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Distillers feeds and feed fractions of barley in the diets of laying hens

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Abstract. Two experiments using 551 and 537 LSK-61 WL laying hens in the tests were conducted to evaluate hen performance and egg quality when graded levels of barley or wheat distillers feeds (BDDGS, WDDGS) from conventional process and barley protein and fibre (BP, BF) from integrated starch-ethanol production were incorporated into the diets. In the first exp. hens were fed diets containing 200 g/kg diet of WDDGS or 100 or 200 g BDDGS either with or without cellulase addition, respectively. In the second trial hens were fed diets with 50 or 100 g BP as protein supplement or 100 or 200 g/kg diet BF with or without multienzyme (Avizyme) addition. Each diet with similar contents of ME, CP, lysine and S-amino acids was fed to hens from 34 to 58 wk of age following 4-wk pretreatment and 2-wk transition periods.

There were only small dietary effects and no significant differences in performance due to treatment in either trial. The production level was rather high; on average the laying rate was 82.3 and 84.5 %, feed intake 119 g and 118 g/d and FCR 2.42 and 2.37 kg feed/kg eggs in exp. 1 and 2, respectively, indicating no adverse effects of the supplements used. A linear decrease ($P<0.01$) in egg weight and yolk colour intensity ($P<0.01$) was found in hens fed on diets with BP, while shell-% was linear improved $P<0.01$) in both BP and BF diets. Distillery feeds and barley feed fractions could be used in laying hens up to 200 g/kg without any reduction in production and up to two thirds of soybean protein could be replaced in diets fortfied with pure amino acids. The treatment of DDGS with cellulase or supplementation of multienzyme in BF diet had no effect on performance except that yolk colour was lighter in group on multienzyme treated BF diet.

Index words: distillery feeds, barley protein, fibre, laying hen

Introduction

Conventional distillers dried grains with solubles (DDGS) has long been known to be a useful feed ingredient for inclusion in poultry diets. No undesirable effects have been reported from feeding diets containing from 100 to 200 g/kg DDG or DDGS mainly from maize based ethanol production. In most of the reports, a significant improvement in

growth, egg production, feed utilization and hatchability has been observed in favor of the diets containing distillers feeds over the control diets (review of JENSEN 1985). DDGS appears to contain some unidentified nutritional factors which affect interior egg quality, liver lipid accumulation, hormone balance and calcium metabolism in laying hens (JENSEN 1985). Barley distillers feeds from the traditional ethanol process have been found to have a relatively low nutritive value due to their denatured protein and high fibre content (NÄSI 1985). In the integrated production of starch and ethanol, barley by-products suitable for use in the diets of both ruminants and monogastrics have been obtained (NÄSI 1988 a, 1989, HUHTANEN et al. 1988, 1989). Barley protein showed high digestibility and, when fortified with pure lysine, gave a nitrogen balance in growing pigs similar to that of the isonitrogenous soybean-barley diet. Up to two-thirds of soybean protein could be replaced with barley protein without differences in the performance of growing pigs (NÄSI 1989).

The objectives of this study were to compare various diets composing by-products from distillery and starch process using barley as a raw material with respect to laying hen performance and egg quality and to study the effect of enzyme addition.

Materials and methods

Feeds

The distillery feeds in the first experiment were obtained from the conventional distillery process (Alko Ltd., Koskenkorva) using dehulled barley or wheat as raw material (BDDGS, WDDGS). BDDGSC treated with cellulase prior to cooking was compared with the untreated material. Previously assayed apparent metabolizable energy values were 12.1, 10.9 and 10.5 MJ/kg DM for BDDGS, BDDGSC and WDDGS, respectively (KIISKINEN 1987). In the second trial barley protein and fibre fractions from the integrated ethanol-starch process (Alko Ltd., Rajamäki) were used. The chemical composition of the feed ingredients is shown in Table 1. KIISKINEN (1988) found the assayed nutrient digestibilities of barley protein (BP) and fibre (BF) to be 0.874, 0.539 for crude protein, 0.849, 0.549 for ether extract and 0.833, 0.480 for carbohydrates, respectively. AMEn values were 14.9 and 9.1 MJ/kg DM for BP and BF, respectively, which were employed in formulation of the feed mixtures.

In the both trials there were six diets: the control diet and five diets formulated with the intention of achieving a similar concentrations of energy, crude protein, amino acids and minerals to meet the requirements (SALO et

Table 1. Chemical composition by-products from distillery and starch production.

Composition g/kg DM	Barley		Wheat	Barley	
	DDGS	DDGSC	DDGS	protein	fibre
Dry matter	900	942	928	939	958
Ash	55	77	38	42	38
Crude protein	344	332	415	355	159
Ether extract	84	94	63	56	72
Crude fibre	78	71	99	14	114
NFE	439	427	385	533	617
NDF	380	333	409	5	507
ADF	220	214	182	—	136
ADL	96	113	87	—	24
Lysine	9.4	5.7	6.4	12.0	4.9
Cystine	5.4	5.8	7.3	8.3	3.1
Methionine	3.3	2.2	3.0	6.6	2.3
Threonine	13.3	12.5	12.9	12.8	4.7
Arginine	14.4	12.0	14.2	15.1	7.7

Table 2. Composition experimental diets containing various distillery by-products fed to layers in experiment 1.

Diet no	1	2	3	4	5	6
DDGS supplement	CONT	BDDGS	BDDGS	BDDGSC	BDDGSC	WDDGS
Level in diet, g/kg		100	200	100	200	200
Ingredients						
Barley	361	309	266	317	284	292
Oats	170	170	170	170	170	170
Wheat	120	120	120	120	120	120
Soybean meal	141	98	53	94	45	19
Fish meal	25	25	25	25	25	25
Meat meal	25	25	25	25	25	25
Barley DDGS	—	100	200			
Barley DDGS, cellul.	—	—	—	100	200	—
Wheat DDGS	—	—	—	—	—	200
Grass meal	20	20	20	20	20	20
Fat mixture	40	36	30	35	27	31
Calcium carbonate	82	82	78	79	69	82
Hostaphos	6	5	4	5	4	4
Trace element mix	5	5	5	5	5	5
Vitamin mix	5	5	5	5	5	5
Methionine	0.5	0.6	0.7	0.7	0.9	0.9
L-lysine	—	—	—	—	—	1.9
Calculated composition, g/kg						
Crude protein	170	176	182	176	183	187
Digestible protein	145	145	145	145	145	145
ME MJ/kg DM	11.2	11.2	11.2	11.2	11.2	11.2
Lysine	9.1	8.6	8.0	8.2	8.0	8.0
S-amino acids	6.0	6.1	6.2	6.1	6.3	6.4
Calcium	35	35	33	34	33	35
Phosphorus	6.3	6.4	6.5	6.4	6.5	6.4
Analysed composition, g/kg DM						
Dry matter	901	894	896	898	904	898
Ash	136	125	123	126	124	127
Crude protein	190	196	206	193	200	206
Ether extract	68	72	72	71	69	68
Crude fibre	65	67	70	69	72	69
NFE	541	540	529	541	535	530
Amino acids						
Arginine	13.5	12.8	11.5	11.8	10.6	10.1
Cystine	3.7	3.9	3.7	3.7	4.2	4.0
Histidine	4.7	4.6	4.1	4.6	4.2	4.1
Isoleucine	7.4	7.9	7.6	7.2	7.1	7.1
Leucine	14.4	15.9	15.5	14.5	14.4	14.8
Lysine	10.5	10.1	8.8	8.7	7.9	7.2
Methionine	4.0	4.4	4.4	4.1	4.1	4.2
Phenylalanine	9.3	9.8	9.4	8.8	9.4	9.4
Serine	9.1	9.6	9.3	9.4	9.5	10.0
Threonine	7.5	7.7	7.5	7.5	7.5	7.3
Tyrosine	6.2	5.9	6.5	5.7	5.4	5.5
Valine	9.0	9.9	9.9	9.1	9.4	9.6

al. 1982). The control diets were normal commercial layer mixtures having 170 g crude protein and 11.2 MJ ME/kg DM. In the first experiment 100 and 200 g/kg diet BDDGS untreated or treated with cellulase enzyme and 200 g WDDGS replaced soybean meal and barley to give mixtures with similar nutrient contents. Coefficients to correct for rather low protein digestibility of distillery feeds found in pigs (NÄSI 1985) were used in the formu-

Table 3. Composition experimental diets containing barley feed fractions from integrated starch-ethanol process fed to layers in experiment 2.

Diet no	1	2	3	4	5	6
Barley fraction	CONT	Barley protein		Barley fibre		Enzym.
Level in diet, g/kg		50	100	100	200	200
Ingredients						
Barley	437	427	420	286	136	136
Oats	150	150	150	150	150	150
Dehulled oats	100	100	100	150	200	200
Soybean meal	121	87	51	107	94	94
Fish meal	25	25	25	25	25	25
Meat and bone meal	20	20	20	20	20	20
Barley protein	—	50	100			
Barley fibre	—	—	—	100	200	200
Grass meal	40	40	40	40	40	40
Fat mixture	27	20	13	40	53	53
Calcium carbonate	36	38	38	37	37	37
Ouster shell	30	30	30	30	30	30
Dicalcium phosphate	5	4	3	5	6	6
Sodium chloride	1	1	1	1	1	1
Trace element mix	6	6	6	6	6	6
Vitamin mix	1.7	1.7	1.7	1.7	1.7	1.7
Methionine	—	0.6	0.5	0.6	0.5	0.6
L-lysine	—	—	0.4	—	—	—
Calculated composition, g/kg						
Dry matter	889	892	894	900	810	910
Crude protein	160	160	161	162	164	164
ME MJ/kg DM	10.8	10.8	10.9	10.9	11.1	11.1
Lysine	9.0	7.6	7.6	7.9	7.8	7.8
S-amino acids	6.5	6.6	6.8	6.7	7.0	7.0
Calcium	32	33	33	33	33	33
Phosphorus	6.3	6.3	6.4	6.3	6.3	6.3
Analysed composition, g/kg DM						
Dry matter	901	899	900	908	913	916
Ash	114	114	109	116	118	112
Crude protein	186	183	183	185	185	178
Ether extract	71	66	61	89	109	108
Crude fibre	61	59	57	72	71	68
NFE	568	578	590	538	517	534
NDF	165	180	159	218	217	209
ADF	53	57	54	74	72	69
Amino acids						
Arginine	10.6	10.3	9.7	10.8	11.1	10.2
Cystine	3.5	3.7	3.9	3.7	3.8	3.7
Histidine	4.0	3.9	3.9	4.0	4.1	3.9
Isoleucine	6.9	6.5	6.6	6.6	6.8	6.5
Leucine	13.0	12.5	12.6	12.7	12.8	13.4
Lysine	8.9	8.0	8.0	8.7	8.8	8.2
Methionine	5.3	3.8	4.0	3.9	4.2	3.5
Phenylalanine	8.2	8.3	8.2	8.0	8.1	8.1
Serine	8.3	7.9	7.7	8.1	8.1	7.9
Threonine	6.7	6.3	6.4	6.5	6.7	6.4
Tyrosine	6.0	6.0	5.8	5.9	6.1	5.8
Valine	8.5	8.3	8.4	8.4	8.6	8.4

lation of the diets (0.69, 0.56 and 0.73 for protein in BDDGS, BDDGSC and WDDGS, respectively).

In the second experiment, two diets replaced either one-third and two-thirds of soybean protein with barley protein (50 and 100 g/kg).

In two other diets barley fibre was substituted for barley at the level of 100 or 200 g/kg. Addition of multienzyme preparate (Avizyme, Cultor, Ltd. Helsinki) was compared in diet containing 200 g/kg BF. Feed fat was used to equalize the ME-content and pure lysine and methionine in fortifying the amino acid composition in mixtures. The feed mixtures were prepared by Suomen Rehu Oy and they were in granular form. The composition of the feeds and their nutrient contents are given in the Tables 2 and 3.

Animals and management

The separate performance trials were carried out with 551 and 537 Finnish hybrid LSK 61 laying hens in each experiment. The hens were housed in stair model cages with three birds in each. The hens were fed pretreatment diet for four weeks followed by distribution according to the pretrial laying rate in experimental groups consisting of six replicates of 14—16 hens per treatment. The tests lasted six 28-day periods from 34 to 58 weeks of age of the hens.

The diets were fed ad libitum and feed consumption was recorded for each subgroup for a 28-day period. Feed was added to feeders quantitatively as required, and weighed back at 4-wk intervals. Intake was calculated (g hen^{-1} d^{-1}) on a 28-d basis. Egg production was recorded daily by weighing and counting the eggs. The feed ingredients and experimental mixtures were analysed according to standard methods.

Egg shell weight, albumen height, Haugh units and yolk pigmentation were also determined. Egg quality measurements in exp. 2 were made once in pretreatment periods and three times in comparison periods on two consecutive days consisting assays of 144 and 432 eggs, respectively. Eggs were weighed individually after collection. The eggs were then broken out onto a glass sheet and the albumen height was measured by a micrometer in order to calculate Haugh units. Yolk colour was scored by comparing the yolks using Roche scale. The dryed egg shells were weighed following day. The presence of blood and meat spots in the eggs was also recorded.

Analysis of variance was performed on the 28-day period data as a split-plot design, with diet as the treatment and period as the split plot, using the statistical package of WSYS (VILVA 1988).

Results and discussion

Experiment 1

The chemical composition of the mixtures were close to the values calculated. Lysine content of mixture with WDDG was lower than expected although pure lysine was added and analysed values of amino acids were used in formulation. The explanation for this error remains uncertain. Crude protein varied between mixtures because different coefficients for crude protein digestibility were applied according to previous trials made in pigs (NÄSI 1985) to equalize the available protein supply. The crude fibre content between mixtures was similar although distillery feeds contained NDF 333—409 g/kg.

Acid detergent lignin contents were high in distillery feeds (87—113 g/kg), but the analysis may reflect a high concentration Maillard products.

The production results in experiment 1. are presented in Table 4. for distillery feed comparisons. There were no statistically significant differences in performance of hens between treatments. Mean production of hens fed BDDGS was numerically higher than the control and other distillery feed groups, but the difference was non significant ($P > 0.05$). Hens on diets supplemented with cellulase treated BDDGS or WDDGS tended to have slightly lower egg production and feed conversion probably indicating deficiencies in amino acids and protein supply. The high egg production level, on average 82.3 % in hens fed diets with distillery feeds, was equal to control. It is notable that up to two thirds soy-

Table 4. Performance of layers fed diets containing various distillery by-products, experiment 1.

Diet no	1	2	3	4	5	6	SEM
DDGS supplement	CONT	BDDGS	BDDGS	BDDGSC	BDDGSC	WDDGS	
Level in diet, g/kg		100	200	100	200	200	
Number of hens							
Beginning of expt.	91	93	93	92	91	91	
End of expt.	89	89	90	92	88	88	
Mortality, %	2.2	4.3	3.2	0	3.3	3.3	
Egg production							
Laying rate, %							
Standard. period	92.0	92.1	92.0	92.0	91.9	92.0	
Transition period	93.4	93.1	93.3	91.0	92.5	91.0	
Test period (168 d)	82.7	84.2	83.0	80.5	82.6	80.5	0.56
Eggs, g/hen/d	49.2	50.5	49.7	48.4	49.4	48.1	0.35
Mean egg weight, g	59.6	59.8	60.0	60.3	60.0	60.0	0.13
Feed intake							
Feed, g/hen/d							
Standard. period	107.6	105.5	109.6	108.1	106.9	107.2	
Test period	116.5	119.3	120.3	118.6	119.6	118.6	0.65
DM, g/hen/d	105.0	106.6	107.7	106.4	108.1	106.5	0.58
Protein, g/hen/d	20.0^{d}	20.9^{bc}	22.2^{a}	20.5^{cd}	21.6^{ab}	21.9^{a}	0.12
ME MJ/hen/d	1.22	1.24	1.25	1.23	1.25	1.23	0.007
Feed conversion							
Feed, kg/kg eggs	2.38	2.38	2.43	2.46	2.43	2.48	0.021
Feed DM, kg/kg eggs	2.14	2.13	2.17	2.21	2.19	2.23	0.019
Feed CP, g/kg eggs	408^{d}	418^{cd}	449^{ab}	425^{bcd}	438^{abc}	458^{a}	3.7
Feed ME MJ/kg eggs	24.9	24.7	25.2	25.6	25.3	25.8	0.022

Means with different letters were significantly different: $^{a-d}$ ($P<0.01$)

bean meal protein could be replaced with distillery feeds and only methionine supplementation was necessary to maintain protein quality. The layers consumed diets including DDGS a littlebit more than that of control mixture. Feed conversion efficiency was not reduced by distillers feeds.

The energy values measured in a previous digestibility trial (KIISKINEN 1987) corresponded well with the present production results. ME-values for DDGS from dehulled barley and that of wheat without bran have been reported as 11.5 and 12.2 MJ/kg DM, respectively (ASKBRANT and THOMKE 1986). These are higher than values for present distillery feeds, but PETTERSSON et al. (1987) found a much higher value of 13.7 for dehulled barley distillers spent grains. The raw material and the process differences cause variability in energy value.

The protein digestibilities of the batches of DDGS in this study were 0.662, 0.622 and 0.713 for barley, cellulase treated barley and wheat distillery feeds (KIISKINEN 1987), the values being quite close those assayed with pigs (NÄSI 1985), which were applied in the feed formulation. The reported protein digestibility of distillers feeds has varied considerable due to differences in cooking, distillation and dehydration processes. Higher digestibilities than the present study were reported by ASKBRANT and THOMKE (1986) and PETTERSSON et al. (1987), the values being 0.7—0.8. Protein digestibility has a great effect on protein utilization of DDGS. Low digestibility value indicate also the deterioration of amino acids and their availability.

Present performance results from experiments with laying hens are in agreement with the other reports which have shown that relatively high levels of DDGS can be incorporated into properly balanced diets. JENSEN (1985) reported that laying hens could be fed up to 200 g/kg DDGS in isocaloric diets with

no adverse effect on egg production or other performance characteristics. MATTERSON et al. (1966) showed that the diets containing 100—200 g/kg DDGS supplied adequate essential amino acids to layers and that supplemental pure lysine did not produce an additional response. However, lysine is a critical amino acid when using DDGS, and when 100 g/kg DDGS has been added to wheat-based diets, lysine supplementation has been necessary to obtain optimum performance (JENSEN 1985). In the present study only methionine was added in barley DDGS diets and only lysine in the wheat DDGS diet which had lower lysine content in oder to obtain contents of the layers requirements. BOSSARD et al. (1981) compared the use of 0, 100, 200 and 300 g/kg DDGS in cornsoybean meal diets for laying hens. The diets were isonitrogenous and isocaloric and were balanced for lysine. No difference in rate of egg production was observed, but birds fed the higher levels had lower egg weight, suggesting that some of other amino acids may have been out of balance. In the present study hens fed diets with DDGS tended to lay heavier eggs than the control group.

Diets containing DDGS or other fermentation by-products have been reported to significantly improve interior egg quality (JENSEN et al. 1978, SAUVEUR 1981). Identification of the activity in DDGS affecting interior egg quality has not yet been achieved. The possibility that the trace mineral content of DDGS might be involved was suggested by JENSEN (1985). Inclusion of DDGS has resulted in a significant reduction in liver lipid accumulation in caged laying hens compared to birds fed simple maize-soybean meal diet (JENSEN 1985). Also DDGS supplements have been shown to affect calcium metabolism of hens and improvements in egg breaking-strength have been observed (JENSEN 1985). Mortality of the hens was low during this 6-month experiment. Cannibalism was rare which is usual in this poulty house.

Table 5. Performance of layers fed with diets containing barley feed fractions from integrated starch-ethanol process, experiment 2.

Diet no	1	2	3	4	5	6	SEM
Barley fraction	CONT	Barley protein		Barley fibre		Enzym.	
Level in diet, g/kg		50	100	100	200	200	
Number of hens							
Beginning of expt.	88	88	87	90	90	88	
End of expt.	86	82	82	88	87	85	
Mortality, %	2.3	6.8	5.7	2.2	3.3	3.4	
Egg production							
Laying rate, %							
Standard. period	93.7	93.7	93.7	93.7	93.7	93.7	
Transition period	92.1	91.3	91.9	92.9	93.1	92.7	
Test period (168 d)	84.5	83.3	85.2	84.3	85.2	84.6	0.98
Eggs, g/hen/d	50.5	49.2	49.8	49.8	50.3	50.2	0.60
Mean egg weight, g	59.8	59.1	58.6	59.2	59.6	59.3	0.30
Feed intake							
Feed, g/hen/d							
Standard. period	118.0	115.2	115.6	117.8	117.9	116.8	
Test period	119.6	119.7	116.8	116.2	118.5	118.3	2.38
DM, g/hen/d	107.7	107.6	105.1	105.5	108.1	108.4	2.15
Protein, g/hen/d	20.0	19.7	19.2	19.5	20.0	19.3	0.39
ME MJ/hen/d	1.29	1.30	1.27	1.27	1.31	1.31	0.02
Feed conversion							
Feed, kg/kg eggs	2.37	2.44	2.35	2.33	2.36	2.36	0.05
Feed DM, kg/kg eggs	2.14	2.19	2.11	2.12	2.15	2.16	0.05
Feed CP, g/kg eggs	397	402	386	392	399	385	8.50
Feed ME MJ/kg eggs	25.6	26.4	25.5	25.5	26.1	26.1	0.56

Experiment 2

Performance results from the experiment 2 are shown in Table 5. Laying rate changed between groups from 83 to 85 % and feed conversion from 2.33 to 2.44 kg/kg eggs, although there were no statistically significant dietary effects. Barley protein had high protein digestibility (0.87) and an AME-value of 14.9 MJ/kg DM (KIISKINEN 1988). It appears from these production data that barley protein fortified with lysine and methionine could be a substitute for a major proportion of the protein of SBM without an adverse effect on performance. This is in accordance with the observation of KIISKINEN (1988) who suggested that BP is suited to broiler finisher diets fortified with lysine and methionine and can replace SBM up to a level of 5—10 %. Similarly barley protein showed high digestibility and if fortified with pure lysine gave a nitrogen balance in growing pigs similar to that of isonitrogenous soybean-barley diet. Up to two-thirds of soybean protein could be replaced with barley protein without a difference in the performance of growing pigs (NÄSI 1989).

Barley fibre had rather low protein digestibility (0.54) and an AME-value of 9.1 MJ/kg DM (KIISKINEN 1987). Those assayed values were in accordance with the production data; BF could replace barley in isocaloric layer diets without adverse effects. NDF contents of these BF-diets were over 200 g/kg and when dietary fibre increases nutrient availability decreases (JANSSEN and CARRE 1985, KROGDAHL 1986), but the characteristics of the fibre are of great importance. A feedstuff similar to barley fibre is corn gluten feed (CGF) a coproduct of the wet milling industry of maize starch and sugar (ANON. 1982). SIBBALD (1986) reported that TME values for 12 samples of CGF ranged from 8.01 to 11.6 MJ/kg DM and digestibility of lysine and methionine from 0.66 to 0.81 and from 0.79 to 0.89, respectively. Lysine and tryptophan were equally limiting in CGF and the bioavailability of lysine by chick assay varied consider-

Table 6. Quality parameters of eggs layed by hens fed diets containing barley feed fractions from integrated starch-ethanol process, experiment 2.

Diet no	1	2	3	4	5	6	Statistical significance of effect								
Barley fraction	CONT	Barley protein		Barley fibre		Enzym.	Protein supplement			Fibre supplement			Enzyme supplement		
Level in diet, g/kg		50	100	100	200	200	SEM	Lin	Quad	SEM	Lin	Quad.	SEM	Sign.
Egg weight, g	60.4	59.6	58.7	60.0	59.6	60.1	0.44	**	NS	0.42	NS	NS	0.43	NS
Shell weight, g	5.50	5.48	5.49	5.61	5.60	5.56	0.05	NS	NS	0.05	NS	NS	0.05	NS
Shell-%	9.11	9.20	9.35	9.36	9.41	9.26	0.07	**	NS	0.07	**	NS	0.07	NS
Albumen height, mm	6.8	6.7	7.0	7.0	6.8	7.0	0.12	NS	NS	0.12	NS	NS	0.12	NS
Haugh number	81.6	81.1	83.4	83.2	81.8	83.2	0.81	NS	NS	0.79	NS	NS	0.80	NS
Yolk colour	9.0	8.7	8.6	8.9	8.9	8.5	0.09	**	NS	0.08	NS	NS	0.08	**

* $P<0.05$, * $P<0.01$

ably, from 0.57 to 0.87 (CASTANON et al. 1990 b). CGF could be incorporated in layer diets up to 250 g/kg without affecting egg production detrimentally, however high levels of CGF may depress egg weight when fed to young hens (CASTANON et al. 1990 a).

A linear decrease was shown in egg weight caused by incremental barley protein supplementation ($P<0.01$, Table 6) and simultaneously egg shell weight increased. Egg weight depression and shell weight increase are usually indications of unsufficient protein supply or deficiency of some essential amino acid (FISHER 1969, GILBERT and PEARSON 1983). The analysed amino acid contents of the diets indicated lower methionine level in experimental groups compared to control and deficiency of S-amino acids have been shown to decrease egg weight (AL BUSTANY and ELWINGER 1987). Average albumen height was 6.9 mm and Haugh number 82.4, with no dietary effects in this trial. Feeding of fermentation by-products and DDGS containing diets has been reported to improve egg interior quality (JANSEN 1985). The integrated ethanol-starch process also yields distillers solubles which could be added to barley fibre and this feed ingredient could have effect on egg interior quality. Egg yolk colour was significantly lighter in hens fed barley protein compared to control and also in enzyme-treated group compared to untreated ($P<0.01$). The diets were supplemented similarly with grass meal and no explanation for this effect is apparent. In contrast to present results AIMONEN and TAKKU (1989) found that enzyme treatment improved yolk colour. Increased fat digestibility following enzyme supplementation (AIMONEN and NÄSI 1991) might be expected to improve carotenoid absorption.

Enzymatic treatment

Present results indicate that no improvement in performance is obtained by treating the DDGS with cellulase or multienzyme supplementation of BF containing diet. This is in agreement with digestibility results in pigs that showed no effect or even reduction after cellulase treatment of DDGS was observed compared with untreated DDGS (NÄSI 1985). PETTERSSON et al. (1987) however, showed β-glucanase supplementation to improve daily gain and feed conversion in chickens fed barley spent grain diet. Also, fermentation of barley DDG with *Rhizopus oligosporus* tended to improve the feed quality in poultry (NEWMAN et al. (1985). Multienzyme supplementation has improved feed conversion in layer diet (NÄSI 1988 b, AL-BUSTANY and ELWINGER 1988, AIMONEN and NÄSI 1991). β-glucanase or cellulase supplements have resulted in performance similar to unsupplemented control diets (AL-BUSTANY and ELWINGER 1988, NÄSI 1988 b, PATTERSON et al. 1988).

The results of two experiments incorporating by-products of grain origin into diets as replacements for cereal and soybean meal demonstrate that laying hens may be fed distillery feeds and feed fractions of barley up to 200 g/kg provided that nutrient requirements are met. Without any reduction in performance up to two thirds of soybean protein can be replaced in diets fortified with lysine and methionine.

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SELOSTUS

Ohra- ja vehnärankkirehut sekä etanoli-tärkkelystuotannon ohrajakeet munivien kanojen ruokinnassa

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Kahdessa tuotantokokeessa selvitettiin vehnästä ja kuoritusta ohrasta saatujen rankkirehujen sekä yhdistetyn etanoli-tärkkelystuotannon ohrajakeiden käyttöä rehuraaka-aineina munivien kanojen ruokinnassa. Koeseoksissa käytettiin 200 g vehnärankkia tai 100 ja 200 g/kg ohrarankkia, jolla korvattiin ohraa ja soijarouhetta. Ohrarankki oli joko sellulaasientsyymillä käsiteltyä tai ilman käsittelyä. Ohravalkuaista käytettiin seoksissa 50 tai 100 g/kg ja ohrarehua 100 tai 200 g. Yhdessä ohrarehuseoksessa käytettiin Avizyme multientsyymilisäystä. Seosten koostumus vakioitiin rasvan sekä puhtaan lysiinin ja metioniinin lisäyksillä. Molemmat kokeet olivat kestoltaan 24 viikkoa.

Kanojen munatuotoksessa ja rehunkäytössä ei ollut merkitseviä eroja ryhmien välillä. Tuotostaso oli kummassakin kokeessa korkea: muninta-% 82.3 ja 84.5; rehunkulutus 119 g ja 118 g/d sekä rehun käyttö 2.42 ja 2.37 kg/kg munia, kokeessa 1 ja 2. Rankkirehujen entsyymikäsittelyllä tai ohrarehua sisältävään rehuseokseen lisätyllä multientsyymillä ei ollut vaikutusta kanojen tuotantotuloksiin. Rankkirehut ja ohrajakeet soveltuivat hyvin munivien kanojen rehuiksi käyttötasojen ollessa 200 g/kg, kun rehuseosten energiaväkevyys ja aminohappojen pitoisuudet oli tasoitettu. Käytetystä soijarouheen valkuaismäärästä voitiin näillä viljavalkuaisrehuilla korvata yli puolet tuotantotulosten huonontumatta.