

## Chapter 30

# Summary of U.S. Grains Council Sponsored International Feeding Trials

## Australia

### Cattle

#### Effect of DDGS inclusion on pelletizing characteristics and milk production of dairy cows

A commercial dairy trial was conducted to measure the effect of varying levels of corn DDGS on pellet quality (pellet durability index (PDI), color, odor and bulk density), milling (tonnes per hour, steam and feed rate, and amps), and on-farm animal performance (palatability and change in milk production). DDGS from corn was sourced from the US Grain Council and shipped to Australia. Energy (14.5MJME/kgDM) and protein (30%, dry matter basis) specifications of DDGS were as provided by USGC. These specifications were used in 'balancing' the ration. Four farmers received various concentrations of the DDGS feed rations, ranging from 5% to 20% inclusion. The choice of ration was maintained as per the current ration purchased by the farmer which were Summer Special (16% Protein and 12.5 MJ ME/kg on a dry matter basis) and Rovers Ration (20% Protein and 12.3 MJ ME/kg on a dry matter basis). Feeding rates were as follows:

<b>Control</b>				Treatment 0
<b>Farm A</b>	6kg/head/day	5% inclusion	DDG-S	Treatment 1
<b>Farm B</b>	6kg/head/day	10% inclusion	DDG-S	Treatment 2
<b>Farm C</b>	7kg/head/day	10% inclusion	DDG-S	Treatment 3
<b>Farm D</b>	10kg/head/day	20% inclusion	DDG-S	Treatment 4

Rations were formulated to same energy and protein as the previous rations supplied.

There were no statistical analyses performed on the results of this trial. All results are numerical and based on raw data. The results on milling parameters are shown in Table 1. Compared to control treatment, there appeared to be no effect of DDGS inclusion on milling parameters.

**Table 1. Effect of DDGS on pelleting parameters**

Ration	Treatment	Steam	Feed	PDI	Amps	Bulk	Tonnes/hr
<b>Control</b>	0	70	3.5	96	150	59	17.8
<b>Summer Special</b>	1	69	3.7	96	150	58	18.5
	2	71	3.6	94.7	148	58	17.6
	3	72	3.4	97	150	60.8	16.9
<b>Rovers ration</b>	4	65	3.2	96.4	155	60	17.3

Milk production results are shown in Table 2. For cows fed the Summer Special ration, milk production did not seem to change following DDGS inclusion in the ration. This trend appears to be same with the 5%, 10% and 20% dietary inclusion of DDGS. Note that the rations were formulated to be the same energy & protein and no significant change were expected. With Rovers ration (20% inclusion), it appears that milk production decreased after the original ration was re-introduced into the diet. The farmer commented that he believed that the change was a result of decreased palatability of the traditional DDGS previously used, but highlighting the good increase in palatability of the US DDGS. All other parameters did not change (i.e. milk fat and protein).

**Table 2. Effect of dry distiller's grain with soluble on milk production parameters**

Ration	Treatment	No. of cows	No. of days	Liters during/post	Fat (%)	Protein (%)
<b>Summer Special</b>						
	1	125	5	26.8/27	3.6	3.1
	2	320	8	27.1/26.7	3.9	3.1
	3	183	9	23.9/22.7	3.4	3.0
<b>Rovers ration</b>						
	4	390	12	34/31.8	4.2	3.1

In conclusion, these preliminary trials suggest that DDGS can be included in dairy rations in the Northern Victorian Dairy region of Australia. It may be possible to include DDGS up to 20% without any adverse effect on milk production of dairy cows or in the pelleting process. DDGS inclusions did not seem to have a major impact on pelleting other than the issue with the steam conditioning of the higher 20% DDGS inclusion. While anecdotal, it is believed that the physical ability of the pelleting process to handle US DDGS is at a maximum of 20% DDGS inclusion. Further trials are required to confirm this. DDGS is a tangible alternative for CopRice Feeds, and will become a great option if economical against current raw material protein and energy sources.

## Indonesia

### Cattle

Evaluation of DDGS for feeding cattle under commercial conditions. PT Lembu. Jantan Perkasa

A feeding trial was conducted to measure the effect of DDGS inclusion on the performance of finishing cattle in Indonesian feedlots (May - September 2007). Two dietary treatments were used in this trial, a control diet (0% DDGS) and treatment diet (20% DDGS) in a concentrate made from locally available ingredients (cassava waste, wheat pollard, copra meal, palm kernel meal) and elephant grass given at 2.4 kg fresh daily. The diets were formulated to have similar protein (13%) and TDN (72%). Each diet was fed to newly arriving cattle (Brahman cross from Australia) in pens containing 25 cattle and replicated 3 times (a total of 150 cattle used in the 105 day trial). Measurements of body weight and feed consumption were taken after 49 and 105 days of feeding. Daily gain of cattle fed 20% DDGS was 1.19 kg and was not statistically

different from daily gain of cattle fed the control diet (1.30 kg). Average concentrate intake between 50-105 days was 8.66 kg and 8.23 kg for DDGS and control diets respectively. Dry matter and protein digestibility, measured by internal marker, of diets containing DDGS was 68.5% and 65.7% respectively and slightly lower than the control treatment at 76.7% and 79.1%, respectively. Carcass percentage of cattle fed DDGS was 52.7 % while those fed the control diet was 50.3%. The pH of feces from cattle fed DDGS was 5.6 compared to 7.3 from those on the control diet. The cost of the feed containing DDGS (Rp 868) was lower than the control feed (Rp 942). In conclusion, DDGS can be economically fed to finishing cattle at a 20% inclusion rate without negative effects on growth performance and carcass characteristics.

DDGS use as a substitute and a supplement to concentrate in dairy nutrition results in significant improvement in milk production. Central Research Institute for Animal Science  
Jl. Pajajaran Bogor

An experiment was undertaken in 2009 to improve milk production by supplementing local feeds with U.S. corn DDGS (*Dried Distiller's Grains with Solubles*). The results indicated that milk production increased by 10% on a farm in Cinagara, West Java and by 30% in a farm in Grati, East Java. Domestic milk production can only supply 30% of Indonesia's total milk requirement. About 70 percent of the total milk requirement is imported from overseas. One of the main problems facing the dairy industry in Indonesia is low quality of dairy feed. DDGS is a co-product of corn ethanol production containing valuable energy and protein levels amid reasonable price. In 2009, Indonesia is estimated to import about 200,000 metric tons of DDGS mainly used for poultry diets. In this research project, DDGS was used as a supplement and a substitute for the dairy concentrate. The experiment was conducted in two locations: 1) a farm in Cinagara, Sukabumi District, West Java, in which 1 kg DDGS was given as a substitute for the concentrate and performance was compared to non-DDGS supplemented animals, and 2) a farm in Grati, Pasuruan District, East Java, in which 1 kg DDGS was given as a supplement on top the concentrate given by the farmer and performance was compared to non-DDGS supplemented animals. Twenty dairy cows were used in each location and divided randomly into two comparable groups. The results show that milk production increased by 10% in Cinagara, West Java and by 30% in Grati, East Java. The higher milk production with the inclusion of DDGS was mainly due to the high protein content in DDGS (30%). Economically, the supplementation with 1 kg of DDGS benefited the dairy farmers due to the income from increased milk production was higher than the cost of including DDGS in the concentrate ration. Results from this project indicate that the milk production and farmer income can increase significantly if DDGS are used in dairy feeds. Results of this project should be disseminated to other dairy farmers in Indonesia.

## Japan

### Broilers

Report of the results of a DDGS feeding trial in broilers. Kimura, N. Access at:  
[http://www.ddgs.umn.edu/international-research/2007-Japan%20DDGS\\_Trial\\_in\\_Broilers-ENG.pdf](http://www.ddgs.umn.edu/international-research/2007-Japan%20DDGS_Trial_in_Broilers-ENG.pdf)

This study was conducted to assess the effects of corn DDGS produced in the U.S. on meat production and quality, such as accumulation of peritoneal fat, composition of fatty acids, meat color, and fecal phosphorus concentration. A total of 63 broilers were allotted to the following 3 groups (21 animals per group) and were fattened for 4 weeks: 1) control group, fed a commercial feed; 2) fed a diet containing 10% DDGS; 3) fed a diet containing 20% DDGS. The higher the inclusion of DDGS in the diet, the higher the growth rate found in the early fattening period. The feed intake was similar across groups. The production of cut meat tended to be higher in the DDGS fed groups. Also, the higher the content of DDGS in the diet, the lower weights of liver and peritoneal adipose tissue, and a smaller amount of fat accumulated in the liver. Meat from the DDGS fed groups was observed to be rich in linoleic acid, which was probably due to the higher content of linoleic acid and unsaturated fatty acid in DDGS.

### Laying hens

Basic studies on the effect on layer hens of DDGS produced in USA

Access at:

<http://www.ddgs.umn.edu/articles-poultry/2005-Kirmura-%20Layer%20hens%20trial%20report%20summary.pdf>

U.S. studies have shown that dietary inclusion rates of 10% DDGS is suitable for hens. However, there are only a few studies in Japan. This study was conducted to evaluate the impact of feeding USA-made DDGS to White Leghorn Julia strain hens (the most commonly reared layer breed in Japan) on egg quality and fat metabolism. DDGS was added to a commercial feed used in Japan, where there is a demand for eggs with stronger yolk color than in the U.S. Dietary treatment consisted of 1) control diet with commercial layer feed; 2) feed containing 10% DDGS; 3) feed containing 20% DDGS; 4) feed containing 10% CS (a 1:1 mixture of crushed corn and soybean cake which is similar to DDGS in protein and ME content); and 5) feed containing 20% CS.

The body weight decreased in all treatment groups throughout the treatment period. This decrease was greater in hens fed higher percentages of DDGS or CS. The weight of individual eggs did not differ among the control and treatment groups, but egg production showed a decreasing trend in the 20% DDGS group, which reduced the total weight of eggs produced in the DDGS group. Eggshell strength and Haugh Unit (HU) was not affected by dietary treatments. Egg yolk color was significantly affected by dietary treatments. The color was reduced immediately after switching to the experimental feeds, but recovered rapidly in the DDGS groups, which reached the level of the control group in about 10 days. In the CS groups, however, the color did not recover and was lighter almost proportionately to the amount of CS in the diet. This suggested that feeding diets containing 10 or 20% DDGS had almost the same yolk color as feeding control diet with paprika to enhance yolk color. The plasma triglyceride

concentration decreased after feeding diets with DDGS, suggesting a decrease in lipid synthesis in the liver. DDGS groups had a higher liver and ovary weight, whereas the weight of their abdominal adipose tissues tended to be low. In 20% DDGS group, fat content was highest in the ovary (follicles) and abdominal adipose tissue. In conclusion, this study suggested that DDGS can be used in the feed of layer hens in Japan without affecting egg quality. DDGS may also improve egg yolk color, which leads to the savings of a yolk coloring agent.

Effects of feeding corn DDGS on ammonia and hydrogen sulfide emissions from manure of laying hens Access at: [http://www.ddgs.umn.edu/international-research/2011-Maki\\_IIDA-Effects\\_of\\_feeding\\_corn\\_DDGS\\_on\\_ammonia.pdf](http://www.ddgs.umn.edu/international-research/2011-Maki_IIDA-Effects_of_feeding_corn_DDGS_on_ammonia.pdf)

One hundred twenty white leghorns (Julia strain, aged 251 days) with stable egg production were used in an experiment to determine the effects of feeding corn DDGS to laying hens on ammonia and hydrogen sulfide emissions from manure. The control diet contained no DDGS, as well as 10%, 20% and 30% DDGS diets that replaced corn and soybean meal, were all formulated to provide similar level of crude protein, metabolizable energy, phosphorous, calcium, methionine, lysine, tryptophan and threonine. Experimental diets were fed ad libitum to three replicates of 10 hens each for 4 weeks.

Egg production performance was investigated during the experiment period and yolk color evaluation was also conducted at the end of the experiment using the eggs produced by one of the replicates of each dietary treatment group. All of the manure was collected from replicates on days 6-7, 13-24 and 27-28 after the start of the experiment and stored in buckets. Ammonia and hydrogen sulfide concentrations were measured in the empty space in the each bucket at 12, 24 and 48 hours later, followed by pH measurement of the manure. Manure water content was also measured using the manure produced on days 5, 12 and 26 after the start of the experiment and nitrogen and dry matter excretion rates were calculated for each dietary treatment. There was no difference in body weight gains during the period from the day of group assignment to the final day of the experiment between the control diet group and the 10% and 20% DDGS diet groups. Body weight gain of the 30% DDGS group was significantly lower than that of the control diet group. Except for one of the laying hens fed 10% DDGS diet that stopped laying eggs and was culled, all of the hens in the experiment were healthy and no abnormal health conditions were observed. There were no differences in egg production rate, average egg weight, or daily egg production between the control diet group and the 10% DDGS group. Hens fed 20% and 30% DDGS diets showed a tendency to decrease in egg production rate, average egg weight and daily egg production at week 2 after the start of the experiment, and thereafter, compared to those fed the control diet. This tendency was more pronounced in the group fed the 30% DDGS diet. There was no significant difference in feed intake in any weeks during the experimental period between the group fed the control diet and the other three dietary treatment groups. Although the weekly feed conversion rate of the DDGS diet groups tended to slightly decrease compared to the control diet group, there was no significant difference in the feed conversion rate throughout the experiment period between the control diet and the other three dietary treatments. Egg yolk color significantly increased as dietary level of DDGS increased. Adding DDGS to diets had no effect on the concentration of ammonia from manure at any time point. The dietary DDGS inclusion level did not affect the concentration of hydrogen sulfide at weeks 1 and 2 after the start of the experiment, however, the concentration of ammonia from the DDGS diet groups tended to decrease at week 4. This tendency was apparent in the treatment groups fed the 20 and 30% DDGS diets. Manure pH significantly decreased as dietary level of DDGS increased. There was no difference in manure water

content among treatment groups at week 1, but there was a trend for decreased in manure water content at weeks 2 and 4, almost directly correlating with the increase in dietary level of DDGS. Nitrogen and dry matter excretion rates showed negligible differences between hens fed the control diet and the 10% DDGS diet, but excretion rates of hens fed the 20% and 30% DDGS diets tended to be higher than those fed the control diet.

## Fish

Report on the feeding trial and usage of DDGS in aquaculture fish diets Access at: [http://www.ddgs.umn.edu/international-research/2010-Japan-Report\\_on\\_feeding\\_trial\\_and\\_usage\\_of\\_ddgs\\_in\\_aquaculture\(ENG\)2.pdf](http://www.ddgs.umn.edu/international-research/2010-Japan-Report_on_feeding_trial_and_usage_of_ddgs_in_aquaculture(ENG)2.pdf)

An experiment was conducted to determine if there are any differences in the quality of fish meat between fish fed diets containing lower cost ingredients compared to diets containing fish meal. High protein (49%) DDG was used in this study to replace a portion of fish meal. Feed cost was reduced by 10% by partially replacing fish meal with 20% HP DDG as a result of the greatest improvement in feed conversion compared to control diets. Replacing 12% of fish meal with corn gluten meal improved feed conversion by 4%, which had less effect on reducing feed cost (3.7%). There was no yellowing of muscle, but rather fish meat was whiter in groups fed corn co-products. No difference in palatability was observed among dietary treatments.

## Swine

Effect of feeding corn distiller's dried grains with solubles (DDGS) on the growth and other parameters of swine. Suga, K., Y. Hashimoto, M. Hanazumi, and C. Yonemochi.

Access at:

[http://www.ddgs.umn.edu/international-research/2006-Keisei%20Suga%20et%20al-%20Feeding%20DDGS%20to%20swine%20\(Japanese%20trial\).pdf](http://www.ddgs.umn.edu/international-research/2006-Keisei%20Suga%20et%20al-%20Feeding%20DDGS%20to%20swine%20(Japanese%20trial).pdf)

This study was conducted to investigate the effect of adding DDGS to the diets of finishing pigs in Japan on growth performance, carcass quality, and other parameters. Fifty LWD pigs (25 barrows and 25 gilts) about 3 months of age were used in this study. Ten pigs were allotted to 1 of the 5 dietary treatments, and barrows and gilts were reared separately in groups. Pigs in the control group were fed a commercial diet without DDGS from a body weight of 30 kg up to marketing. Pigs in Treatment 2, 3, and 4 were fed different levels (10, 15, and 20%, respectively) of DDGS from 30 kg to 70 kg BW followed by the same feed as controls from 70 kg up to marketing. Pigs in Treatment 5 were fed 10% DDGS feed throughout, from 30 kg to marketing. Body weight of each animal was measured weekly. Feed intake of each pen was measured bi-weekly. Pigs were harvested when individual BW achieved 110 kg. Carcass weight, dressing %, backfat thickness were measured. The L\*, a\*, b\* values of the carcass were determined, and carcass meat was graded. There were no significant differences on average daily gain, feed intake, and feed conversion ratio among dietary treatments. Carcass weight, dressing %, backfat thickness, and carcass quality score did not differ among treatments. Among barrows, the b\* value of meat color in the 20% DDGS group was significantly higher than that of the 10% DDGS group, and a\* value was significantly higher when comparing 10% DDGS group with the control group. However, there were no definite trends in relation to the percentage of DDGS added in the feed and its period of feeding. These results showed that adding up to 20% DDGS in the feed of finishing pigs did not impact growth

performance and carcass characteristics, suggesting that DDGS could be used in finishing pigs' diets in Japan.

## Dairy cows

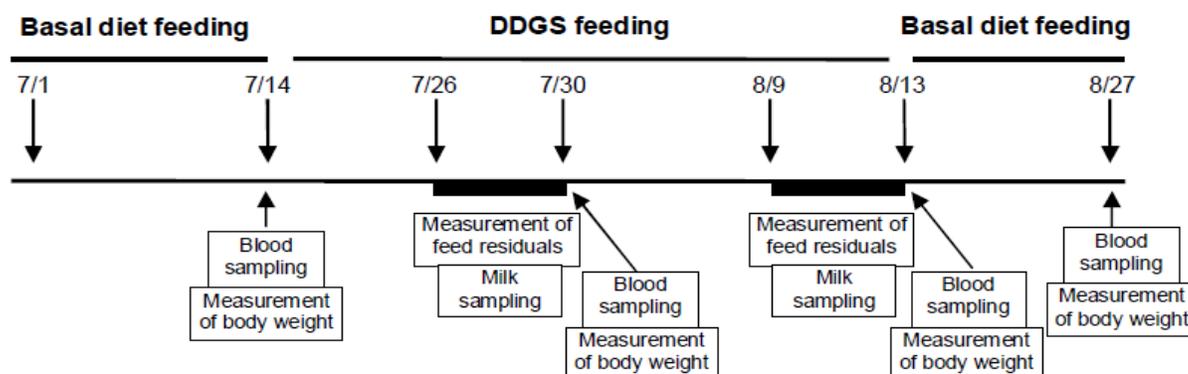
Effects of corn distiller's dried grains with solubles (DDGS) under hot summer conditions in lactating dairy cows. Tanaka, M.

Access at:

[http://www.ddgs.umn.edu/international-research/2008-Japan-%20Study\\_report-DDGS\\_dairy\\_summer.pdf](http://www.ddgs.umn.edu/international-research/2008-Japan-%20Study_report-DDGS_dairy_summer.pdf)

In Japan, the use of DDGS as a feedstuff for livestock animals is increasing dramatically. However, only limited information has been obtained about the properties of DDGS from feeding trials. In lactating dairy cows, in particular, the effects of DDGS on the physical condition and properties of raw milk are poorly understood. In order to obtain information on the use of DDGS in dairy cattle under high temperature conditions, a TMR supplemented with DDGS was fed to lactating dairy cows during the hot summer months, and its effect on DM intake (an indicator of palatability), blood parameters, milk yield, and fatty acid composition in raw milk was assessed.

Three Holstein cows were used in each of the DDGS group (20% DDGS) and the control group (0% DDGS). All animals were kept under the same conditions throughout the study period. Figure 1 shows the treatment and sampling schedule.



**Figure 1. Overview of the DDGS feeding trial.**

Before and after the DDGS feeding period, cows received *ad libitum* a TMR as the basal diet. The body weight of each cow was measured after morning milking on d 17 and 31 of the DDGS feeding period, and on d 14 of the post-DDGS period. Feed intake from d 13 to 27 and from d 27 to 31 of DDGS feeding period was measured. Milk samples were collected at every milking time (morning and evening) throughout the study period. Blood samples were collected prior to morning milking on d 17 and 31 of DDGS feeding period, and on d 14 of the post-DDGS feeding period. The rectal temperature of each cow was measured every morning immediately after milking.

During the DDGS feeding period, the daily mean ambient temperature (29.1°C) was higher than the normal range (23°C), and thus the rectal temperatures of the cows in both groups were

above the normal range, but no significant difference was observed between two groups. There was no significant difference in feed intake, body weight between the DDGS and control group. The blood cell counts, hemoglobin and hematocrit of lactating dairy cows were not significantly affected by DDGS under the high temperature conditions. The plasma levels of total protein, albumin and sulfhydryl (SH) groups in the DDGS group were higher ( $P < 0.05$ ) than those in the control group, although they were within normal ranges, suggesting DDGS feeding may have affected the nutritional condition or oxidative stress level in lactating dairy cows. There was no significant difference in milk yield between the two groups. In the DDGS group, the percentage of milk protein was significantly lower, while the percentage of lactose was significantly higher than those in the control group. There was no significant difference in fatty acid composition of raw milk between the two groups. In conclusion, when lactating dairy cows were fed 20% DDGS in the diet, there were only marginally negative impacts, if at all, on milk composition, and cow's conditions were unaffected. Therefore, if it is cost-effective, DDGS is a possible option as a feedstuff in dairy cows and can be included at rates up to 20% in the diet.

Report on experimental feeding of dairy cattle with distiller's dried grains with solubles (DDGS)

Access at:

[http://www.ddgs.umn.edu/international-research/Japanese%20\(DDGS%20part%201-2004\).pdf](http://www.ddgs.umn.edu/international-research/Japanese%20(DDGS%20part%201-2004).pdf)

This study was conducted to evaluate the usefulness of DDGS as a feedstuff in existing dairy farms in Japan before its large-scale adoption as a feed in the country. Three dairy farms of the Nasu region, which is the leading dairy farm region of the country, were chosen to conduct this study. All cattle were assigned to either DDGS group (12-15% DDGS) or control group (without DDGS). The study was conducted for about 3 months. During the first and third month, all animals were fed a control diet. During the second month, animals were fed their assigned diets (DDGS or control diet). The number of cattle used in this study were 34, 39 and 87 respectively in farms A, B and C. The milk yield and milk components (milk fat, milk protein and non-fat solid contents) were determined each month. The milk yield and milk components showed no significant difference at the time of switchover between non-DDGS and DDGS feeds and did not differ among the different periods at each farm location, indicating that including DDGS in the diet did not affect milk yield and milk composition of dairy cattle, and DDGS could be used as a feed ingredient for dairy cattle in Japan.

## Other

Report on storage experiments with distiller's dried grains with solubles (DDGS)

Access at:

[http://www.ddgs.umn.edu/international-research/Japanese%20\(DDGS%20part%202-2004\).pdf](http://www.ddgs.umn.edu/international-research/Japanese%20(DDGS%20part%202-2004).pdf)

In order to detect quality changes in DDGS, and autoxidation of lipids at high temperature, the authors of this study conducted high temperature storage tests and high temperature and high humidity exposure tests on DDGS samples imported from the U.S. DDGS was stored at high temperatures (40°C and 60°C) for 8 weeks, and at high temperature and high humidity (40°C, relative humidity 75-100%) for 4 weeks to simulate the passage of DDGS through high temperature regions during long transportation. The qualitative changes in lipids, and changes in odor and color were examined. All control samples were stored in a feed store at 23°C consistently.

High temperatures increased off odor in the samples, suggesting that high temperature storage can lower the commercial value of DDGS because of off odor development. The color of DDGS changed during high temperature storage. At 60°C, the color of DDGS samples turned darker and became brown in appearance. This change could be observed after just one week of storage. At 40°C, however, there was little change in external appearance even after 8 weeks of storage. In both high temperature storage and high temperature plus high humidity storage, acid value and peroxide value of lipids in DDGS samples remained low and did not change relative to storage time. In conclusion, under high temperature (60°C), the color and odor of DDGS changes, but there are no degenerative changes of lipids. DDGS has a high lipid content of 10-13%. The results of this study suggest that the lipids do not easily degrade, and therefore the nutritional value of DDGS does not change much under normal conditions of storage.

Report on experiments on variation in nutrient composition and digestibility of distiller's dried grains with solubles (DDGS)

Access at:

[http://www.ddgs.umn.edu/international-research/Japanese%20\(DDGS%20part%203-2004\).pdf](http://www.ddgs.umn.edu/international-research/Japanese%20(DDGS%20part%203-2004).pdf)

This study was conducted to evaluate the relationships between the external appearance of DDGS and its nutrient composition and digestibility. A total of 22 DDGS samples were analyzed for total energy, water-soluble matter, water soluble protein, color values, apparent color depth, and dry matter digestibility. The variation in nutrient composition and the digestibility indices were also analyzed. The correlation between color and nutrient composition and digestibility indices was studied to estimate the nutritional value of DDGS from its external appearance. There was a small variability (coefficient of variation less than 10%) observed in analyzed parameters except for water-soluble matter (coefficient of variation about 23%). Samples with high luminosity measured by the color difference meter had a high fat content and high total energy, and low contents of water-soluble matter and water-soluble nitrogen. DDGS with high apparent color depth (dark in color) had low total energy and high water-soluble matter content.

## Korea

### Broilers

Nutritive and economic values of corn distiller's dried grains with solubles in broiler diets.  
Bong Duk Lee

This study was conducted to evaluate the nutritive and economic values of high quality DDGS in commercial broiler diets. Day-old 3200 unsexed Cobb-500 broiler chicks were randomly allotted to 16 pens with 200 chicks per pen. There were four diet treatments (0, 5, 10, and 15% DDGS), and four replicates per treatment. All birds were fed a commercial pre-starter diet until d 7, and then they were fed their respective starter diets and grower diets from d 8 to 21 and from d 22 to 29, respectively. One bird from each pen was sacrificed for carcass measurements. Muscles from breast and thigh, and shanks from both sides were sampled for texture and color analysis. Thigh meat samples were collected for fatty acid composition analysis. No significant difference was found in growth performances among the four treatments. As the DDGS level increased, the degree of unsaturated fatty acids in meat increased significantly ( $P < 0.05$ ). The color scores of breast and thigh muscles were not influenced by DDGS, however, the yellowness of shank increased significantly by the addition of DDGS. Although not significant, the hardness of

breast and thigh meats tended to decrease by the addition of DDGS. These results suggest that the use of DDGS in broiler diets up to 15% does not have negative effects on growth performance and meat qualities.

## Laying hens

Nutritive and economic values of corn distiller's dried grains with solubles in laying hen diets.  
Bong Duk Lee

A layer feeding trial was conducted for 10 weeks to investigate the effects of the addition of corn distiller's dried grains with solubles (DDGS) to layer diets on laying performance, egg qualities, and yolk fatty acid composition. A total of 900 Hyline Brown layers, 24 weeks of age, were randomly allotted to 20 replicate laying cages, 45 birds per replicate. There were four diet treatments (0, 10, 15, and 20% DDGS), and 5 replicates per treatment. The use of DDGS up to 20% level in layer diets did not have any influence on feed intake, laying rate, total egg mass, mean egg weight, and feed conversion ratio. DDGS did not impact weight, breaking strength, and color of eggshell. The yolk color was significantly increased by DDGS supplementation. As the DDGS level increased, the oleic acid content decreased, and the linoleic acid increased ( $P < 0.05$ ). The degree of saturation of yolk fatty acids was not affected by dietary DDGS. In conclusion, the use DDGS up to 20% level in layer diets could replace corn and soybean meal without any negative effect on laying performance, and possibly decrease the feed cost.

## Swine

Nutritive and economic values of corn distiller's dried grains with solubles in swine diets.  
Young, C.J., C.K. Byung, K.K. Jong, and H.L. Won.

Access at:

[http://www.grains.org/images/stories/technical\\_publications/2008-2009%20DDGS%20feeding%20trials%20\(2\).pdf](http://www.grains.org/images/stories/technical_publications/2008-2009%20DDGS%20feeding%20trials%20(2).pdf)

To evaluate the nutritive and economic values of U.S. corn ethanol DDGS in Korean commercial hog diets, a total of 396 head of three breed crossed (YLD) pigs were utilized in a feeding trial. The experiment was conducted in three phases, nursery (15-30 kg), grower (30-70 kg), and finisher (70-105 kg) simultaneously. Each experimental phase consisted of 3 treatments: control, DDGS 10%, and DDGS 15% for nursery phase (**Table 1**), and control, DDGS 15%, and DDGS 20% for grower/finisher phases (**Table 2, 3**). The corn ethanol DDGS used in this study was imported from the U.S.

**Table 1. Nursery pigs (15-30 kg).**

	Control (DDGS 0%)		Treatment 1 (DDGS 10%)		Treatment 2 (DDGS 15%)	
# of pens(replications)	2	2	2	2	2	2
# of pigs per pen	10	10	10	10	10	10
Total # of pigs per treatment	40		40		40	

**Table 2. Grower pigs (30-70 kg).**

	Control (DDGS 0%)		Treatment 1 (DDGS 15%)		Treatment 2 (DDGS 20%)	
# of pens (replications)	1	1	1	1	1	1
# of pigs per pen	20	20	20	20	20	20
Total # of pigs per treatment	40		40		40	

**Table 3. Finisher pigs (70-105 kg).**

	Control (DDGS 0%)		Treatment 1 (DDGS 15%)		Treatment 2 (DDGS 20%)	
# of pens (replications)	1	1	1	1	1	1
# of pigs per pen	26	26	26	26	26	26
Total # of pigs per treatment	52		52		52	

Body weight for individual pigs on initial and final days of the experiment was recorded to calculate average daily gain (ADG). Feed intake of each pen was measured to determine the average daily feed intake (ADFI). When finisher pigs reached marketing weight, 10 pigs were randomly selected from each treatment to evaluate carcass and pork quality traits, including carcass weight, backfat thickness, loin eye muscle area, lean %, carcass pH 24, and meat color ( $L^*$ ,  $a^*$ ,  $b^*$ ) of longiss muscle. Carcass weight and back fat thickness were measured by Korean carcass grading system. Loin eye area of 5<sup>th</sup> rib was measured. Lean percent (5% fat) was estimated by equation of NSIF. There were no significant differences among treatments for ADG, ADFI, and G:F of nursery, grower, or finisher phase, respectively. Back fat thickness was similar among treatments. However, there was a significant difference ( $P < 0.05$ ) between sexes for back fat thickness (average of gilts was 20.1 mm, barrows was 26.6 mm). There were no significant differences for loin pH after 24 hours, NPPC color, drip loss after 72 hours, or marbling score.

Economic values of including U.S. corn ethanol DDGS in swine diet were also evaluated. In general, as DDGS substitution rates increase, inclusion rates of corn, soybean meal, and crude protein are reduced, whereas those of synthetic lysine and lime stone increase. Addition of DDGS by 15% to nursery, grower, and finisher diets resulted in increased total ingredients cost by 1.1, 0.6, and 0.1%, respectively. The minimal biological and cost impacts under current unstable feed grains and other ingredients supply conditions, indicates U.S. corn DDGS could be immediately utilized in Korean swine diets.

## Mexico

### Swine

Effects of feeding grow-finish pigs conventional swine diets used in Jalisco, Mexico compared to diets containing 10% Norgold DDGS on growth performance

Access at:

<http://www.ddgs.umn.edu/articles-swine/2003-Mexico%20feed%20trials.pdf>

This study was conducted in Jalisco, Mexico (Ramiro Martin) to compare growth rate, feed intake and feed conversion of pigs fed conventional diets used in Mexico with diets containing 10% Norgold DDGS during grower (30 to 60 kg body weight) and finisher (60 to 100 kg) phases. A total of 800 pigs and a total of 600 pigs were assigned to either the control or DDGS diet during the grower and finisher phase, respectively. Pen was the experimental unit with 12 replications during the grower phase and 9 replications during the finisher phase. Pigs were fed experimental diets for 49 days during the grower phase and for 50 days during the finishing phase. During the grower period, pigs fed the DDGS diet grew faster than those fed control diet ( $P < 0.0002$ ). There was no significant difference in feed intake ( $P < 0.12$ ) and feed conversion ( $P < 0.13$ ) between the two dietary treatments. During the finisher period, pigs fed the DDGS diet showed similar ADG as those fed the control diet. Average daily feed intake of pigs fed the DDGS diet was higher ( $P < 0.01$ ) than those fed the control diet, but feed conversion was not significantly different ( $P > 0.79$ ) between the treatments. In conclusion, this study showed that grow-finish pigs fed 10% Norgold DDGS diet had higher ADG during the grower phase, and higher ADFI during the finisher phase compared to those fed the standard diet used in Jalisco, Mexico. Feed conversion was similar between pigs fed the control and the DDGS diets. These results suggest that Norgold DDGS can be added to grow-finish swine diets in Mexico to provide at least equal, and perhaps improved growth performance compared to current commercial swine diets.

#### Distiller's dried grains with solubles – swine feeding trial

This study was conducted to evaluate the effects of feeding diets containing DDGS on pig growth performance in Mexico. Growing finishing pigs were allotted to one of two dietary treatments containing either 0 or 10% DDGS. Pigs were maintained on a feeding plan of 18 d for Phase I diet, followed by 34 d for Phase II diet, followed by 55 d for Phase III diet. Pigs were weighed initially, and at the end of each phase. Average daily gain was similar between DDGS and control treatment. Feed efficiency varied by feeding period. DDGS treatment pigs appeared more efficient during the 18 day and 34 day feeding periods, and the control treatment appeared more efficient during the 54 day feeding period. These results suggest that including 10% DDGS in the grower finisher diets of swine does not have negative effects on growth performance.

### **Others (DDGS demo trials with unknown country):**

Access at

[http://www.grains.org/images/stories/technical\\_publications/2008-2009%20DDGS%20feeding%20trials%20\(2\).pdf](http://www.grains.org/images/stories/technical_publications/2008-2009%20DDGS%20feeding%20trials%20(2).pdf)

Chemical composition of DDGS shipments (RCFF Trials)

In order to evaluate the variation in chemical composition of DDGS, five representative samples of DDGS from 5 shipments were chemically analyzed. Ranges of chemical composition of these 5 shipments are shown below:

#### **Chemical composition of DDGS shipments:**

Item/Sample	Moisture	DM	CP	CF	Fat	Ash
1	12.0	88.0	27.0	7.4	7.2	4.9
2	8.36	91.6	26.4	9.2	8.3	4.5

3	8.4	91.6	24.2	8.2	9.9	5.0
4	10.5	89.5	27.0	6.8	8.3	4.6
5	11.5	88.5	26.1	9.5	7.2	4.6
Average	9.74	90.26	25.94	8.22	8.57	4.72
Range	8.4 to 12.0	88.0 to 91.6	24.2 to 27.0	7.4 to 9.5	7.2 to 9.9	4.5 to 5.0
Variability, %	44.0	4.0	11.5	28.3	37.5	11.0

### Broilers Demo Trials

- Trials with RCFF

**1848 Cobb broilers were fed DDGS in 4 treatments with 3 replicates per treatment. The specific treatment description is shown below:**

Treatment	Starter	Grower	Finisher
1	0% DDGS	0% DDGS	0% DDGS
2	2.5% DDGS	5.0% DDGS	7.5% DDGS
3	5.0% DDGS	7.5% DDGS	10.0% DDGS
4	7.5% DDGS	10.0% DDGS	12.5% DDGS

The results showed that chicks given Treatment 3, which was 5.0, 7.5, and 10% DDGS in the starter, grower and finisher, respectively, performed as good as those of the control rations in terms of mortality, feed intake, daily gains, feed conversion. Feed cost for the chicks given Treatment 3 were 1.2, 3.7, and 3.5% less than those given the control diet for starter, grower, and finisher, respectively.

- Trials with Misr El Arabia Co.

Six broiler farms with a total of 1,804,934 Cub, Ross, Hubbard, Isa and Avian broilers were given Mash diets containing 5% DDGS in starter, grower and finisher rations for 36 days. Performance of broilers given the 5% DDGS in place of soy 44% and corn was similar in terms of mortality, motility, feed intake, body weight and feed conversion, and was even improved (in feed conversion and feed cost saving 2%) to that of broilers fed diets without DDGS.

### Trials with Dairy Buffalo/Cattle Badr Farm

Seventy dairy buffalos were used in this trial. They were given diets containing 15% DDGS in place of 10% cotton seed meal and 5% wheat bran. Performance of the dairy buffalo given 15% DDGS was similar to those given the control diets in terms of milk production. There was 3% feed cost saving for the diets containing DDGS.

## Taiwan

### Broilers

Effects of feeding diets containing U.S. corn distiller's dried grains with solubles on growth performance and carcass quality of domestic colored broiler chickens in Taiwan. Lu, J.J., and Y.K. Chen.

Access at:

<http://www.ddgs.umn.edu/articles-poultry/2005-Lu-%20DDGS%20domestic%20color%20chicken%20final%20report-082405.pdf>

Domestic colored chickens are popular in Asia. There are specific market characteristics for consumer acceptance of chickens, including body maturity, red comb with suitable size, glittering feathers, yellow skin, and tender meat. To achieve the color requirements of comb and skin, artificial pigments are regularly added in the commercial poultry feeds, and thus increase the cost of feed. Xanthophylls are the yellow to orange pigments found in corn, which are more concentrated in corn DDGS. Therefore, the addition of DDGS as a source of xanthophylls pigment in poultry feed is an attractive feature for using DDGS in Taiwan. The objective of this study was to determine the effect of different dietary inclusion rates of DDGS on growth performance, skin color, and carcass quality of domestic colored chickens in Taiwan.

Six hundred and twenty four day-old commercial domestic colored chickens were used in this feeding trial. Six dietary treatments were used in a three-phase commercial feeding program: Phase 1 (0 to 4 weeks of age), Phase 2 (5 to 12 weeks of age), and Phase 3 (13 to 16 weeks of age). 26 chickens (13 male and 13 female) were allotted to one of the six treatments with four replications per treatment, and were fed their respective dietary treatments from 0 to 16 weeks of age. Dietary treatments were as follows:

- 1) Control diet: corn-soybean meal
- 2) Control diet + full amount of artificial pigments during phase 2 and 3 without DDGS
- 3) 10% DDGS diet
- 4) 20% DDGS diet
- 5) 20% DDGS + 50% of the amount of artificial pigments during phase 2 and 3
- 6) Control diet for phase 1 and 20% DDGS diet during phase 2 and 3.

All chickens were weighed individually bi-weekly and feed intake of each pen was recorded. Eight chickens (4 male and 4 female) were randomly selected from each replication and slaughtered at 12, 14, and 16 weeks of age, respectively. Live weight, carcass weight, dressing percentage, amount and color of abdominal fat pad, and liver weight were measured. One half of the breast and thigh muscle were sampled and ground for Hunter's meat color measurements using L\*, a\*, and b\*. The other half of breast and thigh muscle were steam-cooked at 100°C for 10 minutes for shear force measurements. Blood samples were collected at harvest for total protein (TP), albumin (ALB), triglyceride (TG), total cholesterol (CHOL), and creatinine (CREA) analysis to determine the effects of DDGS on chicken protein and lipid metabolism.

Adding 20% corn DDGS to domestic colored chicken diets had no negative effect on weight gain, feed efficiency, meat quality, protein metabolism and fat metabolism. The color of abdominal fat pad was significantly influenced by the dietary treatments (Table 1). The diets with either the full amount of artificial pigments, or 20% DDGS plus half amount of artificial pigments significantly improved ( $P < 0.05$ ) the abdominal fat pad color at 12, 14, 16 weeks of age, respectively. 10% DDGS and 20% DDGS treatments did not impact abdominal fat pad

color at 12 or 16 wks of age, but improved the color score at 14 wks of age. Treatment 6, which switched from the control diet to the 20% DDGS diet during Phase 2, did not show improvement in abdominal fat pad color up to 16 wks of age. Feeding diets containing the full amount of artificial pigments and 20% DDGS plus ½ of the recommended level of artificial pigments resulted in chickens with a bright yellow skin color. These results suggest that although the xanthophylls in DDGS cannot completely replace the artificial pigments to meet the color requirement for the Taiwan market, 20% DDGS plus half of the amount of artificial pigments can achieve the desired carcass quality and color of the abdominal fat pad and skin. Considering the additional savings by adding DDGS in the diet, DDGS could be a good alternative feedstuff for efficient domestic colored chicken production.

**Table 1. Effects of feeding diets containing artificial pigment and DDGS on abdominal fat pad color of Taiwan domestic native chickens.**

Measure	Age	Treatment						MSE
		Control	Control + AP <sup>1</sup>	10% DDGS	20% DDGS	20% DDGS + ½ AP <sup>1</sup>	Control Phase 1, 20% DDGS Phase 2&3	
Abdominal fat pad color score	12 Wks	1.0 <sup>d</sup>	4.4 <sup>b</sup>	1.1 <sup>d</sup>	1.5 <sup>cd</sup>	5.3 <sup>a</sup>	2.0 <sup>c</sup>	0.5
	14 Wks	2.0 <sup>e</sup>	4.2 <sup>b</sup>	2.7 <sup>d</sup>	3.5 <sup>c</sup>	5.0 <sup>a</sup>	2.0 <sup>e</sup>	0.4
	16Wks	2.5 <sup>d</sup>	6.5 <sup>a</sup>	3.0 <sup>d</sup>	4.2 <sup>c</sup>	5.0 <sup>b</sup>	2.5 <sup>d</sup>	0.4

a, b, c, d Means within the same row without the same superscript are significantly different ( $P < 0.05$ ).

<sup>1</sup>AP = artificial pigment.

Growth performance of broiler chickens fed diets containing 0 or 10% DDGS during winter conditions in Taiwan. G.C. Shurson

This study was conducted to evaluate growth performance and livability of broilers fed diets containing 10% DDGS under commercial production conditions in Taiwan during the winter months. A total of 320 broilers were randomly assigned to one of the two dietary treatments containing either 0 or 10% DDGS, and remained on their respective dietary treatments during the starter (d 0 to 14), grower (d 14 to 29), and finisher (d 29 to 38) phases of the 38 d trial. There was no significant difference ( $P > 0.05$ ) for average daily gain between two dietary treatments. Average feed intake and feed/gain were unaffected by dietary treatment in the starter, grower, finisher phases, and overall. Livability was numerically higher for broilers fed the 10% DDGS diet. These results suggest that excellent growth performance can be obtained when adding 10% DDGS to starter, grower, and finisher broiler diets, which are equal to typical commercial broiler diets in the Taiwan broiler industry.

### Laying hens

Effects of corn distiller's dried grains with solubles on the productive performance and egg quality of laying hens. Bor-Ling Shih, A-Li Hsu, Y.K. Chen

This study was conducted to evaluate the effects of DDGS on productive performance and egg quality of laying hens in Taiwan. A total of 240 Hy-Line egg-type layers were used in this study. They were randomly assigned to one of the four dietary treatments with 3 replicates per

treatment and 20 hens per replicate from 23 to 42 weeks of age. The four treatments were as follows: 1) control diet without DDGS; 2) 6% DDGS in the diet; 3) 12% DDGS in the diet; 4) 18% DDGS in the diet. Egg production, body weight, feed intake were recorded. Egg and eggshell quality, including eggshell breaking strength, shell weight and thickness, were measured within 24h of the eggs being laid. Egg yolk color was measured using lightness ( $L^*$ ), redness ( $a^*$ ), and yellowness ( $b^*$ ). Blood samples were collected from 12 randomly selected hens per replicate, and were used for total protein, uric acid, calcium, inorganic phosphate, cholesterol and triglyceride analysis. Six eggs from each treatment were also selected for cholesterol and fatty acids composition analysis. Results from this study suggested that including 6 to 12% DDGS in the diet of laying hens did not influence feed intake, feed efficiency, egg production rate, and egg mass. Yolk color was improved by including more than 12% DDGS in the diets, indicating the xanthophylls in DDGS are well utilized by laying hens. Plasma calcium and phosphate contents were increased and shell break strength was improved when 12% DDGS was used in the diet of laying hens. In conclusion, 12% DDGS dietary inclusion resulted in the best productive performance and egg quality in laying hens. Thus, DDGS can be efficiently used in the diet of laying hens to improve the productive performance, eggshell, and yolk characteristics.

### Laying ducks

Effects of corn distiller's dried grains with solubles on the productive performance and egg quality of brown duck layers. J.F. Huang, M.Y. Chen, H.F. Lee, S.H. Wang, Y.H. Hu, and Y.K. Chen

This study was conducted to investigate the effects of DDGS on productive performance and egg quality in Brown duck layers. A total of 240 Brown Tsaiya ducks were used in this study. They were randomly assigned to one of the four dietary treatments with 3 replicates per treatment and 20 ducks per replicate from 14 to 50 weeks of age. The four treatments were as follows: 1) Control diet without DDGS; 2) 6% DDGS in the diet; 3) 12% DDGS in the diet; 4) 18% DDGS in the diet. Egg production from the first egg, feed intake, feed efficiency, egg weight, eggshell strength, and egg yolk color were recorded. At the age of 20, 30, 40 and 50 week, six eggs per replicate were randomly selected, and egg yolks were used for cholesterol and fatty acid content analysis. Results from this study suggested that adding DDGS at rates up to 18% in the diets of laying ducks did not significantly influence feed intake, feed efficiency, and quality of eggshell. Higher inclusion rates of DDGS (18%) increased egg production rate. Egg weight tended to be higher when 12 or 18% DDGS was added in the diet. Yolk color was linearly improved by the increased amount of DDGS, indicating that xanthophylls in DDGS can be well utilized by laying ducks. When 12 or 18% DDGS was included in the diet, fat percentage of yolk and linoleic acid content of yolk was increased. In conclusion, DDGS can be efficiently used in the diets of duck layers to improve yolk characteristics without influencing the productive performance.

### Swine

Growth performance of nursery and grower pigs fed diets containing 0 or 10% DDGS during winter conditions in Taiwan. G.C. Shurson

This study was conducted to evaluate growth performance and livability of nursery and grower pigs fed diets containing 10% DDGS under commercial production conditions in Taiwan during the winter. Two nursery trials used a total of 232 pigs weaned at 17 to 18 days. At weaning, all

pigs were fed a common creep feed diet for two weeks, and then pigs were randomly assigned to one of two phase II dietary treatments containing either 0 or 10% DDGS. Another grower trial was conducted using a total of 264 pigs with an initial body weight of 23 kg. Pigs were randomly assigned to either 0 or 10% DDGS diets. For the nursery trials, feeding a Phase II nursery diet containing 10% DDGS had no significant effect on ADG, ADFI, and G/F compared to the control diet in Trial 1 ( $P > 0.41$ ). In Trial 2, however, pigs fed the 10% DDGS diet grew significantly faster ( $P < 0.03$ ) and consumed significantly more feed ( $P < 0.002$ ) compared to those fed the control diet, but G/F was unaffected by dietary treatments. Livability was not affected by dietary treatments. For the grower trial, there were no differences in ADG, ADFI, and G/F ( $P > 0.42$ ) between pigs fed the 0 and 10% DDGS diets. These results suggest that pig performance is at least similar, and may even be improved, when 10% DDGS is added to the nursery and grower diets compared to feeding a typical commercial diet in Taiwan during the winter.

Effects of feeding diets containing 0, 2.5% and 5% DDGS to nursery pigs and diets containing 0 and 7.5% DDGS to growing pigs on growth performance during summer conditions in Taiwan. Clare Pei-Ying Feng and Jerry Shurson

This study was conducted to evaluate growth performance and livability of nursery pigs fed diets containing 0, 2.5 and 5% high quality DDGS, and growing pigs fed diets containing 0 or 7.5% DDGS diets under commercial production conditions in Taiwan during the summer. A total of 324 nursery pigs at 3 weeks of age were used in this study. At weaning, all pigs were fed a common creep feed diet (Phase 1) for two weeks, and then they were randomly assigned to one of the three Phase II dietary treatments containing 0, 2.5, or 5.0% DDGS. All pigs were weighed initially and at the end of the 25 day experimental feeding periods. One grower trial was conducted using 96 pigs with the initial BW of 26.8 kg. Pigs were allotted to 4 pens with 2 pens per treatment. Pens were randomly assigned to one of two dietary treatments containing either 0 or 7.5% DDGS. All pigs were weighed initially and at the end of the 42 day experimental feeding period. For the nursery trials, feeding a Phase II nursery diet containing 2.5 or 5.0% DDGS had no significant effect on ADG, ADFI, and G/F compared to the control diet. For the grower trial, there were no differences in ADG, ADFI, and G/F between pigs fed the 0 and 7.5% DDGS diets. Livability was not affected by dietary treatment in both nursery and grower trials. These results suggest that pig performance is similar when 2.5 or 5.0% DDGS is added to Phase II nursery diets, and 7.5% DDGS is added to grower diets, compared to feeding a typical commercial diet without DDGS in Taiwan.

## Fish

The evaluation of dietary DDGS levels for Milkfish (*Chanos chanos*) and hybrid Tilapia (*O. aurea x O. nilotica*)

The objective of these two feeding trials was to estimate the maximal amount of the distiller's dried grains with solubles (DDGS) that could be included in the diets of milkfish and hybrid tilapia. Five isonitrogenic and isoenergetic dietary DDGS levels ranging from 0 to 40% of tested diets were fed to the two fish groups with 3 replicates per treatment in both trials. In the tilapia groups, fish received dietary DDGS level up to 20% exhibited similar growth performance compared with fish with the control diet, but those with 20% DDGS diet showed higher growth rate and better FCR than those with 30 and 40% DDGS in the diet. In the milkfish groups, there were no significant differences in growth performance of milkfish receiving various levels of

DDGS in the diets. These results suggest that DDGS could be included up to 20% in the diet of tilapia fish without sacrificing growth performance. The maximum DDGS level in the milkfish diet could be 40% though it required further confirmation.

## Thailand

### Broilers

Effect of DDGS at different inclusion rates on growth performance and carcass measurements of broilers.

Access at

[http://www.grains.org/images/stories/technical\\_publications/2008-2009%20DDGS%20feeding%20trials%20\(2\).pdf](http://www.grains.org/images/stories/technical_publications/2008-2009%20DDGS%20feeding%20trials%20(2).pdf)

In the U.S., DDGS is now widely used in ruminant feeding, but there remains research to be done on its use in non-ruminant feeds, in particular, broiler and egg layers. In order to better understand how broiler birds respond to DDGS under practical environment, a trial was conducted at the Bangkok Animal Research Center (BARC), Samut Prakan, Thailand, using 960 newly hatched Ross 308 male broilers to compare their growth performance when fed diets containing various levels of DDGS. Broilers were randomly allocated to five treatments with twelve replications. Each replication had 16 birds and these were raised in a pen as a unit. Dietary treatments consisted of four inclusion levels DDGS, namely, 3, 6, 9, and 12% with 0% inclusion level as control. All feeds were corn-soybean meal based (from Soon Soon Oilmills Malaysia), wheat pollard and crude palm oil plus varying levels of DDGS. Starter feeds were fed from 0 to 21 days, and grower feeds from 22 to 42 days. Birds were weighed at the end of 21 days and 42 days. Two birds from each treatment group were sacrificed for carcass evaluation at the end of the trial.

There was little difference in body weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR) for birds up to 21 days. However, at the end of 42<sup>nd</sup> days, FCR for groups using more than 6% DDGS was significantly ( $P < 0.05$ ) higher than those fed feeds using less than 6% DDGS, which indicated that during the growing phase, there was no advantage to including DDGS above 6% because growth performance would be negatively affected. For the overall experimental period, BWG was not different among the treatment groups. Final FI was significantly higher ( $P < 0.05$ ) for the treatment group with 12% DDGS, but FI of the control and the 3, 6, and 9% treatments was similar. Feed conversion ratio (FCR) was significantly higher ( $P < 0.05$ ) for 12% and 9% DDGS groups compared to the control group, while the differences in FCR between the 3, 6, and 9% DDGS groups and the control, 3, and 6% DDGS groups were not significant. There was no significant difference in mortality and culling rate during starter, grower, or overall phase. These results confirmed that DDGS can be used in broiler diets up to a maximum of 10% with no deleterious effect on growth performance. Considering FI and FCR, the maximum usage rate could be between 6 to 9%. Higher than 9%, broiler birds would need additional feed to sustain the fast rate of growth leading to poorer FCR. Eviscerated carcass weight, viscera weight, and total fat pad weight was similar among treatment groups, indicating that the impact of DDGS on carcass quality is minimal, and its use should be judged purely on meeting the growth performance objectives.

## Vietnam

### Swine

Effect of feeding dried distiller's grains and solubles with different protein levels on growing pigs. Chung Kim

A feeding trial on Dried Distiller's Grains and Solubles (DDGS) has been conducted to compare the value of DDGS with different protein contents for feeding growing pigs. A total of 270 pigs in three dietary treatments were used in this trial comprised of a control diet without DDGS, and diets with the inclusion of DDGS with protein content 26% and 40% at 20 %. Three diets having similar digestible amino acids and energy were formulated using ingredients (corn, cassava, soybean meal, peanut meal and rice bran) in pelleted form to meet the requirements of growing pigs. Each ration was fed to growing pigs placed in a concrete pen containing 30 growing pigs at initial weight 35 kg and replicated 3 times. The feeding trial was performed for 81 days to reach marketable weight, which was approximately 90 kg. Feed containing DDGS was readily consumed by pigs and there was no indication of refusal or toxicity related with DDGS. Body weight of pigs after feeding for 81 days was not different between dietary treatments. Daily gain of pigs fed control, DDGS 26% and DDGS 40% were 0.675 kg, 0.672 kg and 0.640 kg respectively. Average daily feed consumptions were similar among the treatments (around 2 kg/day) and therefore the feed per gain ratio was not different by feeding DDGS with different protein contents. Backfat thickness was not different among the dietary treatments. At end of feeding, a digestibility trial was conducted using Acid Insoluble Ash as internal marker. Dry matter, protein and phosphorus digestibility of the diet with DDGS 26% was 91%, 91% and 96%, respectively and was higher than the diet with DDGS 40% with value 83%, 85% and 92.5%, respectively. Income over feed cost of the pig fed DDGS 26% is higher than that of the pig fed DDGS 40% and the control diet without DDGS. In conclusion, DDGS can be successfully and economically fed to growing pigs at a 20% level and DDGS with 26% protein had better dry matter, protein and phosphorus digestibility than those of DDGS with 40% protein.

### Fish

Use of DDGS for feeding red tilapia under Vietnam condition. LE Hung VY

Access at

[http://www.grains.org/images/stories/technical\\_publications/2008-2009%20DDGS%20feeding%20trials%20\(2\).pdf](http://www.grains.org/images/stories/technical_publications/2008-2009%20DDGS%20feeding%20trials%20(2).pdf)

Red tilapia is one of major fish grown in Vietnam and is considered a popular species for human consumption. It has been shown that dried distiller's grains with solubles (DDGS) is economically feasible for animal feed especially in dairy cattle, swine and poultry. However, information on the use of DDGS for feeding fish is limited. This study was conducted to evaluate the impact of feeding increasing levels of DDGS on the performance of Tilapia fish reared under commercial conditions in Vietnam. At least 6000 fingerling of common carp and tilapia with initial weight 190 g were raised for 4 months up to around 800-900 g in floating cages placed in a reservoir. Four dietary treatments containing DDGS at 0, 5, 10 and 15% were included in similar dietary energy (2500 kcal/kg) and protein level (30%) of feed composed mainly with soybean meal, corn, rice bran and fish oil. Results of feeding for 4 months showed that increasing levels of DDGS in Tilapia diets increased growth rate and improved feed

efficiency. The best growth rates were obtained in the 10 and 15% DDGS in combination with soybean meal ( $P < 0.05$ ). The lowest growth rate was presented in the 0% DDGS feed. The lowest feed conversion ratio (FCR) during entire culture period was 2.1 in the 15% DDGS feed treatment. The use of DDGS at 15% inclusion level also improved survivability of the fish compared to treatment without DDGS (97.3% vs. 94%). Fish meat evaluation at the end of trial showed no different in chemical composition. In conclusion, DDGS can be included up to 15% in Tilapia diet and may improve the growth performance.

#### Feeding trial of DDGS for Common Carp. Le Khan Hung

A feeding trial on common carp was conducted at the Hoa Binh reservoir, Hoa Binh Province, Vietnam to measure the optimum inclusion of Dried Distiller Grain Solubles (DDGS) in the feed. The trial was performed using common carp fish with initial weight 26-51g raised for more than 3 months up to around 200 g in floating cages placed in a reservoir. Four dietary treatments containing DDGS at 0%, 5%, 10% and 15% were formulated in similar dietary energy (2.9 Mcal/kg) and protein level (26%) feed, composed mainly with soybean meal, wheat by products, rice bran, fish meal, meat and bone meal and fish oil. Results of feeding for 3 months showed that increasing the level of DDGS in the diet did not affect growth rate and feed consumption of the fish. There was an indication that fish fed 10% and 15% DDGS grew at a faster rate (40 g/month) than the fish fed lower levels (0% and 5%) of DDGS (28 g/month). Fish survivability rate was around 99.3-99.5% and there was no difference due to the dietary treatment. Fish meat evaluation at end of trial indicated no different in moisture, protein and fat content and meat color was similar among the dietary treatment. In conclusion, DDGS can be included in common carp diets up to 15% and not affect the growth performance and meat quality of the fish.



## Summary

The effects of adding U.S. made DDGS as a feed ingredient in domestic livestock feed have been evaluated by many countries. In Japan, where there is a demand for eggs with stronger yolk color than in the U.S., including up to 20% DDGS in the diet of domestic laying hens did not affect egg quality, but could improve egg yolk color which leads to a saves in yolk coloring agent. Positive results were also observed when feeding broilers with up to 20% DDGS in the diet. The higher the content of DDGS in the diet, the better growth rate and higher meat

production was found. In dairy cattle, 20% DDGS could be added in the diet without affecting the cow's condition, milk yield and milk composition. In swine, there were no significant differences in growth performance and carcass characteristics in finishing pigs when 20% DDGS was added to the diet, indicating that 20% DDGS could be used in swine finishing diets in Japan. In Korea, similarly, 20% DDGS could be added to swine diets without affecting growth performance, carcass characteristics and meat quality. In the poultry research conducted in Korea, feeding birds up to 15% DDGS in broiler diets and up to 20% DDGS in layer hens diets had no negative effects on animals growth performance and laying performance. One study conducted in Mexico reported a higher ADG and ADFI, and similar feed efficiency in growing-finishing pigs fed 10% DDGS in the diet compared with those fed a control diet. These results suggested that DDGS can be added to grow-finish swine diets in Mexico to provide at least equal, and probably improved growth performance compared with current commercial swine diets. In Taiwan, where consumers prefer domestic colored chickens with yellow skin, adding 20% DDGS plus only half of the amount of artificial pigments can achieve the desired growth performance, carcass quality and color of the skin, suggesting DDGS could be a good alternative feedstuff for domestic colored chicken production. In addition, 12% DDGS can be added to the diets of laying hens in Taiwan to improve productive performance, eggshell, and yolk characteristics. Similar results were also reported by another study where the authors observed improved yolk characteristics and unaffected productive performance when feeding laying ducks with diets containing up to 18% DDGS. In swine, pig performance is at least similar, and may even be improved, when 10% DDGS is added to the nursery and grower diets compared to feeding a typical commercial diet in Taiwan. In fish species, DDGS can be included up to 20% in the diet of domestic tilapia fish without sacrificing growth performance, while the inclusion level may be up to 40% for milkfish diets in Taiwan. In Thailand, researchers found DDGS could be used in broiler diets up to a maximum of 9% with no deleterious effect on growth rate, feed intake and feed efficiency, but carcass quality was not affected by dietary DDGS. In Vietnam, DDGS can be included up to 15% in the feed of Tilapia, which is one of the most popular fish for consumption in Vietnam, and may improve the growth performance and survivability. For swine, DDGS can be successfully and economically fed to growing pigs at a 20% level. In Indonesia, 20% DDGS can be added to the diets of finishing cattle without negative effects on growth performance and carcass characteristics. These results from different countries suggested that U.S. made DDGS could be added to the feed of many domestic species including swine, dairy cattle, broiler chickens, laying hens, laying ducks and fish with minimal or no negative effects on economic traits.