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Feed Application of High Oil Corn for Poultry : A Review

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가금에 있어서 High Oil Corn의 사료이용

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ABSTRACT: Because of the significant genetic improvement in animal performance, the use of high nutrient density diets has become common practice in animal industry. High oil corn (HOC) became available to feed manufacturers about half a decade ago. Current HOC contains approximately 87 % higher crude fat, making its energy content 4.5 to 6 % higher than that of typical corn. Its protein content is 3.3 to 6.4 % higher; and its qualities are at least equal or better than that of typical corn. In addition, there are several non-nutritional benefits which may result from the use of HOC. These nutritional and non-nutritional advantages could be captured by the feed manufacturers in general, and poultry producers in particular.

(Key words: high oil corn, poultry, ME, amino acid, carcass quality, vitamin E)

INTRODUCTION

Almost 90 % of the world's production is fed to poultry and livestock. Nearly all its co-products from the food processing industry are used as animal feed. It is the world's most common feed ingredient. It is traded globally as a graded, bulk commodit- more than 800 million tons in 1998. Yet, yellow maize- also known as yellow dent corn- is also the most consistently inconsistent raw material available for use in animal feeds.

Yellow dent corn yields have been greatly improved by plant breeders since the 1950s. Unfortunately, as yields heightened and other agronomic traits were improved nutritional quality declined and variability increased. 'Identity preserved' (IP) high oil corn (HOC) became available to feed manufacturers only a few years ago. Already, however, new generations of value enhanced corn with multiple advantage-ous traits are coming into the market.

Grains with designer traits offer opportunities for improved animal performance, potential health benefits for the animal, more flexibility in ration formulation, possible reductions in feed costs, possibility of reducing manufacturing costs, improved pellet quality and potentially environmentally friendly feeding ingredients. Maintaining the integrity and identifying these grains to determine their value to the end user will be a major challenge.

The question becomes, will the livestock and poultry producer pay for the HOC's added value. Because of the significant genetic improvement in animal growth, lean growth, and feed efficiency, the use of high nutrient density diets has become common practice in poultry and swine productions. As indicated later, the need for high-energy diets, and concerns for quality and prices of fat sources, may make the attributes and benefits of HOC an attractive alternative to fat sources and other ingredients.

HIGH OIL CORN AS A FEED INGREDIENT

One of the genetically improved grains that have gained commercial feed ingredient status is HOC. The increased oil content is largely due to an increase in the germ portion of the kernel, and there is an increase of 0.38 % in protein with each 1 % increase in oil (Watson and Freeman, 1975). Because corn germ proteins are of better quality compared to endosperm proteins (Araba, 1999), the protein increase in HOC results in an improvement of its total protein make-up compared to typical corn. While several types of HOC grain

Table 1. Proximate composition of high quality typical corn and high oil corn (HOC)[1]

	Typical corn	HOC
Crude fat, %	3.60	6.73
Crude protein, %	8.17	8.44
Crude fiber, %	2.08	2.08
Ash, %	1.21	1.30

[1] Values were expressed at 87% dry matter.
Source: Araba, 1999.

have been commercialized in the past 5 years, nutrient composition of one of the widely commercialized HOC is listed in Tables 1 through 5.

Current HOC contains approximately 87 % higher crude fat, 3.3~6.4 % higher crude protein compared to typical corn. An increase of 1 % point in crude fat concentration typically results in 1 % point decrease in starch concentration. Since fat contains approximately 2.25 times more energy than a similar unit of carbohydrate the net outcome is an increase in the energy content of the grain.

Due to the increase in the germ fraction of the kernel in HOC at the expense of that of the endosperm, protein quality of the entire grain is improved (Table 2). Germ proteins in corn contain only a very small quantity of the protein zein which is very deficient in amino acids such as lysine, tryptophan and alanine (Araba, 1999). Endosperm proteins, on the other hand, contain as much as 52 % zein. In addition to the improved chemical composition of HOC, the method of production and supply of the grain through identity preservation typically results in improved physical quality in terms of lower levels of foreign matter, broken and damaged kernel. According to the report of USGC (1998), the physical quality of HOC in the market channel is equal or better than US No.2.

The increase in crude fat in HOC results in a change in the fatty acid profile of the oil (Table 3). Typically, the concentration of linoleic acid (C18:2) in the grain is inversely correlated to that of oleic acid (C18:1). Oil from the HOC contains approximately 8 % point less C18:2 and 8 % more C18:1 than oil from typical corn grain. Unlike the commonly made assumption, oil from HOC grain contains less polyunsaturated fatty acids than that from typical corn grain.

Table 2. Amino acids composition of high quality typical dent corn and high oil corn (HOC)[1]

	Typical corn		HOC	
Mean crude fat and crude protein;				
Crude fat, %	3.51		6.34	
Crude protein, %	7.65		8.02	
Amino acids;	Mean	%P[2]	Mean	%P
Lysine, %	0.248	3.20	0.274	3.54
Methionine, %	0.183	2.36	0.201	2.60
Cystine, %	0.183	2.37	0.196	2.54
Tryptophan, %	0.059	0.76	0.065	0.83
Threonine, %	0.289	3.73	0.307	3.98
Valine, %	0.379	4.90	0.420	5.43
Isoleucine, %	0.276	3.57	0.305	3.95
Leucine, %	0.921	11.9	1.046	13.5
Tyrosine, %	0.370	4.79	0.386	4.99
Phenylalanine, %	0.418	5.40	0.416	5.37
Alanine, %	0.565	7.31	0.642	8.30
Glycine, %	0.311	4.02	0.345	4.46
Histidine, %	0.240	3.10	0.264	3.42
Arginine, %	0.388	5.03	0.439	5.68
Aspartate, %	0.544	7.03	0.577	7.45
Glutamate, %	1.416	18.3	1.572	20.3

[1] Values were expressed at 87% dry matter.
[2] % P = Amino acids as a % of crude protein.
Source: Araba, 1999.

Due primarily to the quantitative exchange between C18:1 and C18:2, the iodine value of oil from HOC is slightly lower than that of oil from typical corn, suggesting a more stable HOC oil. Due to the higher oil concentration in HOC, the latter will contain greater concentrations of both C18:1 and C18:2 compared to typical corn. This may have implications in feeding meat-type or egg-type birds. Results from a recent study with broiler chickens (Araba and MacNaughton, 1997; unpublished data) suggested that meat from birds fed HOC may have greater oxidative stability, compared to meat from birds fed typical corn. These results may, however, be due to the 60~65 % higher total tocopherol concentration in HOC, compared to typical corn.

Tocopherol concentrations are usually proportional to the concentration of oil in the grain. Oilseeds such as soybeans contain high levels of tocopherols. HOC appears to contain

Table 3. Fatty acid composition of high quality tipical dent corn and high oil corn (HOC)[1]

	Typical corn	HOC
Mean crude fat and crude protein;		
Crude fat, %	3.35	6.32
Crude protein, %	7.34	7.80
Fatty acids;[2]		
Palmitic, C16:0	10.48	11.22
Stearic, C18:0	2.13	2.65
Oleic, C18:1	28.00	34.80
Linoleic, C18:2	56.35	48.93
Linolenic, C18:3	1.50	1.01
Total saturated fatty acids	12.61	13.87
Total unsaturated fatty acids	85.85	84.74
Calculated iodine value[3]	131	123

[1] Values expressed at 87 % dry matter.
[2] Total fatty acids may not add up to 100 %; only main fatty acids are represented above.
[3] Calculated IV = Calculated Iodine Value based on the fatty acids listed above.
Source: Araba, 1999.

Table 4. Comparison of high quality typical dent corn and high oil corn (HOC); Tocopherols and xanthophylls[1,2]

	Typical corn	HOC
Tocopherol (mg/kg);		
Alpha	22.6	34.1
Delta	2.57	2.87
Gamma	46.3	79.5
Xanthophyll, (mg/kg)[3]	17.40	18.36

[1] Values are expressed at 87 % dry matter.
[2] Values are means of samples up to 1996 production.
Source : Araba, 1999.

as much as 60~70 % greater concentrations of tocopherols compared to typical corn (Table 4). In particular, α- and γ-tocopherols appear to increase in HOC, compared to typical corn. Under similar conditions of production and storage, total xanthophyll concentration in HOC is practically similar to that in typical corn.

Mineral concentration in feed grains is highly variable and dependent on a number of growing conditions. Although small, the number of samples analyzed indicate that the concentrations of major and trace minerals in HOC are within the range of variability in those typically found in corn (Table 5). Phosphorus concentration in HOC tends to be greater than that in typical corn.

Table 5. Mineral composition of high quality typical dent corn and high oil corn (HOC)[1]

Minerals	Typical corn	HOC
Ca, %	0.01	0.01
P, %	0.24	0.26
Mg, %	0.08	0.09
S, %	0.08	0.08
Mn, ppm	4.60	6.60
Fe, ppm	20.1	27.6
Cu, ppm	3.13	5.12
Zn, ppm	17.4	20.9
Se, ppm	0.08	0.09
Co, ppm	0.98	1.00

[1] Values are expressed at 87% dry matter.
Source: Araba, 1999.

HIGH OIL CORN IN POULTRY DIET

A number of reports that have evaluated HOC for its nutritive value for poultry have appeared in the literature in the past 10 years. The poultry industry worldwide has also conducted research under practical poultry production conditions to determine the nutritive and economic values of HOC. These reports show that due to its high metabolizable energy or nutrient density, HOC can be of great importance to the poultry industry.

1. Metabolizable Energy

Metabolizable energy increases of 4.5 to 6 % for HOC (6 to 7 % oil at 86~87 % dry matter) above that of typical corn have been reported repeatedly (Han et al., 1987; Dale and Whittle, 1991; Bartov and Bar-Zur,1995; Noy et al., 1996a,b; Adams et al., 1994; Vieira et al., 1997).

A summary of seven true metabolizable energy studies (Araba et al., 1996a) is summarized in Table 6. Each study included a control typical corn grain and a number of HOC grain which differ genetically but provides similar chemical

Table 6. Proximate composition, NFE, starch, gross energy (GE) and TMEn of high oil corn (HOC) and typical corn in adult roosters[1]

	Crude fat	Crude protein	Crude fiber	Ash	NFE	Starch	GE	TMEn	TMEn/GE ×100(%)
	%						----kcal/kg----		%
Corn	3.5^B	7.9^B	1.7	1.1	72.9^A	61.5^A	3892^B	3408^B	87.5
HOC	6.8^A	8.7^A	1.8	1.2	68.5^B	58.6^B	4107^A	3615^A	88.0

[1] *Values within a column with different superscripts are significantly different* (P<.05).
All values are expressed at 87 % dry matter.
Source : Araba, Dyer, and Dale, 1996.

Table 7. Comparison of protein quality of conventional (CONV) and high-oil corn (HOC)[1]

Treatment[2]	Gain	Gain/feed	PER[3]	NPR[3]
	(g)	(g/g)		
1. Protein-free basal (B)[4]	−7.5	−0.119	...	...
2. B+CONV corn (7% CP)[5]	25.95	0.215	3.08	3.98
3. B+HOC (7% CP)	23.05	0.214	3.06	4.07
4. B+89.23% CONV corn	27.67	0.236	3.12	3.97
5. B+89.23% HOC	28.71	0.249	2.94	3.92
Pooled SEM	1.28	0.010	0.15	0.14

[1] Data are means of three groups of seven female crossbred chicks from 8 to 15 days posthaching; average initial weight was 67.2g.
[2] Treatments 2 and 3 contained CONV or HOC on an equal protein basis, and treatments 4 and 5 contained the corns on an equal weight basis.
[3] PER = Protein efficiency ratio = weight gain (g) divided by protein intake (g). NPR = Net protein ratio = [weight gain (g) of birds fed test diet minus weight gain (g) of birds fed the nitrogen-free diet] divided by protein intake (g).
[4] Protein quality assay II; Willis and Baker (1980).
[5] CP = crude protein.
Source: Han et al. 1987.

compositions. Data from these and other experiments resulted in the development of prediction equations for a HOC. Nitrogen-corrected true metabolizable energy can be predicted from crude fat alone through the equation shown below (Araba et al., 1998).

$$TMEn(kcal/kg\ DM) = 3623 + 99.5\ (Crude\ Fat,\ \%\ DM) - 3.9(Crude\ Fat,\ \%\ DM)^2$$

It is apparent from the data that TMEn of HOC can be predicted fairly reliably from crude fat alone. This is important because near infra red (NIR) technology can be successfully used at elevators and feed mills to identity-preserve the chemical quality of HOC.

2. Protein Quality and Amino Acid Digestibility

The protein qualities of HOC and typical corn were compared with female crossbred chicks fed corn as the sole source of dietary protein (Han et al., 1987). As shown in Table 7, there was no difference in either protein efficiency ratio or in net protein ratio between the two types of corn.

Amino acid digestibility coefficients (Table 8) in HOC have been shown to be equal to or greater than those in typical corn (Zhang et al., 1995). Three HOC varieties, with 5.9%, 6.6%, or 9.5% oil, respectively, on a 100 % DM basis, were evaluated for their true amino acid digestibility coefficients using the precision fed rooster bioassay. On average, true digestibility coefficients of amino acids in the

Table 8. True digestibility(%) of amino acids in conventional(CC) and high oil corns (HOC)[1]

Amini acids	CC	HOC_1	HOC_2	HOC_3	SEM
Aspartic acid	79.9^{b}	80.9^{b}	91.5^{a}	91.8^{a}	2.8
Threonine	67.4^{b}	65.8^{b}	79.8^{a}	81.0^{a}	4.2
Serine	72.7^{b}	72.0^{b}	87.8^{a}	86.7^{a}	4.1
Glutamic acid	88.7^{b}	88.1^{b}	95.9^{a}	95.6^{a}	2.0
Proline	84.0^{b}	83.2^{b}	92.4^{a}	92.9^{a}	2.3
Alanine	88.7^{ab}	85.3^{b}	96.9^{a}	96.6^{a}	2.9
Valine	85.8^{b}	88.3^{b}	100.8^{a}	100.7^{a}	3.6
Isoleucine	84.2^{b}	86.4^{b}	100.0^{a}	98.7^{a}	3.8
Leucine	92.4^{b}	92.2^{b}	99.0^{a}	99.6^{a}	1.9
Phenylalanine	67.2	63.9	73.2	74.5	7.6
Histidine	81.2	81.6	87.7	85.9	3.1
Lysine	79.3	78.6	92.8	87.8	6.5
Arginine	79.3^{b}	81.2^{b}	95.4^{a}	94.1^{a}	3.7
Cystine	65.2^{c}	71.2^{bc}	85.4^{a}	81.5^{ab}	4.0
Methionine	83.0	85.6	92.1	89.3	3.8
Mean	79.9	80.3	90.8	91.1	

[1] Means within rows having no common superscripts are significantly different ($P<.05$).

Source: Zhang et al., 1995.

Table 9. Performance of turkeys fed diets containing control (Ctrl) typical corn or high oil corn (HOC)[1]

Breed	Sex	Age (wk)	Body weight or gain(lb)		Feed Conversion	
			Ctrl	HOC	Ctrl	HOC
Nicholas	M	16	22.06	22.26	2.567	2.560
British	M	19	34.30	34.07	2.474	2.488
United	F	15	18.30	18.29	2.264	2.259

[1] In each study, diets with or without HOC were formulated to be isocaloric and isonitrogenous. Bird performance was expected to be similar between treatments.

Source : Araba et al., 1996.

Table 10. Effect of feed form on the performance of turkey hens fed diets with or without two sources of high oil corn (HOC): a 6.5% oil HOC and a 8.5% oil HOC[1]

Treatment	Corn type	Feed form	Weight gain(LB)	Feed conversion
1	Typical	Mash	21.8^{BC}	2.396^{B}
2		Pellet	22.6^{A}	2.252^{A}
3	6.5% HOC	Mash	21.5^{CD}	2.410^{BC}
4		Pelle	22.2^{AB}	2.278^{A}
5	8.5% HOC	Mash	21.0^{D}	2.434^{C}
6		Pelle	21.9^{ABC}	2.225^{A}

[1] Values within each row with similar letters are significantly different ($P<.05$).

Source: Araba et al., 1996b.

6.6 and 9.5 % oil varieties were greater than, while those of the 5.9 % variety were equal to that of typical corn.

3. Practical Nutritional Value of HOC

The increase in metabolizable energy and amino acids in HOC have also been shown to be reflected in broiler chickens, turkeys, and laying hens (Han et al., 1987; Noy et al., 1996a, Adams et al., 1994; Mireles et al., 1996).

A number of studies have been conducted with HOC in broiler chickens and turkeys. Han et.al.(1987) showed that weight gain and feed conversion were improved in broiler chickens fed diets containing HOC. The magnitude of response was highly correlated to oil content of the corn. The same authors also concluded that hens fed diets containing HOC from 23 to 38 weeks of age had a better feed-to-egg ratio than those fed the same diet containing typical corn when the corn sources were substituted on an isonitrogenous basis. Egg production and egg yield tended to be improved for hens fed diets containing HOC. Adams et al.(1994) concluded that HOC can be used to increase the energy density of broiler diets without the use of high levels of supplemental fat. This means that HOC provides significant space flexibility in feed formulation that can be exploited to further reduce feed cost (Noy et al., 1996a,b).

The nutritional value of HOC has also been evaluated in turkeys. Table 9 shows an example of results from two studies conducted with Nicholas and British United Turkey (BUT) breeds. HOC can be included at high inclusion levels in turkey diets, and expected performance with each of the breeds used can be reached according to production goals. Recently, a study was conducted with HOC in turkey hens to evaluate the effects of feed form (mash vs. pellet) on bird performance (Araba et al., 1996b). Turkeys of the BUT breed were fed diets with or without HOC (two HOC grain types:

Table 11. Effects of feeding high oil corn (HOC) to Avian x Peterson birds on live performance and carcass characteristics[1,2]

		Control	HOC
Males	Live weight, lb	6.54[b]	6.66[a]
	Adjusted feed:gain	1.89[a]	1.87[b]
	Hot weight, lb	4.38[b]	4.50[a]
	% hot weight, lb	67.4	67.5
	Fat pad weight, lb	0.13	0.13
	Fat pad, % hot weight	2.94	2.88
	Chill weight, lb	4.45[b]	4.61[a]
	% chill weight	69.3	69.1
	Breast weight, lb	0.85[b]	0.90[a]
	Breast, % chill weight	19.33	19.45
Females	Live weight, lb	5.48	5.46
	Adjusted feed:gain	1.89[a]	1.87[b]
	Hot weight, lb	3.72	3.77
	% hot weight, lb	67.0[b]	67.6[a]
	Fat pad weight, lb	0.15	0.16
	Fat pad, % hot weight	4.10	4.23
	Chill weight, lb	3.84	3.87
	% chill weight	69.1	69.4
	Breast weight, lb	0.79	0.80
	Breast, % chill weight	20.46	20.61

[1] Means within each row with different letters are significantly different (P<.05).
[2] Feed:gain ratio for males and females were combined (pen value).
Source: Mireles et al., 1996.

the 6.5 % oil and the 8.5 % oil were used) in mash and pellet form up to 115 days of age. Results from this study are shown in Table 10. It was concluded that birds fed the 6.5 % HOC-feed had weight gain and feed conversion ratios which did not differ from those fed isocaloric typical corn-based diets, regardless of feed form. When the 8.5 % HOC was fed, the results appeared to be feed form dependent. In pellet form, feed conversion of birds fed control or 8.5 % HOC-diets did not differ significantly. However, in mash form, hens fed the 8.5 % HOC-diets had a poorer performance than control birds. The poorer bird performance appears to be due to the finer ground particle size of 8.5 % HOC. This latter grain, which is no longer produced commercially, did have a softer endosperm than typical corn or the 6.5 % HOC, a characteristic that may have contributed to the finer grind.

4. Carcass Quality

Feeding HOC to broiler chickens or turkeys can, not only result in expected live weights and feed conversion ratios, but it can also result in good processing carcass characteristics. Results from a study conducted with Avian x Peterson birds where iso-caloric and iso-nitrogenous diets with or without HOC were fed from 1 to 52 days of age are shown in Table 11. While parameters were expected to be similar between treatments, weights and feed conversion of males fed HOC-diets were slightly better than those of the control birds.

Due to the change in the fatty acid profile and the concentration of oil of HOC, fatty acid profile of carcass fat may be slightly changed. The magnitude of this change will depend upon the source of fat, the level of fat, and the level of HOC in the diet. The change, however, is very small and may be practically insignificant (Araba et al., 1996b; Mireles et al., 1996). Table 12 shows changes in fatty acid profile of carcass fat in broiler chickens fed diets based on typical corn or on HOC (Mireles et al., 1996). Due to the higher linoleic acid content of the HOC-diets, there is a slight and non significant increase in carcass fat linoleic acid percentage.

Table 12. Carcass fatty acid profile of broiler chickens fed diets with or without HOC from 11 to 48 days of age[1]

	Carcass fatty acid profile (% total fat)									
Treatment	C12:0	C14:0	C16:0	C16:1	C17:0	C18:0	C18:1	C18:2	C18:3	C20:1
Control	0.2	1.0	24.6	8.7	0.0	5.0	42.8	16.8	0.5	0.4
HOC	0.0	0.7	22.5	8.7	0.1	4.5	41.9	20.7	0.7	0.3

[1] Carcass crude fat and moisture contents for control and HOC birds were 17.2 and 61.0%, 17.0% and 64.1%, respectively.
Source : Mireles et al., 1996.

Similar conclusions were reported by Adams et al. (1994). Noy et al. (1996a), however, reported that feeding HOC to broiler chickens resulted in increases in oleic acid concentration in carcass fat, and that this may lead to better oxidative stability, relative to control birds. Results from a recent study with broiler chickens suggested that meat from birds fed HOC may have greater oxidative stability, compared to meat from birds fed typical diets. The improved oxidative stability of meat from birds fed HOC was thought to likely be due to the 60~65 % higher total tocopherol concentration in HOC, compared to typical corn (Araba and MacNaughton, 1997; unpublished data).

HIGH OIL CORN : VALUE ADDED FEED INGREDIENT

It is evident that the nutritional and physical attributes of HOC can translate into a number of benefits to the animal feed industry. Potential benefits of currently available or future HOC grain to feed manufacturers in general, and poultry producers in particular are:

- Reduced feed costs due to reduction or elimination of poor or unknown-quality added fats;
- Reduced feed costs due to reduction in protein or crystalline amino acid supplements;
- Reduction or elimination of purchase, storage, and mixing needs of added fats;
- Higher nutrient-dense diets can be attained at comparable levels of supplemental fats;
- Feed formulation flexibility and use of low energy feed ingredients;
- Uniformity in physical grain quality due to identity preservation grain production and supply system (i. e., at least US No. 2 is guaranteed);
- Reduction in dust generation (Rand et al., 1997);
- Transportation of high nutrient-dense grain at similar cost to that of transporting conventional corn;
- Improvement of pellet quality (Rand et al., 1997; Dorr, 1997)
- Reduction in time to grind the grain (Dorr, 1997)

The value added of HOC is embedded in the benefits and ways by which HOC can be used to enhance animal production and profitability. For instance, under current conditions of production of broiler chickens in some Asian, Latin American, and Middle Eastern countries, HOC may have an added nutritional value of as high as $25 per metric ton, i. e., $25 above the value or cost of U.S. typical corn. It is important to note that the above value refers to a nutritional value only. Non-nutritional benefits (see above) which may result from the use of HOC are estimated to have a significant and quantifiable value. The latter could be captured by the end-user and should be added to the nutritional value to establish the entire value added of HOC to a feeding program. Overall, animal producers will capture a significant fraction of the total added value.

Added value of the HOC in meat-type birds or hogs is self-evident. Most of these animals are fed expensive high-energy diets that are commonly supplemented with one or several sources of fat. Thus, the primary nutritional value of HOC in operations employing high-density diets may be in significant reductions in the cost of feed through reduction or elimination of the use of added fat, while maintaining expected growth rate and efficiency of feed utilization. On the other hand, because of the high energy density of HOC, one can increase the dietary energy density above what can be accomplished with current means. Additionally, due to its high energy and nutrient density, HOC can be used to increase feed formulation flexibility by creating space and permitting the inclusion of less expensive low energy ingredients such as wheat middlings or other locally available ingredients. Laying hen diets, for instance, contain a significant amount of limestone or oyster shell which makes it difficult to achieve the energy density required for optimum egg production, particularly during peak egg production and hot weather conditions. Therefore, HOC can be used to increase energy intake of the laying hen. Additionally, inclusion of HOC in a layer diet will increase the linoleic acid concentration of ration, and may help increase egg weight. All of the above will contribute to the added value of HOC.

CONCLUSIONS

As in the past, modern agriculture and the food industry continue to be benefactors of scientific development and the application of resulting technologies. Unlike the past where engineering-based technologies resulted in various important improvements, it appears that biology-based technologies will predominate in the future and will be the driver for innovative agricultural products. New grain varieties with applications in the feed industry represent the product of these technologies which will benefit agriculture.

HOC is an ingredient that has high concentrations of metabolizable energy, fatty acids, amino acids, and tocopherols. These nutritional attributes provide a remarkable tool to add significant value in current animal production. Additionally, practical use of HOC introduces several non-nutritional benefits that further increase the positive impact this ingredient has on the overall efficiency of animal production.

적 요

가축능력의 뚜렷한 유전적 개량으로 인하여 고영양밀도의 사육이 축산업에서 일반적으로 도입되고 있다. High oil corn (HOC)은 10년 전부터 사료생산에 이용되고 있으며 현재 HOC는 77 % 이상의 조지방을 함유하여 전통적인 옥수수보다 4.5~6.0 % 높은 에너지 함량을 가지고 있다. 단백질 함량도 3.3~6.4 % 높으며 그 품질도 전통적인 옥수수보다 적어도 동일하거나 더 높다. 더구나 HOC 이용으로 얻을 수 있는 비 영양학적 이점들이 있다. 이 같은 영양학 및 비영양학적 이점은 일반적으로 사료제조업자, 특히 양계업자들이 취할 수 있을 것이다.

(색인어: high oil corn (HOC), 가금, ME, 아미노산, 육질, 비타민 E)

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