experiment 1, Trials 1 and 2, analyses of variance were performed for all traits by the GLM procedure (SAS, 1986) considering dependent variables body weight, feed efficiency, energy intake, GIT data (SI length, SI weight without chyme, and chyme weight) as well as behaviors. For all dependent variables, analyses were done for specific days.

Feed efficiencies were calculated by dividing the total body weight in a pen by the total feed consumed in that pen for days 0-3 and 0-5. Percent body weight gains to days 3, 5, 6, 13, 14, 20 and 21 were calculated by subtracting the initial body weight from the weight on those days and dividing the difference by the former of the two values and multiplying that value by 100. Percent GIT data were calculated by dividing the weight of each organ by the 21-day body weight and multiplying that value by 100. In addition, in Trial 2, each day from day 1 to day 6, yolk choice data were expressed by amount of UY eaten divided by the total yolk eaten in a pen.

Prior to analyses, energy intake data were transformed to common logarithms. Relative organ weight, as well as percent of chicks involved in particular behaviors were transformed to arc sine square roots. Some percent body weight changes were negative, thus preventing arc sine square root transformations, so absolute values for percent body weight gained were analyzed. Absolute values for feed efficiency in Trial 2 were converted to arc sine square roots. Percent GIT values were also transformed to arc sine square roots prior to analyses. Absolute values for body weights and absolute values for organ weights and lengths were not presented due to great variation in body weight.

The main effect for analyses for individual body weight, length of SI, weight of SI and chyme weight was diet. The main effect for feed efficiency and energy intake was diet, but was analyzed on a pen basis. Main effects for behavior were time of day and diet. The average of the 0730 and 0800 behavioral observations constituted an AM reading and the average of the 1530 and 1600 behavioral observations constituted the PM reading. All possible two-way interactions were tested. Significance was taken at the .05 level.

RESULTS

Mortality

Because of mortality of Diet Y chicks (9 chicks out of 20 died), within the first few days of Experiment 1, Trial 1, instead of feeding half of the chicks yolk until day 6 the chicks were switched to Diet M five days post hatch. Mortality was exclusively in the Diet Y fed chicks.

Growth

Trial 1.

There were significant differences due to diet for body weight gain from days 0-3 and 3-5 where values were larger in the chicks fed Diet M than Diet Y and days 5-13 where the body weight gain values were larger in the chicks fed Diet Y than Diet M (Table 1.1). There was no difference due to diets for body weight gained between days 13 and 20.

Trial 2.

There were no differences in relative body weight gain from days 6-14 and 14-21, however, there were differences from days 1-4 and 4-6 with the mash fed chicks gaining relatively more body weight than those fed yolk (Table 1.1).

Feed Efficiency

Trial 1.

The chicks fed Diet M utilized their feed more efficiently than those fed Diet Y. The total mean feed efficiency from 0 to 3 days of age for all chicks fed Diet Y was .71 while those fed Diet M had a feed efficiency of .95 (Table 1.2). By day 5, there was a difference in feed efficiency of .19, with the Diet M fed chicks being more efficient.

Trial 2.

It appeared from the data analysis that the chicks consumed an enormous amount of feed and didn't gain its equivalent in weight, but it was obvious from observing the chicks that they wasted a substantial amount of feed. For this reason, feed efficiency and energy intake data were not reported.

Energy Intake

Trial 1.

The chicks fed Diet Y had a higher energy intake than those fed Diet M (Table 1.2). The total mean energy intake from 0 to 3 days of age for all chicks fed Diet Y was 1308 kcal ME, while the total mean energy intake for those fed Diet M was 600 kcal ME. By day 5, there was a 1493 difference, with energy intake for the Diet Y fed chicks being higher than those fed Diet M.

GIT Maturation

Trial 1.

On a relative basis, where organ weight was divided by 21d BW, there were significant differences due to diet for length of the SI, weight of the SI and weight of the chyme (Table 1.3). The relative weight and length of the organ was greater in the Diet Y-fed chicks while the weight of the chyme was greater in the Diet M-fed chicks.

Trial 2.

There were differences in the relative weight and length of the SI between Diet Y and Diet M-fed chicks, both of which were greater in the Diet Y-fed chicks (Table 1.3). There was no difference between diets in the weight of chyme.

Behavior

Trial 1.

There were no significant interactions between time of day and diet for any of the behaviors measured (Table 1.4). Diet M-fed chicks spent more time standing and less time resting than Diet Y-fed chicks on day 3. There was no difference between diets for percent time spent eating or drinking.

Trial 2.

There were no significant interactions between time of day, day or diet for any of the behaviors measured. Chicks fed Diet Y spent more time resting than chicks fed Diet M, while chicks fed Diet M spent more time standing than those fed Diet Y (Table 1.5). Chicks spent more time standing on day 14 than days 3 and 6, and they spent more time eating on day 6 than on days 3 and 14. Chicks spent less time resting on day 14 than they did on days 3 and 6. There were no significant differences due to time of day or for the percent of chicks drinking for any of the main effects.

DISCUSSION

The three diets fed in this experiment differed in protein and fat content. Diet M contained 20% CP and 2,685 kcal ME/kg, while RY contained 51% and 5,093 and UY contained 33% and 5,954 respectively. It would seem logical that the chicks fed Diet Y would gain more weight than those fed mash, because not only did they have their endogenous yolk to utilize, but they were allowed to eat and utilize an exogenous food source. Yet, the chicks fed Diet M gained more weight. Huey *et al.* (1982) reported that, when allowed to select from two diets, chickens will choose the diet which supplies the nutrients which allow more efficient maintenance. It is possible that the chicks fed Diet Y weighed less (in both experiments) because the yolk was so rich and heavy that they simply did not eat much of it because they were already internally saturated with lipids (the endogenous source of yolk). The Diet M-fed chicks gained more weight because they ate more, their exogenous source of feed (mash) was not as rich or as filling as the yolk. Thus chicks offered Diet M had to eat more to "feel" satisfied. Some of the Diet Y fed chicks ate just enough to survive, but definitely not enough to efficiently convert feed to body weight.

It has also been suggested that endogenous yolk is not digested in the intestine, but transported directly into circulation (Turro *et al.*, 1994). Because yolk is extremely high in lipids, it may have been difficult to digest. This could have caused the food to remain in the SI longer, hence the increased length and increased weight of the SI weight in both trials, in the yolk-fed chicks, compared to those fed mash (a food lower in lipid content and easier to digest). These results are consistent with those of Baker (data unpublished) where in a similar experiment, the lengths of the SI were also greater in the yolk-fed chicks.

Because of the high mortality, apparently the chicks were not getting the nutrients that they needed to survive or properly allocate their resources. In a similar experiment Baker, (data unpublished) a number of yolk fed chicks developed yolk stalk infections and did not survive.

TABLE 1.1. Relative body weight gain ± SEM post hatch of chicks fed Diet M and Diet Y (Trial 1 and Trial 2).

	Trial 1						Trial 2				
	Diet M			Diet Y			Diet M			Diet Y	
Age (day)	N	X±SEM		N	X±SEM	Age (day)	N	X±SEM		N	X±SEM
0-3	20	35 ± 2	**	20	-4 ± 1	1-4	20	17 ± 2	**	80	-3 ± <1
3-5	20	52 ± 2	**	11	19 ± 4	4-6	20	31 ± 2	**	80	6 ± 1
5-13	20	131 ± 4	**	11	183 ± 6	6-14	20	98 ± 3	NS	75	118 ± 5
13-20	20	78 ± 2	NS	11	90 ± 7	14-21	20	60 ± 2	NS	75	68 ± 3

Diet Y = unincubated yolk; Diet M = standard starter mash.

*$p \leq .05$ between adjacent means.

**$p \leq .01$ between adjacent means.

NS = no significance between adjacent means.

TABLE 1.2. Feed efficiencies and energy intake ± SEM of chicks fed Diet M compared to those fed Diet Y in Trial 1

	Diet M			Diet Y	
Age	N	X±SEM		N	X±SEM
(day) efficiency					
0-3	5	.95 ± .02	**	5	.71 ± .02
0-5	5	.54 ± .03	*	2	.35 ± .01
(day) energy intake					
0-3	5	600 ± 13	**	5	1308 ± 12
0-5	5	1615 ± 83	**	2	3108 ± 18

Diet Y = unincubated yolk; Diet M = standard starter mash.
*$p \leq .05$ between adjacent means.
**$p \leq .01$ between adjacent means.

TABLE 1.3. Relative weight and length ± SEM of the SI along with chyme weight at 21 days of age of chicks fed Diet M or Diet Y in Trial 1 and Trial 2

	Trial 1			Trial 2		
	Diet M		Diet Y	Diet M		Diet Y
Organ	X±SEM		X±SEM	X±SEM		X±SEM
Weight	2.69 ± 0.06	**	3.09 ± 0.15	2.66 ± 0.08	**	3.14 ± 0.06
Length	27.19 ± 0.69	**	33.64 ± 0.90	42.47 ± 0.87	**	46.94 ± 0.55
Chyme	2.02 ± 0.11	*	1.53 ± 0.30	3.55 ± 0.11	NS	3.60 ± 0.09

N in Trial 1 = 20; N in Trial 2 = 66.

GIT weights are expressed in percentages.

Diet Y = unincubated yolk; Diet M = Standard starter mash.

*$p \leq .05$ between adjacent means.

**$p \leq .01$ between adjacent means.

NS = no significance between adjacent means.

TABLE 1.4. Results from ANOVA (A) of behavioral main effects and their interactions and (B) mean percent chicks involved in various behaviors ± SEM, fed Diet Y and Diet M in the morning and in the afternoon on day 3 in Trial 1

(A)

Main effect	Standing	Eating	Drinking	Resting
Time	NS	NS	NS	NS
Diet	*	NS	NS	*
Time*Diet	NS	NS	NS	NS

(B)	Diet			Time		
Behavior	M		Y	am		pm
Standing	40 ± 8	*	18 ± 7	21 ± 7	NS	36 ± 8
Eating	18 ± 8	NS	3 ± 2	13 ± 8	NS	8 ± 3
Drinking	1 ± 1	NS	3 ± 2	1 ± 1	NS	3 ± 2
Resting	41 ± 12	*	78 ± 8	65 ± 12	NS	54 ± 11

Time = am or pm; Diet = mash or yolk.
Diet M = mash; Diet Y = yolk.
*p≤.05 between adjacent means.
**p≤.01 between adjacent means.
NS = no significance between adjacent means.

TABLE 1.5. Results from ANOVA (A) of behavioral main effects and their interactions and (B) means of percent chicks involved in various behaviors ± SEM, fed Diet Y and Diet M in the morning and in the afternoon in Trial 2

(A)

Main effect	Eating	Resting	Standing	Drinking
Time	NS	NS	NS	NS
Day	**	**	**	NS
Time*Day	NS	NS	NS	NS
Diet	NS	**	*	NS
Time*Diet	NS	NS	NS	NS
Day*Diet	NS	NS	NS	NS

(B)	Diet			Time			Day		
Behavior	M		Y	am		pm	3	6	14
Standing	30 ± 6	*	19 ± 2	25 ± 3	NS	17 ± 3	18 ± 3[b]	8 ± 2[b]	39 ± 4[a]
Eating	17 ± 4	NS	12 ± 2	16 ± 2	NS	10 ± 2	7 ± 2[b]	20 ± 3[a]	12 ± 3[b]
Drinking	3 ± 2	NS	3 ± 1	4 ± 1	NS	3 ± 1	3 ± 1	3 ± 1	3 ± 1
Resting	50 ± 5	**	66 ± 3	55 ± 4	NS	70 ± 3	72 ± 4[a]	68 ± 3[a]	46 ± 5[b]

Diet M = mash; Diet Y = yolk; *$p \leq .05$ between adjacent means; **$p \leq .01$ between adjacent means.

NS = no significance between adjacent means.

Means ± SE with no common superscripts are significantly different.

Time = am or pm; Day = 3,6 or 13; Diet = mash or yolk.

CHAPTER 2

EXPERIMENT 2: GROWTH, FEED EFFICIENCY AND GIT MATURATION OF CHICKS WITH AND WITHOUT YOLK SACS

OBJECTIVE

This experiment was designed to study feed efficiency, body weight, GIT maturation, energy intake and behavior in newly hatched chicks with and without yolk sacs. Chicks were fed a choice of residual yolk (Y) harvested from chicks and freeze dried, and a mash (M) diet containing 20% CP and 2,685 kcal ME/kg for the first six days post hatch, after which, all chicks were fed the mash diet. Biological responses were then compared between the yolk removed chicks and the yolk intact chicks.

MATERIALS AND METHODS

Stocks, husbandry procedures, experimental procedures and feeds

One hundred twelve cockerels from a commercial layer stock were wingbanded on the day after hatch and yolk sacs of 56 chicks were removed. The yolk-removed (Trt YR) chicks were allowed to recover for an hour under a heat lamp, then randomly assigned to seven pens (eight chicks per pen). The remaining 56 yolk-intact (Trt YI) chicks were also weighed and randomly assigned to seven pens (eight chicks per pen). All chicks were given a choice of residual yolk (Y - yolk harvested from newly hatched chicks and freeze dried) and mash (M - a diet containing 20% CP and 2,685 kcal ME/kg) from day 0 to 6. Beginning on day 6, all chicks were fed Diet M until d 20.

Food, water and light were always available. The chicks were individually weighed to the nearest gram on days 0, 3, 6, 13, and 20 along with the feed and feeders. On days 3, 6, 13, and 19 at 0730, 0800, 1530, and 1600 hr chicks were recorded as eating, drinking, resting, or standing. All behaviors were considered mutually exclusive. On days 3 and 6 when chicks had a choice of feeds, eating was recorded as to Diet Y or Diet M.

Organ Data

On day 21, all chicks were killed and the SI dissected. The length of the empty SI was recorded to the nearest millimeter. Weight of the SI was obtained with and without the chyme to the nearest hundredth of a gram. Weight of the chyme was calculated by subtracting the weight of the empty SI from the weight of the full SI.

Statistical Analysis

Analyses of variance were performed for all traits by the GLM procedure (SAS, 1986) considering dependent variables body weight, feed efficiency, energy intake, GIT data (SI length, SI weight without chyme, and chyme weight) as well as behaviors. For all dependent variables, analyses were done for specific days.

Percent body weight gains from 0-3, 3-6, 6-13 and 13-20 days of age were calculated by subtracting the initial body weight from that on the last day and dividing the difference by the former of the two values and multiplying that value by 100. Percent GIT data were calculated by dividing the organ weight by the 21-day body weight and multiplying that value by 100. Total yolk consumed from day 0 to 6 was expressed by amount of Diet Y eaten divided by the total feed eaten (Diet Y plus Diet M) on a pen basis.

Prior to analyses, energy intake data were transformed to common logarithms. Relative organ weights along with percent of chicks involved in particular behaviors were transformed to arc sine square roots prior to analysis. Some percent body weights were negative, thus preventing arc sine square root transformations, and analyses were conducted on percent body weight gain.

The main effect for body weight was treatment (YI and YR) with the individual as the unit, while the main effect for feed efficiency and energy intake was also treatment, but analyzed on a pen basis. The main effect for GIT (SI length, SI weight without chyme and weight of chyme) was treatment and the main effects for behavior were time of day and treatment. The average of the 0730 and 0800 behavioral observations constituted an AM reading and the average of the 1530 and 1600 behavioral observations constituted the PM reading. All possible two-way interactions were tested. Significance was taken at the .05 level.

RESULTS

Growth

The only significant difference due to treatment for relative body weight gain was from day 6-13, with the Trt YR chicks gaining relatively more body weight than the YI chicks (Table 2.1).

Feed Efficiency

It appeared from the analysis that the chicks consumed an enormous amount of feed and didn't gain its equivalent in weight, but it was obvious from observing the chicks that they wasted a substantial amount of feed. For this reason, feed efficiency and energy intake data were not reported.

GIT

On a relative basis, where each variable was expressed relative to 21 day BW, weight of the SI and its length were similar for Trt YR and Trt YI (Table 2.2). There was however a significant difference in the weight of the chyme, which was greater in the Trt YI than Trt YR chicks.

Behavior

There were no differences due to treatment for percent chicks eating yolk, drinking or eating mash, however, Trt YI chicks stood more and rested less than Trt YR chicks, (Tables 2.3 and 2.4). There were no differences due to time of day for drinking or standing, but there were differences among days for these two behaviors. Chicks drank less on days 3 and 6 than on days 13 and 19, and stood significantly less on day 6 than on days 3, 13 and 19. With respect to the choice of diets the chicks were given from day 0 to 6, chicks ate more of Diet Y than Diet M in the morning (Table 2.4). The only evidence of significant interactions was that of time by day for percent resting and percent eating mash (Table 2.5). Both interactions occurred as a result of significant differences in time of day on day 6 but not at other ages.

DISCUSSION

On day one, the Trt YR chicks were lighter in weight than the Trt YI chicks, (36 and 39 respectively) which was expected since the residual yolk in the abdomen of a chick at hatch is normally about 6.4g (Murakami *et al.*, 1992). It was expected that between days 0 and 6 that the Trt YR chicks would overeat in comparison to the Trt YI chicks to compensate for the missing yolk (Turro *et al.*, 1994). This finding was neither confirmed or disproved by the present experiment. Because of the wasted food, the intake data as well as the energy data were not presented.

Nitsan *et al.* (1991b) suggested that nutrients from the yolk are used to develop the GIT of the embryo, and Turro-Vincent et al. (1994) suggested that this role continues for the first few days post hatch. If this hypothesis is true, then significant reductions in the length and weight of the SI should have been seen in the Trt YR chicks of the present experiment, as a consequence of the lack of nutrients provided by the yolk to sufficiently develop the GIT. In contrast to this hypothesis, there was no difference in the weight or the length of the small intestine.

It is understood that the yolk sac provides 50% of the chicks' energy on the first day after hatch and is negligible by the fourth, being only about 2% (Nitsan *et al*., 1991a). This may be why the yolk-removed chicks rested so much more than the yolk-intact chicks, and the yolk-intact chicks stood much more than those from which the yolks were removed. It is also a possibility the intrusive surgery caused the Trt YR chicks to rest more and stand less.

TABLE 2.1. Relative body weight gain ± SEM by 3, 6, 13, and 20 days post hatch of yolk intact and yolk removed chicks

Age (day)	Trt YI N	Trt YI X±SEM		Trt YR N	Trt YR X±SEM
0-3	55	15 ± 0.2	NS	55	13 ± 0.2
3-6	55	32 ± 0.2	NS	53	33 ± 0.2
6-13	54	99 ± 0.2	*	52	104 ± 0.2
13-20	54	59 ± 0.1	NS	52	58 ± 0.2

Trt YI = yolk intact chicks; Trt YR = yolk removed chicks.
*$p \leq .05$ between adjacent means.
**$p \leq .01$ between adjacent means.
NS = no significance between adjacent means.

TABLE 2.2. Relative weight and length ± SEM of the SI along with the weight of the chyme of yolk intact chicks and yolk removed chicks on day 20

	Trt YI		Trt YR
Organ	X±SEM		X±SEM
Weight	3.76 ± <1	NS	3.88 ± <1
Length	41.42 ± <1	NS	43.36 ± <1
Chyme	2.63 ± <1	*	2.14 ± <1

GIT weights are expressed in percentages.
Diet Y = unincubated yolk; Diet M = Standard starter mash.
*$p \leq .05$ between adjacent means.
**$p \leq .01$ between adjacent means.
NS = no significance between adjacent means.

TABLE 2.3. Results from ANOVA for behaviors main effects ± SEM including percent chicks standing, eating, drinking, resting, and their interactions due to time, day and treatment

Main effect	Eating(y)	Standing	Drinking	Resting	Eating(m)
Time	*	NS	NS	*	**
Day	NS	**	*	**	**
Time*Day	NS	NS	NS	**	*
Trt	NS	*	NS	*	NS
Time*Trt	NS	NS	NS	NS	NS
Day*Trt	NS	NS	NS	NS	NS

Time = am or pm; Day = 3,6,13 or 19.

Trt = yolk intact or yolk removed; Eating(y) = eating yolk (from d0 to d6); Eating yolk (m) = eating mash.

*$p \leq .05$ between adjacent means.

**$p \leq .01$ between adjacent means.

NS = no significance between adjacent means.

Table 2.4. Percent of Trt YI and Trt YR chicks ± SEM involved in various behaviors, in the morning and afternoon on days 3, 6, 13 and 19

	Trt			Time			Day			
Behavior	YI		YR	am		pm	3	6	13	19
Eating(Y)	7 ± 4	NS	7 ± 3	12 ± 4	*	3 ± 1	7^{a} ± 3	8^{a} ± 4	---	---
Eating(M)♦	24 ± 3	NS	20 ± 3							
Drinking	1 ± <1	NS	2 ± 1	1 ± <1	NS	2 ± <1	$<1^{b}$ ± <1	1^{ab} ± <1	2^{a} ± 1	3^{a} ± <1
Resting♦	41 ± 3	*	51 ± 4							
Standing	33 ± 2	*	26 ± 3	30 ± 3	NS	29 ± 2	29^{a} ± 3	18^{b} ± 3	37^{a} ± 3	35^{a} ± 4

Trt YI = yolk intact chicks; Trt YR = yolk removed chicks.

*$p \leq .05$; **$p \leq .01$ between adjacent means.

NS = no significance between adjacent means.

Means with no common superscripts are significantly different.

Eating (y) = eating yolk; Eating (m) = eating mash.

♦ = See table 2.5 for interactions.

TABLE 2.5. Time of day by age interactions of percent chicks ± SEM eating mash (A) and percent chicks resting (B) in Experiment 2

	Time of Day		
(Eating Mash)	AM		PM
Day			
3	$5^{c} \pm 3$	NS	$4^{c} \pm 2$
6	$14^{bc} \pm 4$	**	$43^{a} \pm 5$
13	$30^{a} \pm 6$	NS	$36^{ab} \pm 5$
19	$26^{ab} \pm 4$	NS	$25^{b} \pm 5$

	Time of Day		
(Resting)	AM		PM
Day			
3	$66^{a} \pm 7$	NS	$67^{a} \pm 5$
6	$71^{a} \pm 7$	**	$35^{bc} \pm 5$
13	$33^{b} \pm 5$	NS	$22^{c} \pm 5$
19	$31^{b} \pm 6$	NS	$44^{b} \pm 6$

*$p \leq .05$ between adjacent means.
**$p \leq .01$ between adjacent means.
NS = no significance between adjacent means.
Means with no common superscripts are significantly different.

CHAPTER 3

EXPERIMENT 3: GROWTH, FEED EFFICIENCY AND GIT MATURATION OF CHICKS WITH AND WITHOUT YOLK SACS FED DIETS DIFFERING IN PROTEIN AND ENERGY CONTENT

OBJECTIVE

This experiment was designed to evaluate growth of segments of the GIT, feed efficiency, body weight, behavior and energy intake in newly hatched chicks with and without yolk sacs, fed diets differing in energy and protein. On the day after hatch, the yolk sacs of half of the chicks used in this experiment were removed. They and the remaining yolk-intact chicks were each divided into two subgroups, those fed Diet A (mash diet relatively low in protein and energy) and those fed Diet E (mash diet relatively high in protein and energy). Three serial dissections were done and biological responses were compared.

MATERIALS AND METHODS

Stocks, husbandry procedures and experimental procedures

Two hundred twenty-four cockerels from a commercial layer stock were used in this experiment. Yolk sacs were removed from 112 chicks the day after hatch by techniques described by Harvey *et al*. (1955) and kept under a heat lamp for two hours to recover. Because sham operations had no effect on growth rate of yolk intact chicks (Turro *et al*., 1994), sham operations were not conducted in this experiment. Fifty-six of the yolk removed chicks and 56 of the yolk intact chicks were fed a mash diet containing 20% CP and 2,685 kcal ME/kg (Diet A). The remaining 56 yolk removed and 56 yolk intact chicks were fed a mash diet containing 24% CP and 3,146 kcal ME/kg (Diet E). All chicks were wingbanded and randomly assigned eight per pen for a total of 28 pens. Food, water and light were provided at all times.

Chicks were weighed to the nearest gram on days 1, (before and after yolk sac removal) 3, 6, 13, and 20. The feeders with feed were also weighed on the same days. On days 3, 6, 13, and 19 at 0700 and 1600 hr the chicks were recorded as eating, drinking, resting, or standing. All behaviors were considered mutually exclusive.

On days 6, 13, and 20 ten randomly chosen individuals from seven pens from the yolk sac removed (Trt - YR) group fed Diet E, yolk sac intact (Trt - YI) group fed Diet E , Trt YR group fed Diet A and the Trt YI group fed Diet A were selected and dissected according to the number of live chicks per pen. Individuals were chosen at random within each pen, but a conscious effort was made to maintain relatively constant number of chicks per pen.

Organ Data

The weight of the empty SI (weighed to the nearest hundredth of a gram) and length of the SI (measured to the nearest millimeter) as well as the weight of the esophagus plus crop, proventriculus, and gizzard were recorded to the nearest hundredth of a gram for each individual, during each dissection.

Statistical Analysis

Analyses of variance were performed for all traits by the GLM procedure (SAS, 1986) considering dependent variables body weight, feed utilization, energy intake, GIT data and behaviors. For all dependent variables, analyses were done for specific days.

Percent body weight gain from 0-3, 3-6, 6-13 and 13-20 days of age were calculated by subtracting the initial body weight from that on the last days and dividing the difference by the former of the two values and multiplying that value by 100. Percent GIT data were calculated by dividing the organ weight by the body weight on the day it was dissected and multiplying that value by 100.

Prior to analyses, energy intake data were transformed to common logarithms. Relative organ weights along with feed efficiency values and percent of chicks involved in particular behaviors were transformed to arc sine square roots prior to analyses. Some percent body weights were negative, thus preventing arc sine square root transformations, and analyzes were conducted on percent body weight gained were analyzed. Absolute values for feed efficiency were presented for the same reason. Percent GIT data and behavior data were transformed to arc sine square roots prior to analyses. Absolute values for body weight and absolute organ weight and length were not presented.

The main effects for body weight were treatment (YI and YR) and diet (A and E) with the individual as the unit. The main effects for feed efficiency and energy intake were also treatment and diet, with analysis on a pen basis. The main effects for GIT were treatment and diet and the main effects for behavior were time of day, diet and treatment. All possible two-way interactions were tested. Significance was taken at the .05 level.

RESULTS

Growth

Although relative body weight gain between days 3-6 were similar to Trt YI and Trt YR chicks, chicks fed Diet E gained more weight than those fed Diet A (Table 3.1). For days 13 through 20, the Trt YR chicks gained more than the Trt YI chicks and the Diet E-fed chicks weighed more than those fed Diet A. There were treatment by diet interactions for days 0-3 and 6-13 (Table 3.2). For days 0-3, Trt YI chicks fed Diet E gained relatively less weight than those of Trt YI fed Diet A and those of Trt YR fed Diet E. Percent gain was higher from days 6-13 for chicks the Trt YR chicks fed Diet A and Trt YI chicks fed Diet E, than for the Trt YI chicks fed Diet A.

Feed Efficiencies

Feed intake values were unusually high, which made the feed efficiency values biologically impossible. For this reason, feed efficiency and energy intake values were not presented.

GIT Growth

Day 6

There were no significant differences due to treatment or diet for the weight of the SI or the weight of the chyme (Table 3.3). There was, however, a difference due to diet and treatment for the weight of the gizzard. This organ was heavier in the Trt YR chicks than the Trt YI chicks and heavier in the Diet A-fed chicks than the Diet E-fed chicks. Although there was no difference due to diet for the weight of the esophagus plus crop and proventriculus, both values were greater in the Trt YR than Trt YI chicks. Although there was no difference due to treatment for the length of the SI, the organ was longer in the Diet E-fed chicks than in the Diet A-fed chicks.

Day 13

There were no significant differences due to treatment or diet for the length of the SI, weight of the SI, esophagus plus crop, proventriculus or chyme (Table 3.4). Although there was no difference due to treatment for the weight of the gizzard, it was proportionately heavier in the Diet A-fed chicks than those fed Diet E.

Day 20

There were no significant differences due to treatment or diet for the length of the SI, weight of the SI, esophagus plus crop, proventriculus or chyme (Table 3.5). Although there was no difference due to treatment for the weight of the gizzard, it was heavier in the Diet A-fed chicks than those fed Diet E.

Behavior

Day 3

There were no significant interactions or differences due to time of day, diet or treatment for eating, standing, drinking or resting on day 3 (Table 3.6). All chicks behaved similarly.

Day 6

There were no significant interactions or differences due to diet, treatment or time of day for drinking or resting (Table 3.7). At this age, chicks stood more in the morning than in the afternoon. There was a diet by treatment interaction for standing (Table 3.8) because Trt YR chicks fed Diet E stood more than any of the other chicks. Data also showed that Trt YI chicks ate more than the Trt YR chicks (Table 3.7).

Day 13

There were no significant interactions or differences due to time of day, diet or treatment for eating, standing, drinking or resting on day 3 (Table 3.9). All chicks behaved similarly.

Day 20

There were no significant interactions or significant differences due to diet or treatment for percent chicks eating or drinking (Table 3.10). Chicks stood more in the afternoon than they did in the morning and rested more in the morning than in the afternoon.

DISCUSSION

On day one, the Trt YR chicks were lighter in weight than the Trt YI chicks, (35g and 39g respectively) which was expected since the residual yolk in the abdomen of a chick at hatch is normally about 6.4g (Murakami *et al.,* 1992). Because of this, body weight data were analyzed so that percent body weight relative to treatment could by studied. With respect to the relative body weight gained, there was a significant interaction between diet and treatment by day 3 occurring as a result of a higher percent of body weight in the Trt YI Diet A-fed chicks opposed to the Trt YI, Diet E-fed chicks and a higher percent of body weight gain in the Trt YR, Diet E-fed chicks as opposed to the Trt YI, Diet E fed chicks. The interaction on day 13 resulted from a significantly lower percent body weight gain in the Trt YI, Diet A-fed chicks than any other group. Results showed that by day 20, the Trt YR chicks gained significantly more weight than the Trt YI chicks and that the Diet E-fed chicks gained more than those fed Diet A.

There were no differences due to treatment for the weight of the gizzard on days 13 and 20, however, gizzard weight was consistently heavier throughout for Diet A-fed chicks than those fed Diet E. On day 6, where there was a treatment effect, all organs including esophagus plus crop, gizzard and proventriculus were heavier in the Trt YR than Trt YI chicks. It has been suggested that the nutrients from the yolk are used in development of the GIT of the embryo (Nitsan *et al*., 1991b). A possibility as to why the weight of certain organs were heavier, in the earlier part of the experiment, is that the food needed to stay in the GIT longer in order to be fully digested, because its lack of development would not allow for normal rate of digestion.

It is understood that the yolk sac provides 50% of the chick's energy on the first day after hatch and is negligible by the fourth being only about 2% (Nitsan *et al.,* 1991a), this may be why the Trt YR chicks seemed to rest more than the other chicks. The treatment by diet interaction on day 6 showed a significant difference in the percent chicks standing with respect to treatment. Ironically, the Trt YR chicks spent more time standing than the Trt YI chicks. And the Trt YR, Diet E-fed chicks spent more time standing than the Trt YR, Diet A, which was partially expected because the Diet E feed is higher in energy.

TABLE 3.1. Relative body weight gain ± SEM of Trt YI and Trt YR chicks and relative body weight gain± SEM of chicks fed Diet A or Diet E (Experiment 3).

	Trt					Diet				
	Trt YI			Trt YR		Diet A			Diet E	
Age (day)	N	Mean±SE		N	Mean±SE	N	Mean±SE		N	Mean±SE
0-3♦										
3-6	112	34 ± 1	NS	109	35 ± 1	110	33 ± 1	**	111	36 ± 1
6-13♦										
13-20	73	59 ± 2	*	69	63 ± 1	71	58 ± 1	**	71	65 ± 1

Trt YI = yolk-intact chicks; Trt YR = yolk-removed chicks.
Diet A = low fat diet; Diet E = high fat diet.
*$p \leq .05$; **$p \leq .01$ between adjacent means.
NS = no significance between adjacent means.
♦ = See table 3.2 for interactions.

TABLE 3.2. Diet by treatment interaction ± SEM of relative body weight gain between days 0-3 and 6-13 in Experiment 3

(PBw0-3) Diet	Trt YI		Trt YR
Diet A	29 ± 1	NS	27 ± 2
	*		NS
Diet E	24 ± 1	*	29 ± 2

(PBw6-13) Diet	Trt YI		Trt YR
Diet A	78 ± 1	**	90 ± 2
	**		NS
Diet E	89 ± 2	NS	92 ± 2

Trt YI = yolk intact chicks; Trt YR = yolk removed chicks.
*$p \leq .05$ between adjacent means.
**$p \leq .01$ between adjacent means.
NS = no significance between adjacent means.
Bw = body weight; PBw = percent body weight.
Diet A = low protein and energy diet; Diet E = high protein and energy diet.

TABLE 3.3. Relative weight and length ± SEM of the SI along with the weight of the esophagus and crop, gizzard and the proventriculus of Trt YI and Trt YR chicks and of chicks fed Diet M or Diet Y in Experiment 3 on day 6

	Trt			Diet		
	Trt YI		Trt YR	Diet A		Diet E
Organ	Mean±SEM		Mean±SEM	Mean±SEM		Mean±SEM
SI weight	4.67 ± .20	NS	5.09 ± .20	4.74 ± .19	NS	5.02 ± .21
SI length	10.48 ± .21	NS	10.49 ± .34	9.90 ± .32	**	11.08 ± .13
Escro	1.48 ± .08	*	1.70 ± .04	1.57 ± .08	NS	1.61 ± .05
Gizzard	4.94 ± .15	**	5.46 ± .15	5.54 ± .16	**	4.85 ± .11
Provent	1.18 ± .06	*	1.36 ± .03	1.32 ± .03	NS	1.22 ± .06
SI chyme	5.46 ± .19	NS	5.62 ± .23	5.56 ± .21	NS	5.52 ± .22

SI = Small intestine; Escro = esophagus and crop; Provent = percent proventriculus.
Trt YI = yolk-intact chicks; Trt YR = yolk-removed chicks;
Diet A = low fat diet; Diet E = high fat diet.
*p≤.05 between adjacent means; **p≤.01 between adjacent means.
NS = no significance between adjacent means; There were no significant interactions.

TABLE 3.4. Relative weight and length ± SEM of the SI along with the weight of the esophagus and crop, gizzard and the proventriculus of Trt YI and Trt YR chicks and of chicks fed Diet M or Diet Y in Experiment 3 on day 13

	Trt			Diet		
	Trt YI		Trt YR	Diet A		Diet E
Organ	Mean±SEM		Mean±SEM	Mean±SEM		Mean±SEM
SI weight	4.22 ± .18	NS	4.41 ± .17	4.33 ± .18	NS	4.30 ± .17
SI length	6.42 ± .12	NS	6.56 ± .15	6.45 ± .16	NS	6.54 ± .09
Escro	.97 ± .03	NS	.97 ± .03	.93 ± .03	NS	1.02 ± .03
Gizzard	4.04 ± .11	NS	4.05 ± .14	4.47 ± .08	**	3.58 ± .05
Provent	.90 ± .02	NS	.95 ± .02	.92 ± .02	NS	.93 ± .02
Chyme	2.57 ± .24	NS	2.61 ± .24	2.50 ± .22	NS	2.68 ± .26

SI = small intestine; Pescro = esophagus and crop; Provent = proventriculus.
There were no significant interactions.
Trt YI = yolk-intact chicks; Trt YR = yolk-removed chicks.
Diet A = low fat diet; Diet E = high fat diet.
*$p \leq .05$ between adjacent means.
**$p \leq .01$ between adjacent means.
NS = no significance between adjacent means.

TABLE 3.5. Relative weight and length ± SEM of the SI along with the weight of the esophagus and crop, gizzard and the proventriculus of Trt YI and Trt YR chicks and of chicks fed Diet M or Diet Y in Experiment 3 on day 20

	Trt			Diet		
	Trt YI		Trt YR	Diet A		Diet E
Organ	Mean±SEM		Mean±SEM	Mean±SEM		Mean±SEM
SI weight	3.77 ± .24	NS	3.61 ± .10	3.48 ± .18	NS	3.90 ± .17
SI length	4.57 ± .19	NS	4.37 ± .08	4.54 ± .10	NS	4.40 ± .17
Escro	.86 ± .04	NS	.87 ± .03	.87 ± .03	NS	.87 ± .04
Gizzard	3.57 ± .12	NS	3.51 ± .10	3.74 ± .07	**	3.35 ± .12
Provent	.80 ± .03	NS	0.76 ± .01	0.76 ± .01	NS	0.80 ± .03
Chyme	2.92 ± .31	NS	2.90 ± .18	3.01 ± .29	NS	2.81 ± .20

SI = small intestine; Pescro = esophagus and crop; Provent = proventriculus.
Trt YI = yolk-intact chicks; Trt YR = yolk-removed chicks;
Diet A = low fat diet; Diet E = high fat diet.
*$p \leq .05$ between adjacent means.
**$p \leq .01$ between adjacent means.
NS = no significance between adjacent means.
There were no significant interactions.

TABLE 3.6. Results from ANOVA (A) of behavioral main effects, and their interactions and (B) means of percent yolk intact and percent yolk removed chicks ± SEM involved in various behaviors, fed Diet E or Diet A on day 3 (Experiment 3)

(A)

Main effect	Eating	Standing	Drinking	Resting
Time	NS	NS	NS	NS
Diet	NS	NS	NS	NS
Time*Diet	NS	NS	NS	NS
Trt	NS	NS	NS	NS
Time*Trt	NS	NS	NS	NS
Diet*Trt	NS	NS	NS	NS

(B)

	Feed			Trt			Time		
Behavior	A		E	I		R	am		pm
Eating	9 ± 4	NS	9 ± 4	9 ± 5	NS	9 ± 3	5 ± 2	NS	13 ± 5
Drinking	1 ± 1	NS	<1 ± <1	<1 ± <1	NS	1 ± 1	<1 ± <1	NS	1 ± 1
Resting	58 ± 7	NS	67 ± 6	70 ± 7	NS	58 ± 7	71 ± 5	NS	54 ± 8
Standing	32 ± 6	NS	23 ± 4	24 ± 5	NS	31 ± 5	24 ± 4	NS	31 ± 6

Trt YI = yolk intact chicks; Trt YR = yolk removed chicks.
*$p \leq .05$ between adjacent means.
**$p \leq .01$ between adjacent means.
NS = no significance between adjacent means.
Means with no common superscripts are significantly different.
Eating (y) = eating yolk; Eating (m) = eating mash.

TABLE 3.7. Results from ANOVA (A) of behavioral main effects and their interactions and (B) means of percent yolk intact and percent yolk removed chicks ± SEM involved in various behaviors, fed Diet E or Diet A on day 6 (Experiment 3)

(A)

Main effect	Eating	Standing	Drinking	Resting
Diet	NS	NS	NS	NS
Trt	*	*	NS	NS
Diet*Trt	NS	*	NS	NS
TOD	NS	*	NS	NS
Diet*TOD	NS	NS	NS	NS
Trt*TOD	NS	NS	NS	NS

(B)	Diet			Trt			Time		
Behavior	A		E	I		R	am		pm
Eating	1 ± 1	NS	6 ± 3	7 ± 4	*	<1 ± <1	3 ± 2	NS	5 ± 3
Drinking	1 ± 1	NS	<1 ± <1	1 ± 1	NS	<1 ± <1	1 ± 1	NS	<1 ± <1
Resting	83 ± 5	NS	66 ± 8	78 ± 7	NS	71 ± 7	67 ± 6	NS	82 ± 7
Standing♦							29 ± 6	*	13 ± 6

Trt YI = yolk intact chicks; Trt YR = yolk removed chicks.

Diet A = low fat diet; Diet E = high fat diet; Eating (y) = eating yolk; Eating (m) = eating mash.

*p≤.05 between adjacent means; **p≤.01 between adjacent means; NS = no significance between adjacent means.

Means with no common superscripts are significantly different.

N = 28;

♦ = See table 3.8 for interaction.

TABLE 3.8. Diet by treatment interaction ± SEM of percent chicks standing on day 6 (Experiment 3)

	Trt		
	Trt YI		Trt YR
Diet			
Diet E	11 ± 5	*	44 ± 12
	NS		*
Diet A	15 ± 6	NS	14 ± 5

N = 14
Diet A = low fat diet; Diet E = high fat diet
Trt YI = yolk intact chicks; Trt YR = yolk removed chicks.
*$p \leq .05$ between adjacent means.
**$p \leq .01$ between adjacent means.
NS = no significance between adjacent means.

TABLE 3.9. Results from ANOVA (A)of behavioral main effects and their interactions and (B) means of percent yolk intact and percent yolk removed chicks ± SEM involved in various behaviors, fed Diet E or Diet A on day 13 (Experiment 3)

(A)

Main effect	Eating	Standing	Drinking	Resting
Diet	NS	NS	NS	NS
Trt	NS`	NS	NS	NS
Diet*Trt	NS	NS	NS	NS
TOD	NS	NS	NS	NS
Diet*TOD	NS	NS	NS	NS
Trt*TOD	NS	NS	NS	NS

(B)

	Diet			Trt			Time		
Behavior	A		E	I		R	am		pm
Eating	<1 ± <1	NS	<1 ± <1	<1 ± <1	NS	<1 ±<1	<1 ± <1	NS	<1 ± <1
Drinking	<1 ± <1	NS	<1 ± <1	<1 ± <1	NS	<1 ± <1	<1 ± <1	NS	<1 ± <1
Resting	78 ± 6	NS	81 ± 7	80 ± 7	NS	80 ± 6	71 ± 8	NS	89 ± 5
Standing	22 ± 6	NS	19 ± 7	20 ± 7	NS	20 ± 6	29 ± 8	NS	11 ± 5

Trt YI = yolk intact chicks; Trt YR = yolk removed chicks.
NS = no significance between adjacent means.
Eating (y) = eating yolk; Eating (m) = eating mash.
N = 28
Diet A = low fat diet; Diet E = high fat diet.

TABLE 3.10 Results from ANOVA (A) of behavioral main effects and their interactions and (B) means of percent yolk intact and percent yolk removed chicks ± SEM involved in various behaviors, fed Diet E or Diet A on day 20 (Experiment 3)

(A)

Main effect	Eating	Standing	Drinking	Resting
Diet	NS	NS	NS	NS
Trt	NS	NS	NS	NS
Diet*Trt	NS	NS	NS	NS
TOD	NS	**	NS	**
Diet*TOD	NS	NS	NS	NS
Trt*TOD	NS	NS	NS	NS

(B)

Behavior	Diet A		Diet E	Trt I		Trt R	Time am		Time pm
Eating	<1 ± <1	NS	<1 ± <1	<1 ± <1	NS	<1 ± <1	<1 ± <1	NS	<1 ± <1
Drinking	<1 ± <1	NS	<1 ± <1	<1 ± <1	NS	<1 ± <1	<1 ± <1	NS	<1 ± <1
Resting	61 ± 8	NS	64 ± 8	61 ± 8	NS	64 ± 8	87 ± 5	**	39 ± 8
Standing	39 ± 8	NS	36 ± 8	39 ± 8	NS	36 ± 8	13 ± 5	**	61 ±8

Trt YI = yolk intact chicks; Trt YR = yolk removed chicks.
*$p \leq .05$ between adjacent means; **$p \leq .01$ between adjacent means.
NS = no significance between adjacent means; N = 28.
Means with no common superscripts are significantly different.
Eating (y) = eating yolk; Eating (m) = eating mash.
Diet A = low fat diet; Diet E = high fat diet.

SUMMARY

This project was designed to answer questions about digestion, growth and behavior in newly hatched chicks. Experiment 1 was designed to determine the effects of supplying yolk as a feed source to newly hatched chicks on feed efficiency, body weight, energy intake, GIT maturation and behavior. The three major points from this experiment were: 1) yolk is too "rich" a diet to be fed to newly hatched beacause their digestive systems aren't sufficiently developed to effectively digest it, 2) the role of the yolk appears to be minimal 2 or 3 days after hatch and mortality increased such that the yolk fed chicks could not survive without alternative feed, and 3) mash-fed chicks stood more, while yolk-fed chicks rested more.

The objectives in Experiment 2 were to study feed efficiency, energy intake, behavior, growth and body weight in newly hatched chicks with and without yolk sacs fed a choice of mash and yolk to five days post hatch, as well as to study the differences in behavior, growth, body weight and GIT growth in chicks with and without yolk sacs from 6 to 20 days post hatch. The three most important points from this experiment were: 1) yolk intact chicks fed mash (Diet A) stood more than the yolk removed chicks fed the same diet, 2) the only difference in percent body weight gain was on day 13, when chicks were no longer offered dietary yolk, and 3) yolk-intact chicks had more chyme than those in which yolks had been removed.

Experiment 3 was designed to answer questions about growth, body weight, energy intake, behavior and GIT growth in chicks with and without yolk sacs fed mash diets differing in energy and protein content. The three most important points from this experiment were: 1) yolk intact chicks fed the diet lower in energy and protein (Diet A) stood more than those in the other three groups, 2) gizzard weight was consistently higher in the chicks fed the diet lower in protein and energy (Diet A), and 3) just as seen in experiment 2, on day 13, and 3) the yolk removed chicks fed Diet A gained more body weight than the yolk intact chicks fed the same diet.

GENERAL SYNTHESIS

In the present project, if chicks fed yolk as their food source for a number of days died, then results of this project concur with the Thesis of Turro *et al.*, 1994, that the endogenous yolk is not digested in the intestine, but transported directly into circulation. This became apparent when a large number of chicks fed an exogenous source of yolk died. It was extremely difficult for the chicks fed yolk to gain body weight. If the digestion of the exogenous source of yolk had enhanced weight gain or feed efficiency in the early stages of chick development, then a possible implication for industry would be to synthetically devise a yolk diet.

In the present experiments feeding only residual yolk retarded early body weight gains. In the experiments where the residual yolks were removed from the chick, results with respect to body weight gain were fairly consistent. On a percent basis, where there was a significant difference in body weight gain and the yolk removed chicks gained more.

A problem with this project is that although individual experiments examined similar traits, (e.g., body weight, GIT growth, behavior, feed efficiency and energy intake) the main effects were too different. For example, a possible reason why the behavior data were inconsistent is because in Experiment 1, the main effect was diet, (yolk or mash) in Experiment 2, the main effect was treatment, (yolk-intact or yolk-removed) and in Experiment 3, the main effects were diet (high protein/energy or low protein/energy) and treatment (yolk-intact or yolk removed). No two experiments had the same behavioral effects. The same is true for the GIT information, had there been some consistency in the main effects, there could have possibly been some consistency in the significance of the data. Only in Experiment 1 were chicks offered yolk as a feed source and remained yolk-intact, and only in Experiment 3 were they offered a mash diet differing in fat and protein and were subject to serial dissections. Again, main effects were too different.

With respect to feed efficiency and energy intake, in Experiment 1 Trial 2 and Experiment 2, the data values were not believable. Given the consistency and texture of the freeze dried yolk, whenever the chicks would play in the water, then play in the yolk, the food would become attached to their down like paste. Because of this, feed in and feed out values used to calculate feed efficiency were not valid. In conclusion, even if feed efficiency and energy intake values were consistent throughout the project, it wouldn't explain much. The feed as well as treatments between experiments were different every time.

This project could have been improved if the main effect in one experiment was maintained, while implementing other main effects in the second, as opposed to creating the second experiment so that the main effects are unrelated to the previous one.

If this project were to be continued, an experiment to determine what effect yolk removal has on major parts of the digestive tract up through market age as well as body weight at market age, should be devised, to answer questions like:

- Is the effect of yolk removal on body weight lasting? If not, at what age do the body weight of the yolk-removed chicks match those of the yolk-intact chicks?

- Do the body weights of the yolk-removed chicks at some point surpass those of the yolk-intact chicks, and is the weight advantage maintained?

- What would happen to digestive organs of chicks that have been fasted for the first three days post hatch?
- What would be the effects of feeding yolk to older, more developed chickens?
- Will the gizzard always be larger in chicks fed a diet higher in energy and protein than those fed diets lower in energy and protein?
- More specifically, if on the same diet, what digestive organs are consistently effected by yolk removal?
- And more importantly, why?

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