

SUPPLEMENTAL FATS AND OILS – THEIR ROLE IN TURKEY PRODUCTION

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EXECUTIVE SUMMARY

Fats and oils, a.k.a. lipids, are a chemically diverse group of compounds with the highest energy density among all major macro nutrients. Lipids play an important role in commercial turkey diets both physically and physiologically. From a physical standpoint, lipids are associated with processes related to improvement of live weight gain and feed efficiencies in commercial turkeys. Breeder turkeys respond to added dietary fat (4-8%) with significantly increased egg production and hatching rates. Supplemental fats also contribute to a reduction of dust in feed, decreased feed particle separation, increased palatability, digestive lubrication (i.e. emulsification and rate of passage) and increased feed digestibility (via micelle and bile salt formation).

From a physiological aspect, lipids play functional roles in processes associated with energy metabolism, nutrient transport and cellular structure. For example, good performance has been demonstrated using readily digestible supplemental feed fats such as animal-vegetable blends in poults, beginning on day one. During this time in a bird's life, feed fats can play an important role in accommodating and assisting with the metabolic shift in energy from yolk lipid sources to feed based glycolytic-based pathways, reducing the likelihood of "starve out" mortalities.

As discussed in the companion white paper (R. Murugesan, 2012) besides having high caloric values, lipids are major sources for essential fatty acids (Ω -3 and Ω -6), fat soluble vitamins (A, D, E and K) and lecithin. The main factor affecting the metabolizable energy of fats is their digestibility, which is dependent on the length of the carbon chain and the degree of saturation of the fatty acids. In general, fats of vegetable origin show better absorption and show higher levels of metabolizable energy as they contain high amounts of unsaturated fatty acids (U) unlike fats of animal origin (tallow, choice white grease), which contain high amounts of saturated fatty acids (S). Turkey poults do not utilize saturated long-chain fatty acids nearly as efficiently as unsaturated fatty acids (U).

Fats and oils from animal and vegetable sources are often blended to attain a specific U/S ratio, which increases the efficiency of normally harder to digest animal fats, and thus produces a product with superior ("extra caloric") metabolizable energy. For example, tallow fed with soy oils even at relatively low levels (2%) demonstrate greater ME values beyond their individual expected contributions. In addition, custom blends of oils can be used to modulate or control carcass meat quality. Iodine Values (IV) are often used to quantify and limit the degree of unsaturation with higher IV values representing more highly unsaturated fats. Feeding turkeys with high levels of DDG with corn oil can create soft fat issues, such as fat purging in consumer packaging.

Finally, the quality of the fat and the fat source(s) is vitally important as fats with high moisture, impurities and unsaponifiables (MIU), such as hydrolyzed vegetable restaurant grease, can lead to decreased digestibility and thus lower realizable metabolizable energy. Hence, conscientious producers consider the fatty acid profile, the quality of the fat source(s) and the intended targeted use when evaluating supplemental fat options and predicting performance benefits.

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INTRODUCTION

Beginning in the 1980s, the turkey industry began to realize the benefits of large consumer increases in per capita consumption of turkey, in part due to increased consumer awareness of the health benefits of eating the low fat, nutrient rich protein. This surge in consumer demand (8.3 lbs per capita in 1975 compared to 16.4 lbs per capita in 2010)², fueled interest in funding turkey research that could increase production levels while improving production efficiencies.

For the past 30 years, my greatest responsibility as a turkey nutritionist has been to ensure that feed suppliers deliver consistent feed ingredient quality. After all, feed costs are the single largest production cost in growing turkeys. Formulating diets with supplemental feed fat has been an important part of modern commercial turkey nutrition in the United States, as will be discussed in greater detail in this white paper. Via scores of research trials and through other extensive research efforts, researchers at several land-grant and other major universities have studied and published the effects and efficacy of feeding supplemental fat in both commercial and breeder layer turkeys.

Today, it is commonly accepted that turkey diets are typically formulated with greater added fat levels than other types of poultry, including broilers and layers. This is true because turkeys, in general, are known to have greater nutrient requirements (energy, amino acids, minerals, etc.) than broilers to support very rapid genetic growth potential throughout a much longer production cycle. Since supplemental feed fat is crucial in formulating modern turkey diets, this white paper will focus on providing more detailed information related to the three topical areas of discussion listed below, including clarifying some less understood areas of the science and addressing a number of common misconceptions about supplemental fats and oils:

1. Why use supplemental feed fats in turkey diets?
2. What are the advantages & disadvantages of vegetable oils, animal fats and blended oil/fat sources for turkey production?
3. Why are acidulated all vegetable and animal-vegetable (AV) fat blends superior to other sources (i.e. choice white grease, tallow, restaurant grease)?

WHY USE SUPPLEMENTAL FEED FATS IN TURKEY DIETS?

A consistent supply of high-quality feed fat, with accurately estimated levels of metabolizable energy (ME), is crucial to feeding turkeys in accordance with corporate expectations and industry guidelines.

Among the most important live turkey production metrics are: feed conversion (F/G), average daily gain (ADG) and resulting feed costs per Live Weight (\$/LW). Fat supplementation can improve feed efficiencies, growth rates and feed palatability, while enhancing carcass and meat characteristics. Consequently, when properly selected and incorporated into the feed diet, fats and oils will significantly influence resulting production performance and profit margins.

Turkeys respond favorably to the feeding of added fats in the diet. Researchers at Iowa State University, Sell and Owing (1981) found commercial toms (males) have significant linear improvements of both live weight and feed efficiency when fed added graded fat levels (1 - 8%), regardless of whether nutrients (crude protein, lysine, etc.) were adjusted for ME changes. Similarly, at Virginia Polytechnic Institute - Virginia State University, Blair and Potter (1988), found evidence that nutrients (crude protein, lysine, etc.) need not be adjusted in proportion to the ME supplied from added dietary fat sources. In other words, turkey producers can expect increased ADG and feed efficiencies by using increasing levels of supplemental fat without the need for a lot of tinkering with other nutrients in the diet.

TURKEY BREEDER IMPLICATIONS – INCREASED LAYER RATION ENERGY AND NUTRIENT DENSITY

Research regarding the benefits of supplement fats and oils for turkey breeders is sparse, but nutritionists understand that turkey breeder candidates require different feeding strategies than the commercial turkeys they produce as progeny. Therefore, modern turkey genetic companies need to balance growth and reproductive traits, which are often in direct conflict with one other, as described below.

In order for commercial progeny to have increased rates of daily gain (ADG), meat yield and improved feed conversions, the breeder hens and toms are selected for these traits as well. Primary turkey breeder companies (Nicholas, B.U.T. and Hybrid) accomplish this by creating male and female genetic lines. Male lines focus on growth, feed efficiency and semen fertility parameters, thus male line toms have much larger mature body weights than the commercial toms they sire. Meanwhile, female line breeder hens are selected with primary emphasis on egg production and growth parameters as well.

² National Turkey Foundation

Turkey breeder hens have the inherent potential to gain excess body weight (abdominal fat pad) during grow-out which can be of concern. For example, overweight hens at lighting (about 30 weeks of age) can create potential egg production losses and increased hatching, egg and poult costs. Consequently, weight gain in turkey breeders, between 12 – 30 weeks of age and prior to egg production, is typically controlled by either: a.) feeding low-energy, low-protein diets (qualitative); or b.) “limited feed” (quantitative) feeding strategies. Then, once egg production commences, a unique phenomena found in turkey breeder hens can occur with the loss of body weight during the first few weeks of egg production. In order to counteract this weight loss, turkey nutritionists will implement feeding programs that increase layer ration energy and nutrient densities to prevent body weight losses. Increasing dietary nutrient density of turkey breeder diets usually requires supplemental feed fat usage.

TURKEY POULT IMPLICATIONS – IMPROVED GROWTH, FEED EFFICIENCIES, REDUCED STARVE OUT

Feeding high-fat diets to young poults (up to 14 days of age) is an important topic that deserves some discussion. Current industry wisdom among nutritionists is to minimize supplemental fat levels in diets for poults between 14 and 28 days of age. Thereafter, it is generally accepted that fat utilization increases with age. Several researchers have supported this concept from a fat digestibility perspective (Whitehead and Fisher, 1975; Salmon, 1977; Sell et al, 1986). The improvement in fat utilization with age is largely a function of increased bile production and intestinal lipase activity as the poult matures.

However, good performance has been demonstrated using high supplemental feed fat levels even in starting poults. For example, two respected university researchers (Sell et al., 1986; Moran, 1978) have both observed improved growth and feed efficiencies in 2 week old poults fed diets containing 8-10% supplemental A-V fat. These findings suggest that the type of fat selected may play an important role in the ability of young poults to metabolize fat at two weeks of age.

Another benefit of feeding high levels of A-V fat to newly hatched poults has to do with accommodating and assisting the metabolic shift in energy sources early in the bird's life cycle. Embryos derive over 80% of energy needs from the oxidation of yolk lipid during incubation (Romanoff, 1960). Then, post-hatch they eat feed with primary energy sources coming from carbohydrates, as their metabolism shifts to glycolytic and glycogenic-based pathways. Phelps et al. (1987a,b) have questioned the ability of the newly hatched poults to effectively regulate glucose metabolism. This is because newly hatched turkey poults previously derived their embryonic energy sources from gluconeogenic and ketogenic substrates found in the yolk sac reserves. However, post-hatch, the liver must begin processing any consumed feed for energy which can be a challenge for the immature digestive system.

Pre-starter turkey feed energy (in the United States) is largely comprised of carbohydrate (starches from corn, soy), gluconeogenic precursors from amino acids (protein), some inherent crude fat from vegetable and animal sources, and normally only 1-3% supplemental feed fat. The availability of dietary carbohydrates (CHO) for newly hatched poults has been shown to increase the rate at which energy metabolism shifts from gluconeogenic to glycolytic pathways (Donaldson 1991, 1992). In addition, Rosenbrough (1976) had demonstrated previously that a high-fat diet will increase glucose-6-phosphatase enzyme activity to sustain gluconeogenesis without dramatically shifting the metabolic system toward glycolysis.

Some researchers have questioned the ability of poults to regulate their glucose metabolism after hatching. They have also suggested this lack of glucose metabolism control may contribute to a common early peak in mortality, usually beginning around 4 days of age (Phelps, 1987). This is an important turkey production malady, commonly called “starve-out” mortality. “Starve out” is a recognized cause of commercial turkey mortality. Poults overwhelmed by environmental challenges such as: lack of temperature control, lack of water space, lack of feed space, disease challenges and/or inattentive management may result in some poults becoming dehydrated and not accessing feed, thus the term “starve out”. These poult mortalities typically have no feed in their crops.

“Starve out” is potentially caused by several metabolic issues that are inherent to poult physiology. First, newly hatched poults have no control over their body temperature for their first 14-21 days of life. Second, poults are changing their energy metabolism from egg yolk-based substrates to finished feeds and start with no feed in their crops. Third, poults have an immature digestive system, lacking in optimum levels of enzymes (proteolytic and lipase) and bile salts, in addition to a lack of glucose metabolism control. As a consequence, turkey producers understand that the challenges of rearing several thousand poults at a time, often requires specialized techniques and attention.

To facilitate this important period of transition, poult are normally placed in freshly cleaned buildings. They are allotted to brooder rings within the house to control poult movement and micro-climates. Research has been conducted to understand how to improve and optimize the performance of newly hatched poult. Access to first feed and various fat sources have been investigated to evaluate their effects upon poult performance for the critical first 14 days of life.

As described below, Ohio State University researchers following Rosenbrough's earlier work have suggested that supplemental fat sources (A-V, MCT) may ease the metabolic shift toward glycolysis post-hatch, thus improving body weight growth through the first 14 days of age. To further examine, Turner et al. (1999a) conducted 3 experiments to determine the effect of diet and 48-hour delayed access to feed (post-hatch) on growth and carbohydrate (CHO) metabolism. The CHO diets contained 0% added fat, although they did contain the inherent corn oil carried with the corn feed. The added fat diets contained either an animal-vegetable fat (A-V) or a medium chain triglyceride (MCT) included at 10% in the test diets. The A-V fatty acid composition was primarily C16:0 (25.6%), C18:0 (19%), C18:1 (29%) and C18:2 (12.4%). The MCT blend composition (largely Coconut oil) was C8:0 (75.9%) and C18:2 (10.6%).

The hepatic (liver) glycogen stores of poult in the study were nearly depleted prior to initial feeding (this means that poult have little, if any, energy stored prior to their first bite of feed). While feeding the CHO diet improved live weight (LW) and feed intake through the first 5 days of age, feeding added fat diets (A-V blend or MCT) had the most beneficial effects as measured at 14 days. The elevated plasma glucose and hepatic levels found in the CHO-poult following feed access may help provide some understanding of the depressed growth and feed intake after 5 days of age. Poult fed the A-V and MCT were 41 grams heavier than CHO fed treatments at 13 days ($p < .05$). The researchers concluded from these studies that supplemental feed fat may ease the metabolic shift toward glycolysis after hatching, thus improving growth rates through 14 days of age.

Turner et al. (1999b), as a companion paper to 1999a, used the same diets as Turner et al (1999a). They reported the apparent lipid digestibility of an A-V fat and CHO diets averaged 70.8 and 76.4%, respectively. The reduction in lipid absorption for the A-V fat treatment was attributed to the poor digestibility of the saturated FA components, C16:0 and C18:0 fatty acids, which represented 35.7% and 44.2% of total dietary fatty acids, respectively. However, as noted by others in this paper, the apparent digestibility of the unsaturated FA and MCFA components of A-V and MCT fats were found to be consistently high, at >80% and >95%, respectively. The MCFA components verified earlier work that the short and medium chain FA are highly absorbed, even without the presence of lipase, bile salts and formation of micelles.

When feed intake was adjusted, the apparent digestibility of lipids for each treatment (CHO, A-V, MCT) within each feed period (3-5, 6-8, 9-11 days) was significantly ($p < .05$) increased with increasing age. This confirms the premise that it takes some time for young poult to efficiently utilize feed fat sources. However, between days 3-11, no significant apparent digestibility difference was found for poult fed either A-V or MCT diets. Their data suggests that feeding fat sources containing high levels of polyunsaturated FA or medium-chain FA is well utilized by the young poult. The authors also concluded with an important finding – poult demonstrated significantly greater feed intake when the A-V fat source was fed, compared to the high-carbohydrate diet. Anything we can do to stimulate feed consumption is a positive step in reducing “starve-out” and improving overall poult performance.

From a practical nutrition perspective, most turkey nutritionists limit fat additions to diets of young poult (0 to 2 weeks) because they know the post-hatch poult has limited digestive capacity for fats. However, there may be potential to make further strides in early poult performance, especially reducing mortality losses through some creative research using high-quality and targeted fat sources.

In summary, use of fats early in the poult's lifecycle is an overlooked nutrient strategy that may reduce mortality rates and significantly improve performance and meat yields. Moreover, the type and source of fat utilized early in the life cycle is an important consideration with a preference for fats and oils that contain high levels of unsaturated FA or, medium or short chained FA (whether saturated or unsaturated).

ADVANTAGES & DISADVANTAGES OF ANIMAL, VEGETABLE AND BLENDED FAT SOURCES

Turkey research that has evaluated specific feeding or energy values of supplemental fats is limited. Most research in commercial poultry (turkey, broilers, and layers) is conducted with broilers, since they command the largest market share. In addition, research with turkeys is much more costly and time consuming (due to longer production cycles).

During the 1960's and 1970's there was a "gold rush" of poultry research conducted for many topics including those for understanding the role of fat sources and fat digestion. In fact, there was so much research generated that many articles were submitted to journals other than Poultry Science, including Journal of Nutrition, Journal of Biochemistry, and Journal of Lipid Research.

There are a number of pertinent research articles that support an accepted poultry (turkeys, broilers) nutrition belief that unsaturated fatty acid sources (vegetable oils, A-V blends, acidulated soap stocks) are: a) absorbed more readily and b) have greater energy values than saturated fatty acid sources (tallow, choice white grease).

Researchers in the early 1950's, M.L. Sunde (1954) and Carver et al (1954) both reported that a saturated fat or stearic acid would not improve feed utilization, when all other fats tested did show improvements. Both researchers reported and agreed that saturated fats were not absorbed from the digestive tract of the chick. Seidler et al (1954) reported that feeding 3% or 6% free fatty acids (FFA) did not decrease average daily gain (ADG) and were utilized efficiently.

Subsequently, University of Wisconsin poultry researcher, M.L. Sunde (1956) evaluated the use of local fats (choice white grease, brown grease, prime tallow and a commercially stabilized fat) supplied by Darling Manufacturing Co. In addition, individual fatty acids (stearic, oleic, linoleic, linolenic) were also evaluated. The primary conclusions were: 1.) all intact unsaturated fat sources (oleic, linoleic, linolenic) used in the chick starter feeds at 5% improved feed utilization (FCR) without any performance issues; 2.) however, when stearic acid or a hydrogenated fat was fed, no improvements in feed utilization were observed. Dr. Sunde concluded that chicks did not utilize the saturated long chain fatty acids very well.

At Cornell University, Renner and Hill (1958) were involved in the earliest work to quantify the available energy from varied fat sources used by the chick. These researchers determined the ME value and apparent digestibility of various fat sources containing Iodine Values (IV) ranging from 44 to 169. They also demonstrated that the metabolizable energy of fatty acid mixtures produced by hydrolyzing tallow, lard and soy oil (by controlled heating) were much lower than when fed as their respective intact triglycerides. Additionally, they showed that when stearic and palmitic acids (saturated fatty acids) are fed individually they were completely unutilized by the chick, suggesting the opportunity for blending fats to improve ME values.

A number of other researchers have reported that broiler chicks fed diets containing partially hydrolyzed fats, or individual fatty acids, showed poorer (higher ratio) feed conversions than expected, based upon the calculated ME values of these fatty acid mixtures. Therefore, R.J. Young (1960) conducted an investigation to evaluate the utilizable energy and absorbability of individual fatty acids found in various fats and fatty acid mixtures fed to chicks using practical-type diets. Dr. Young conducted this study while working for The Proctor and Gamble Company (P&G). P&G manufactured soap and as a by-product, acidulated soap stock was produced. Dr. Young questioned and challenged the results of Renner & Hill, and others, who had been using "purified" diets to test fats and fatty acid mixtures with chicks. This is because purified diets use pharmaceutical (USP) grade materials (cerelose, glucose, sucrose) with little or no common practical ingredients, like corn soy meal. Young believed the use of purified diets could lead to different conclusions compared to diets containing common practical feedstuffs. However, the beef tallow and fatty acids used by Young were identical to that used by Renner & Hill (1958).

Young's work, which used "practical type" diets, yielded a number of important conclusions, many challenging the earlier results from Renner & Hill (1958):

1. Soy oil, corn oil, tallow, lard and hydrolyzed A-V fat were similar in ME value and absorbability found by other researchers;
2. The ME values for FFA (tallow, lard, hydrolyzed A-V fat) were all significantly higher than those found by other researchers using more purified diets;
3. Stearic and palmitic acids were both found to have significantly improved utilization when fed in mixtures of FFA. This was, in contrast, to the zero absorbability of either stearic or palmitic when fed singularly;
4. Saturated fatty acids in mixtures of FFA was significantly utilized by the chick and the degree of saturated fatty acid utilization was increased as the unsaturated fatty acid content increased.

Next, Fedde, Waibel and Burger (1960) at the University of Minnesota began evaluating other factors affecting the absorbability of a poorly utilized fat (tallow) by the chick. These investigators evaluated the age of the bird, addition of dietary ox bile, feed intake restriction and dietary calcium. Various fat sources were: safflower oil, corn oil, hog grease, and beef tallow. These workers chose to use two high levels of fat inclusion, 10% or 20%, for each intact fat source (above). Significant findings were:

1. Apparent absorption of test fats by chicks was similar when fed in diets at either 10% or 20%. Absorption was high for safflower oil, corn oil and hog grease, while low for beef tallow.
2. Apparent absorption for beef tallow was 53% at 1 week of age, increasing to 80% by 12 weeks of age, indicating increased utilization of saturated fat with age.
3. Ox bile additions of 0.5% or more significantly increased absorption of beef tallow. However, at levels of 4% and 8% ox bile levels depressed growth rates, suggesting that bile is only one of several factors necessary for fat utilization.

EVALUATING FEED ENERGY VALUES USING PRACTICAL DIETS

The following discussion describes further attempts to refine the experimental protocols used to evaluate the feeding value (energy) of lipids by using practical diets, and streamlining lab techniques to provide more rapid, low cost and accurate results.

Scott and Kummerow (1958) used an equalized feed intake technique to evaluate growth stimulation using corn oil fed to chicks. They found that chicks fed equal amounts of a basal diet (adequate in all nutrients, but low in energy) will gain weight in proportion to the amount of available energy added to the diet by fat addition. When each experimental group consumes the same amount of feed, differences in caloric density and feed intake differences (due to birds eating to meet their energy needs) are no longer experimental variables. It is critical that all diets are adequate for all nutrients, including the calorie-to-protein ratio at the highest dietary energy treatment. This procedure also offered the benefits of not having to analyze feed and excreta for moisture, fat, chromic oxide markers, nitrogen and combustible energy (bomb calorimeter) as required for determining absorbability and metabolizable energy. This procedure also eliminated the need to correct for endogenous fat and nitrogen retention. Therefore, this procedure measured the energy actually available to the chick.

Young and Artman (1961a), both from The Procter & Gamble Co., continued work to explain the differences they found with absorbability of FFA mixtures (from hydrolyzed lard and tallow) and that of Renner & Hill (1958). They chose to evaluate degummed soy oil and edible beef tallow in a controlled feed intake test environment, along with soy oil fatty acids, lard fatty acids and tallow fatty acids. Young and Artman were attempting to evaluate the energy value of various fats and FFA mixtures by using practical diets and controlling the feed intake of test birds.³

Again, while at The Procter & Gamble Company, Young and Artman (1961b) used this controlled feed intake method to also evaluate the utilizable energy of intact and hydrolyzed triglycerides. These investigators found their utilizable energy values confirmed the ME values reported earlier by Young (1961a). Meanwhile, the values found for lard fatty acids and tallow fatty acids had a greater energy value than found by Renner & Hill (1958).

As lipid research moved forward, other important factors affecting fat utilization were hypothesized and tested. Among these factors is the benefit of having a fatty acids in an esterified form (to glycerol) and even placement of a saturated fatty acids within the glycerol molecule.

Renner and Hill (1961a) recognized that the absorbability of individual fatty acids are affected by the presence of other fatty acid, neutral fat, fat breakdown products and forms of the fatty acid. They conducted trials to compare the absorbability of tallow fatty acids, lard fatty acids and soy fatty acids when fed as triglycerides or as mixtures of FFA. They also evaluated the effect of the saturated fatty acid position within the triglyceride molecule has upon absorbability. They demonstrated that the absorbability of saturated fatty acids varies directly with the level of unsaturated fatty acids in the mixture. For example, the absorbability of palmitic and stearic increased from 51% to 84% and from 35% to 78%, respectively, when fed in a mixture containing 76 parts vs. 63 parts of unsaturated fatty acids.

³ Feeding graded levels of a test ingredient has been used to determine the quality of proteins and the availability of nutrients such as phosphorus and amino acids. However, this method has inherent limitations when evaluating feed fats. When substituting test fat for a non-digestible ingredient, such as cellulose, the caloric content between test diets is altered. Chicks have the ability to compensate for dietary energy needs by increasing feed intake with lower energy diets.

In conclusion, Renner and Hill (1961a) data showed even greater absorbability of palmitic and stearic acids when they were fed in ester linkages, as mixed triglycerides, in the natural fat. The authors noted that this marked improvement in absorbability of saturated fatty acids, when fed in esterified form suggested that either neutral fat or some metabolic product from triglycerides is required for the absorption of FFAs. Renner and Hill also demonstrated that palmitic acid in the TG's of lard, was utilized nearly to the same extent as the unsaturated fatty acids. This is likely due to the fact that lard contains most of its saturated fatty acid (palmitic) in the carbon-2 position (Mattson et al, 1959; Savary et al, 1957). Renner & Hill (1961a) reached the similar conclusion- the absorbability of palmitic acid within lard varies with the point of attachment within the triglyceride molecule. Absorbability is significantly greater when palmitic acid (saturated fatty acid) is located in the carbon-2 position, as opposed to the carbon-1 position.

Renner & Hill (1961b) continued research to further understand the utilization of individual fatty acids for both the chick and the hen. In both chick and hen, the utilization of saturated fatty acids decreased as carbon chain length increased from C12 to C18. Again, they showed that palmitic and stearic fatty acids (16:0 and 18:0 carbon length) was not well utilized by the chick (only 3% absorbability). In comparison, oleic acid, an 18:1 carbon length, unsaturated fatty acids, was 88% utilized by the chick.

Ontario Agriculture College (Guelph) researchers Sibbald et al (1961) designed experiments to investigate the synergistic relationship between commercially available fat sources. They evaluated tallow from three different sources, along with acidulated soapstocks (ASS), undegummed soy oil (UDGSO) and dried soy gums (DSG), fed singularly, and in combination. ASS was a recently available commercial product used by Canadian poultry producers. The researchers also included ASS because it frequently contained soybean gums. They hypothesized that the components in soybean gums (glycerol, lecithin and other phospholipids) could improve the utilization of the FFA found in the ASS.

There were several notable findings from the work:

1. Increased ME values for the 3 tallow sources were linearly associated with;
 - a. Increasing Iodine Value (IV). The greater the IV, the greater the degree of unsaturation
 - b. Decreasing titres. Titre, in simple terms, is the melting point of fat. The lower the melting point of fat, the greater the degree of unsaturation;
2. Increasing linoleic acid content. Linoleic acid is a highly unsaturated fatty acid (18:2 carbon) that is found in high concentrations in common feed ingredients such as corn, soy meal or canola meal;
3. Acidulated soapstocks were a good source of feed energy for the chick;
4. Tallow fed with UDGSO, ASS or DSG demonstrated greater ME values than expected (beyond their individual contributions), thus demonstrating "extra caloric" synergies;
5. Mixtures of tallow + ASS and tallow + DSG, both demonstrated greater energy value than when fed individually;
6. The "active agent" within UDGSO that is responsible for creating the synergy is unknown to the authors at this time.

Sibbald et al (1963) followed up with another study to evaluate the nutritive content of tallow and acidulated soapstock (ASS) samples when fed at practical feeding levels. Earlier studies had evaluated fat utilization in non-practical type diets (purified, semi-purified components) and at test fat dietary inclusion levels of 10 or 20% of diet. Sibbald challenged these types of experimental diets and fat feeding levels since they are not anything like diets actually fed to commercial poultry. Consequently, they designed a 3 x 5 factorial trial using three fat levels (2, 4, 6%) and five fat sources (tallow, ASS and three ratios of tallow: ASS at 3:1, 1:1 and 1:3). The discussion and conclusions revealed the following notable findings:

1. Dietary ME content was linearly ($p < .01$) increased as fat level increased;
2. Chick body weights were linearly ($p < .01$) increased as fat level increased;
3. They concluded that feed grade tallow and ASS are of equal nutritive value for young chicks fed at 2, 4 and 6% levels, using weight gain and gain: feed ratios as criterion.
4. Sibbald et al stated that body weights and gain: feed ratios of the chicks were increased in some "extra-caloric" manner. Therefore, they stressed that ME value, alone, was not a satisfactory method of assessing the value of fat. This contention is supported by their earlier work (Sibbald et al, 1962) demonstrating that even though they found a 300 cal. per lb. difference between tallow and ASS (3,850 vs. 3,530, respectively), there was no difference in their weight gain promoting abilities. One may conclude that ASS must have some other component to "boost" utilization of the FFA found in ASS.

RJ Young is now a professor at Cornell University. Dr. Young, along with researchers RL Garrett and M Griffith (1963) conducted yet another study to understand factors affecting the absorbability of fatty acid mixtures containing high levels of saturated fatty acids. Specifically, these researchers were challenging differences in results found between their work and that of former Cornell University investigators, Renner & Hill (1961). This is a continued effort to explain the marked differences found between these two research groups conducting fat research at the same institution. They continued refining feed fat testing procedures and were concerned with three primary differences between the experimental designs used by each lab:

1. Practical vs. semi-purified basal and test diets. Renner & Hill used semi-purified diets, while Young et al.'s practical diets contained 28% crude protein and corn as the primary carbohydrate (CHO). In contrast, Renner & Hill's semi-purified diets used glucose as the primary CHO;
2. Breed of the chicks and the nature and duration of basal diet conditioning prior to test feeding. Renner & Hill used crossbred cockerels (Rhode Island Red x Barred Plymouth Rock) fed a basal conditioning diet for only 2 weeks, while feeding test diets for 2 weeks. Young et al. used Arbor Acre White Plymouth Rock fed a basal diet to condition for only 1 week, while feeding test diet for 3 weeks;
3. Laboratory Husbandry/environmental management practices. Renner & Hill did not clean and fumigate facilities between flocks and often had multi-ages housed in the same facility. Young's laboratory was cleaned and disinfected between each flock and contained only one age group at a time.

Several key points affecting the utilization of lard fed to chicks were reported by Young et al. (1963):

1. Lard fatty acid absorbability was increased by feeding 28% or 30% crude protein compared to 24%. Also, fatty acid absorbability was increased when the test diets were fed for 3 weeks compared to only 2 weeks, thus indicating that feeding practices can affect fat utilization;
2. Absorbability was greater when fatty acids were substituted in test diets on an equivalent 'weight for weight' basis rather than making adjustments based on "isocaloric" substitution;
3. The use of corn as the primary CHO source did improve lard absorption in one experiment, but did not have a consistent effect in another;
4. No difference in fatty acid absorption was observed between the 2 breeds of chicks;
5. Rearing chicks in fumigated facilities significantly improved the absorbability of lard fatty acids, especially if fed the high protein diet;
6. Feeding an antibiotic combination (penicillin, zinc bacitracin and chlortetracycline, each at 50 grams per ton) improved lard fatty acid absorption.

Both research groups at Cornell University (Renner and Hill, 1961a; Young, 1961) demonstrated that the absorbability of fatty acid mixtures was influenced by the presence, or absence, of an ester linkage to a glycerides moiety. No free glycerol was present in the fatty acid mixtures used by either research group.

Young & Garrett (1963) suggested that the improved utilization of saturated fatty acids (stearic and palmitic) may have been due to the presence of unsaturated fatty acids within the free fatty acid mixtures. Therefore, these Cornell investigators conducted a series of experiments to quantify the influence of absorbability that unsaturated fatty acid (oleic, linoleic) have upon saturated fatty acids (stearic, palmitic), when these fatty acids are fed in controlled ratios of saturated to unsaturated fatty acids.

Young & Garrett eliminated the effects of ester linkages or glycerides on absorbability by feeding only free fatty acids as the lipid sources. Their results showed that the absorbability of palmitic and stearic fatty acids, from any given fatty acid mixture, is influenced not only by the ratio of these two saturated fatty acids to oleic or linoleic fatty acids, or both, but also to the ratio of palmitic to stearic acid in the fatty acid mixture. They also noted that the absorbability of either pure fatty acid or various ratios of palmitic to oleic and palmitic to linoleic was expected to be low based on earlier observations. However, they found values much lower than expected. The authors stated they did not know if these lower than expected values were due to feeding lipids as pure fatty acids, or perhaps due to the lack of some component found within the hydrolyzed oils or other feed ingredients that may be necessary for increased absorption of these fatty acids.

Continuing their work, Young and Garrett (1963) indicated that two possible phenomena were involved in the absorption of fatty acids:

1. The transformation of fatty acids to a physical-chemical form that is more readily absorbed in the intestinal lumen;
2. The esterification of the fatty acid to form triglycerides within the intestinal mucosa that are found in the lymphatic chyle.

Young and Garrett concluded that they did not know why linoleic acid is not as effective as oleic in improving the absorbability of palmitic acid. It appears that the improvement in absorbability of the saturated fatty acid cannot be attributed simply to a decrease in melting point due to the presence of the unsaturated fatty acid. Therefore, oleic acid must play a more direct function in the absorption of fats within the lumen of the mucosal cells, in order to facilitate the increased absorption of palmitic acid.

Consistent with this hypothesis, Hofmann and Borgstrom (1962) earlier proposed that, prior to absorption from the intestinal lumen, mono-glycerides and fatty acid hydrolysis of fats form mixed micelles with bile acids. The authors conducted *in vitro* studies. Using micelles of bile acids and mono-olein, they were able to increase the solubilization of both stearic and palmitic acids. They also discovered oleic acid forms micelles with bile acids that will solubilize the saturated fatty acids. However, the micelles made with oleic acid are not as effective as those made with mono-olein. This indicates that glycerol induces a positive response in solubilizing the unsaturated fatty acid, oleic acid.

This work confirmed earlier work by Renner. Renner (1960), during her Ph.D. thesis work, showed that chicks fed palmitic acid in a mixture with triolein showed stepwise improvement in absorption of palmitic acid, up to 49% when fed in a ratio of 1 to 3, palmitic acid to triolein. Renner reported it appears that pancreatic lipase hydrolyzes the triolein to oleic acid and mono-olein. Additionally, both the formation of micelles and the synthesis or absorption of mono-olein as an “acceptor” is involved in the improved absorption of palmitic acid.

Intestinal mucosal enzyme systems responsible for the esterification of fatty acids to form triglycerides were evaluated with rats and rabbits during the early 1960's. Clark and Hubscher (1961) observed that a mitochondrial preparation required either alpha-glycerophosphate or a monoglycerides as an “acceptor” during the formation of triglycerides.

Swedish researcher, Borgstrom (1967) discussed the current understanding of fat digestion. The lumen of the intestinal tract contains an oil phase dispersed in a micellar bile salt solution. This emulsified oil phase contains primarily tri- and di-glycerides, while the micellar phase contains bile salt and the polar end products of pancreatic lipolysis, specifically monoglycerides and FFAs. Evidence, at the time, indicated that the absorption of lipids occurs primarily from the micellar phase. The micellar phase is continuously produced from the emulsified phase by products formed by pancreatic lipase action. Therefore, Borgstrom speculated that the redistribution of lipid-soluble products originating in the oil phase and moving to the micellar phase might be critical to the rate and magnitude of absorption. Using *in vivo* testing conditions, the oil phase is continuously used up with the production of polar (mono glycerides and fatty acids) products. It seemed reasonable (to Borgstrom) that, under these conditions, a portion of the non-polar (tri- and diglycerides) substances will remain dispersed but not solubilized when the oil phase is used up.

Ten years later, Cornell University researchers (Young and Garrett, 1974) continued the work to better understand the role that micelle formation plays in fat digestion. They conducted *in vivo* experiments using chicks reared under near normal physiological conditions to determine the absorption of specific fatty acids, glycerides and mixtures of both. Some test chicks were surgically altered to prevent the release of bile salts or pancreatic lipase into their intestinal tracts. Elimination of bile or pancreatic lipase was necessary to compare the absorption characteristics of specific glycerides unaltered by the digestive process.

The products of pancreatic lipolysis are solubilized to some degree in micellar solutions. These compounds are poorly soluble in water. The polar (amphiphilic) solutes have greater micellar solubility. It is believed that these compounds are aligned with their polar ends facing outward from the surface of the micelle. These polar solutes may also increase the solubility of the non-polar solutes, which are located within the center of the micelle. Palmitic acid is a relatively non-polar solute and has very low micellar solubility in aqueous solutions containing bile salts. Palmitic acid is completely insoluble in water without bile salts.

Young and Garrett classified polar solutes as the unsaturated fatty acids. In contrast, non-polar components were noted as being the saturated fatty acids and the higher melting point mono-glycerides. An additional property of the polar solutes is their ability to solubilize considerable amounts of non-polar molecules such as palmitic acid within the interior of the micelle. The *in vitro* solubility of palmitic acid was shown to increase several fold in the presence of suitable amphiphiles, such as mono-olein.

Young and Garrett (1974) also reported the very poor absorption of triolein (only 7% apparent absorption) and suggested that intact triglycerides are very poorly absorbed, even in the presence of bile salts. Mono-olein was absorbed significantly better than oleic acid and also demonstrated greater *in vitro* micellar solubility. Mono-olein was also superior to oleic acid in promoting the absorption of palmitic acid at various ratios. They presumed this was result of increased solubilization of the saturated FA mono-glyceride within the lipid bile salt micelles.

FACTORS AFFECTING THE ABSORPTION OF FREE FATTY ACIDS

Sklan (1978, Hebrew University, Israel) conducted research to study the factors affecting the absorption of FFAs by the chick. He discussed acidulated soapstocks (ASS) since they are a common feed fat source for poultry. Sklan commented that ASS usually contains a large amount of FFA and little neutral oils. Earlier work from several authors found that absorption of FFA was up to 9% less than for those in neutral oils (triglyceride form). Sklan speculated that the reduction in fat absorption observed when feeding FFA or ASS may be related to a lack of mono-glycerides, resulting in incomplete micellar solubilization of the FFA.⁴ Sklan (1978) compared diets fed containing either; soy oil, soy oil FFA or soy oil FFA plus glycerol. Sklan found absorption of individual fatty acids was poorest for stearic acid (58-66%) and greatest for linoleic and linolenic acids (92 to 85%). The following notable observations were reported:

1. Absorption of total fatty acids in the chick was greater for those fed triglyceride (TG) compared to FFA.
2. Polyunsaturated FFA had greater total absorption than did saturated FFA;
3. Feeding FFA plus glycerol, gave an intermediate response to absorption and mono-glyceride (MG) levels in the lower ileum, compared to feeding only triglycerides or only FFA;
4. The presence of MG in the intestinal tract of chicks fed FFA plus glycerol indicated that MG was synthesized in vitro in the presence of the pancreatic homogenate. MG was also recovered from chicks fed only FFA plus glycerol;
5. Chicks fed only FFA secreted less bile salt than TG fed chicks. Less bile salts secretion would result in less micellar solubilization of fatty acids;
6. These results support the need for mono-glycerides in the efficient solubilization of FFA.

TRUE METABOLIZABLE ENERGY

Canadian researcher, Sibbald (1978), developed methods to determine the True Metabolizable Energy (TME) content of feed ingredients by using cecectomized adult roosters. Sibbald and Kramer (1977) earlier demonstrated that the TME values of some fat sources are improved by feeding a 50:50 blend with another fat. Therefore, Sibbald designed experiments to evaluate the effect on TME when substituting soy oil for tallow and substituting lard for tallow. Nine levels of substitution for soy and lard were 0, 1, 2, 4, 8, 16, 32, 64 and 100%. This work demonstrated that as little as 2% soy oil mixed with 98% tallow substantially increases the TME of tallow. His data also suggested that small additions of soy oil to tallow elicit greater energy responses than do larger additions within these blends. This supports the hypothesis given by Leeson and Summers (1976) that small quantities of certain types of lipids found in some feedstuffs can profoundly affect the total utilization of fat in the poultry diets.

Belgium workers Huyghebaert, De Munter and De Groote (1987) recognized the need and evaluated the metabolizable energy (AME_n) and digestibility values of 23 varied feed fats and oils using broiler chicks. The Dutch market traditionally used tallow, lards and various blends thereof. Soybean oil was used commercially if it was economically priced in the market. Additionally, "used frying fats" (aka. spent restaurant grease) became increasingly available and was used in many fat blends. Great variation in quality had been seen among current Belgium fat supplies and consequently there was a recognized need to better predict the energy value of such varied fat blends. Consequently, De Munter and De Groote designed a practical testing procedure to predict energy values. They did so by feeding 13-24 day old chicks sorghum-soybean diets that had test fat inclusion at 9% and which used a total excreta collection system.

These researchers conducted analytical testing and in vivo feeding trials to collect data that could be used in calculating regression equations to predict apparent metabolizable energy values with nitrogen corrected (AME_n). AME_n methods and determination are fully explained in a previous article by Huyghebaert and De Groote, 1986. Nitrogen correction is necessary within a total excreta collection system due to the fact that poultry void both fecal and urinary excreta together through the cloaca. De Munter and De Groote corrected for zero nitrogen balance (AME_n) by using 34.89 kJ g⁻¹ N retained.

Several chemical and physical parameters were used to develop regression equations that would correlate with the AME_n values found in the chick feeding trials. They included: gross energy, moisture, impurities, melting point, FFA, peroxide value, saponification value, unsaponifiable matter and iodine matter. In doing so, column chromatography values, FR1, FR2 and FR3 were explained. FR1 was the first fraction and contains the practically unaltered triglycerides and non-polar components. FR2 contains degradation products which are the more polar substances such as, FFA, phospholipids, peroxides, aldehydes). FR3 was eluted with methanol and was expected to contain fat components with higher molecular weight, but unknown chemical structure.

⁴ Absorption of triglycerides proceeds after partial hydrolysis by pancreatic lipase to produce 2 free fatty acids and the FA carbon-2 position mono-glyceride. The C-2 mono-glyceride promotes solubility and resulting absorption of FFA in the mixed bile salt-mono-glyceride-fatty acid micelle.

De Munter and De Groote determined Iodine Value (a measure of the degree of unsaturation) was higher for vegetable oils than for animal fats, and was also reduced by high frying temperatures. Unsaturated fatty acids were more subject to oxidation. Heating also caused increases in peroxides and aldehydes, but not FFA, as shown by decreases in FR1 and FR2. They noted that heating reduced the sum of FR1+FR2, while increasing FR3. FR3 contained the more complex and higher molecular weights components. This change caused by heating fats was pronounced in the TGF sample. The TGF fat sample was presumed to contain more heat damage and/or polymerized fatty acids since it was an end product of fatty acid manufacture.

Within the AME_n determinations, soy oil values were much greater than for animal fats or palm oil. AME_n for Palm oil was comparable to tallow which suggests that the saturated FA, especially C16:0, are mainly located in the 1, 3 positions of the glycerol molecule.

Heating fats and oils created more variability among AME_n values. It is known that unsaturated fatty acids were more prone to oxidative degradation than saturated fatty acids. Chemical analysis of heated soy oil showed a decrease in linoleic acid, iodine value and the non-polar (FR1) content. However, the reduction in FR1 was not accompanied by an increase in polar FR2 (FFA), thus suggesting the formation of non-eluable high molecular weight compounds (polymers).

Regression analysis of the chemical analyses and AME_n determinations demonstrated the following for these 23 Belgium fat sources:

1. Energy value is greater for unsaturated than saturated fatty acids;
2. Energy is greater for C16:0 than for C18:0 FAs. This is more pronounced in the animal fats (lard vs. tallow);
3. I2 x FR1 (Iodine value x first fraction containing unaltered triglycerides, TG) was important because it combined the degree of saturation with the quality and quantity of TG, including oxidative conversion and polymerization. High temperature heating of fats and oils reduced IV value and the amount of unaltered TG;
4. The authors cautioned against extrapolation of these equations to other fats types;
5. They also stated that the predictive equations would have broader accuracy and application if other parameters were introduced (C14:0 content; proportion of C16:0 to C18:0 in the C2 position of the TG; and the degree of fat polymerization);
6. Energy values may be reduced by the presence of damaged fats (dimeric or polymerized FA).

DEGREE OF FAT SATURATION AND AME_n VALUES

Belgium investigators, Ketels and De Groote (1988), followed up with another sets of experiments to study the relationship between the degree of saturation and AME_n values of two-week-old broiler chicks. They speculated that the ratio of unsaturated to saturated FA (U:S ratio) is important in affecting the energy content of dietary fat sources, since the U:S ratio is an important criterion affecting the metabolizable energy of fats fed to swine (Stahly, 1984). They evaluated soy oil, tallow, lard and three commercial blends of tallow and lard. They also used three basal diets which consisted of sorghum, wheat or corn as a base cereal. The fat inclusion levels were in a practical range of 2.5 to 12.5%. A total of 45 test diets were evaluated and used to calculate the regression equations. Prior to these experiments, most AME_n determinations were conducted using adult roosters or older broilers.

The authors determined that the fatty acid composition of the basal dietary fat (grain of oils seed sources) and supplemental fat inclusion rates are very important when evaluating the energy content of an added fat source:

1. Increasing the rates of supplemental animal fat to basal diets resulted in a stepwise decrease in AME_n for that fat.
 - a. Diets composed of cereal grains naturally contain small amounts of unsaturated FAs with a U:S value generally between 3.5 – 4.5. The authors described these values as “hinge points” in their regression equations. In other words, at lower U:S ratios, fat utilization parameters can change quickly if a saturated animal fat is fed;
 - b. However, adding an unsaturated vegetable oil to the basal diet can increase or sustain the U:S ratio at levels greater than 4. At high U:S ratios, supplemental fat utilization and AME_n are nearly unaffected.
2. Small amounts of basal diet unsaturated fatty acids may improve the absorption of added animal fats. AME_n values of added animal fats were greater in corn basal diets than for wheat or sorghum. Corn has a greater U:S ratio for its crude fat content than wheat or sorghum.

3. Synergy of fat sources was observed in all experiments. For example, increasing the U:S value of a 10% added tallow diet by substituting 1 part with soy oil (1% soy, 9% tallow) raised the dietary U:S ration from 1.35 to 1.80. This small amount of soy oil added to tallow increased AME_n values from 6,100 to 7,000 kcal/kg. The calculated theoretical value of this blend should be only 6,300 kcal/kg. This supports findings of Lall and Slinger (1973) and Sibbald (1978) that showed increases in total AME_n, greater than expected, by replacing 10 to 20% tallow with soy oil.
4. The authors concluded that for young (2 week) broilers, the chemical composition of the basal diet, especially the degree of unsaturation (U:S) accounted for about 75% of the variation in AME_n of the added fats tested.

By now, it should be apparent that many factors are involved in the absorption and utilization of fats and oils within poultry. Fed as single sources, unsaturated fats are more readily utilized than saturated fats. Meanwhile, blends of unsaturated and saturated fats can improve utilization. Understanding why this is true requires some familiarity with the critical role that bile salts and micellar solubilization have in fat absorption, especially for fat sources rich in saturated FA. As discussed earlier, mono-glycerides are important in the solubilization of fatty acids within the micelle. Free fatty acids and acidulated soapstocks have demonstrated good feeding values.

FAT CHARACTERISTICS EFFECT MEAT QUALITY

Custom blends can also be used to modulate or control carcass meat quality. The Dietary fatty acid profile will directly modify carcass fatty acid composition in turkeys, as well as other poultry and swine. (Marion and Woodruff, 1963; Yau et al., 1991; Edwards et al., 1973; Salmon and O'Neil, 1973; Salmon, 1971; Cruickshank, 1934; Hilditch et al., 1934.)

Turkeys have the ability to alter their carcass fatty acid composition to mirror the fatty acid composition in the diet. In this regard, "they are what they eat". R.E. Salmon (1976) found that the rate of change in turkey carcass fatty acids was a general phenomenon and was not related to feed fat saturation or carbon chain length. It takes about 2-3 weeks to turn over the FA composition of carcass fat in the turkeys. Turkey hens changed their FA composition more quickly than males. Also, carcass FA response to dietary fat changes decreased with age. This suggests that commencement and duration of feeding FA to change carcass composition requires additional understanding to accomplish the desired benefits. It also likely means that you have to start earlier, rather than later, to make desired carcass FA changes in the turkey.

Dietary FA profile can alter carcass composition (meat yield) in broilers. Feeding higher levels of saturated or monounsaturated FA can lower broiler carcass yields by increasing abdominal fat pads, compared to feeding unsaturated FA. (Peebles et al., 1999; Sanz et al; 1999.; Crespo and Esteve-Garcia, 2001; Crespo and Esteve-Garcia, 2002) Other researchers have suggested that the reduction in broiler abdominal fat accumulation, using polyunsaturated FA, may be partly due to increased lipid catabolism and decreased FA synthesis rates (Sanz et al., 2000). No research in turkeys for this topic was found.

Iodine Value (level of unsaturation) of feed fat can directly influence turkey carcass fat composition. Feeding turkeys solely with vegetable oil will create soft fat that purges out in consumer packages. Controlling the hardness of carcass fat has not been a huge concern in the past, although the author has experienced brief isolated occurrences of "soft, purging" turkey fat in finished meat products when inadvertently fed high levels of unsaturated fats. Nutritionists usually could not afford high cost vegetable fat sources (corn oil, soybean oil) in diets, so this fat softness was not a concern. However, with the explosion of ethanol production, a new corn co-product, DDGS, is now used in relatively great abundance, especially in Midwest turkey diets. Corn derived DDGS contain crude fat levels ranging from 6 – 10%, thus adding an additional supply of straight corn (vegetable) oil to the turkeys.⁵

Moran et al. (1973) evaluated the effects of full-fat soybeans (soy oil) and tallow upon the tissue FA and organoleptic properties of large white turkeys. These researchers reported that tallow fed turkeys contained more saturation, while those fed full-fat soybeans contained more unsaturation in the neutral lipid extracts of skin and breast tissues. Organoleptic evaluations demonstrated a significant improvement for turkey breast meat flavor using the full-fat soy bean fed turkey, compared to tallow fed birds.

⁵ As a side note, this is an extremely critical issue in pork production. The ability to acceptably slice bacon is primarily dependent upon the firmness of the pork carcass fat. Swine nutritionists now actually formulate feed using Iodine Value as a nutrient constraint to control carcass fat properties.

UNRELIABLE SERVICE CAN NEGATIVELY IMPACT BIRD NUTRITION AND HEALTH

Feed suppliers need to supply turkey feed producers with a consistent product, on-time delivery, and minimal handling issues. Running out of feed fat at the mill usually leaves no choice but to halt feed production until inventory is replenished. There are no other ingredients in a feed mill to substitute for fat. Modern turkeys are “eating machines”. When turkeys are “off” feed for even a couple of hours, serious gut health ramifications can occur. The longer the turkey is out of feed, the more likely a potential serious health event may occur (litter eating, gut micro-flora changes, disease- coccidiosis, E. coli, enteritis, crop mycosis).

While turkeys can be fed diets without supplemental fats and this option is better than no feed by reducing the immediate health risks associated with eating litter, feed intake will likely suffer as well as dust control and air quality. Sometimes flocks will refuse feed produced without added fat because of poor palatability. The best remedy against these types of negative outcomes is working with a reputable, Certified Safe Feed/Safe Food supplier that can deliver high-quality products, on time.

SUMMARY

1. Why use supplemental feed fats in turkey diets?

- a. Commercial turkeys respond to dietary fat supplementation positively through increased weight gains and feed efficiencies.
- b. Breeder turkeys respond to added dietary fat though increase egg production.
- c. An opportunity may exist to improve body weights, feed efficiencies and breast meat yield by feeding higher than traditional levels of A-V fat sources to young poults (1-14 days of age).

2. What are the advantages & disadvantages of vegetable or animal fat sources for turkey production?

- a. Large body of poultry research (Turkeys, Broilers) conclude that unsaturated (vegetable) fats are absorbed more readily, and have greater metabolizable energy, than saturated (animal) fat sources.
- b. Traditional analytical and quality measures (moisture, insolubles, unsaponifiables, iodine value, FFA) do not adequately explain potential metabolizable energy values of blended fat sources, particularly those containing FFA from acidulated soap stocks.
- c. Several papers have been cited to provide the reader with a better understanding on other areas necessary for turkeys (broilers) to utilize FFA optimally:
 - i. Fats are primarily absorbed as lipid-bile salt micelles in the gut.
 - ii. Mono-glycerides are necessary to maximize lipid micelle solubilization of FFA.
 - iii. FFA from unsaturated sources are utilized better than those from saturated sources.

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