THE NUTRITIONAL VALUE OF WHEAT MILLING BY-PRODUCTS FOR THE GROWING CHICK

II. Evaluation of Protein[1]

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ABSTRACT

Two experiments were conducted to evaluate the protein of a series of wheat by-product fractions and of wheat germ meal. Growth of chicks was relatively rapid when they were fed either wheat shorts or wheat germ meal diluted with 50% of a corn-soybean ration. The carcass fat content of the chicks fed wheat bran rations similarly diluted was relatively low and the protein content relatively high; those fed middlings rations were relatively low in protein content; chicks fed shorts rations were intermediate in composition between these extremes. Values for net protein utilization (NPU) of the wheat by-products, when fed to chicks in equicaloric, equiprotein diets, did not correlate well with weight gains; values for shorts were highest and for bran were lower; the sample of wheat germ meal used in the second experiment had a very low NPU value. The value of the protein of all wheat by-products, except the brans and wheat germ meal, compared favorably with methionine-supplemented soybean meal.

The nutritional value of the protein of wheat milling by-products has been reviewed by Chick *et al.* (1). Evidence indicates that the protein content of these by-products is relatively high and that digestibility (2,3), the protein efficiency ratio (4), and the biological value (5) of the protein compare favorably with those of other proteins. The cells of the embryo and of the aleurone layer are particularly rich in protein (6). For germ meal and those fractions with higher aleurone content, such as shorts or middlings, nitrogen retention and biological values (4) are better than for other fractions of wheat.

Studies of the amino acid pattern of wheat by-products (7) have shown that, compared with other plant sources of protein, they have high contents of lysine, tryptophan, and arginine. The intestinal absorption of amino acids of wheat has been shown to be very high (8). The value of a protein lies not only in its amino acid content and pattern, but also in its potential to complement the amino acid pattern of other proteins in the same ration. In this regard, the protein efficiency ratio (9) and the biological value (10) of the proteins of wheat are considerably increased by inclusion in a diet with a relatively small proportion of meat, fish, or soybean meal.

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The two following experiments were carried out as part of a study to assess the nutritional value of wheat by-products and to investigate means of improving their nutrient availability to the chick.

Methods

In experiment 1 the effect of high levels of dietary wheat by-products on carcass composition was investigated. Nine wheat by-products which have been previously characterized (11) were each included in rations with 50% of a basal corn-soy diet and fed *ad libitum*, as mash, to five replicate groups of 11 male White Leghorn chicks, from day-old through to 4 weeks of age, using a randomized incomplete block design. The basal diet employed is shown in Table I.

TABLE I
COMPOSITION OF BASAL DIET

INGREDIENT	AMOUNT
	%
Ground yellow corn	27.25
Soybean oil meal (50% protein)	56.0
Dehydrated alfalfa meal (17% protein)	4.0
Meat meal (50% protein)	2.5
Fish meal (60% protein)	2.5
Dried whey (55% lactose)	2.5
Ground limestone	2.0
Dicalcium phosphate	2.0
Iodized salt	0.5
Vitamin-mineral premix[a]	0.75

[a] The vitamin-mineral premix supplied the following nutrients per 100 g. of diet:

Vitamin A, 1,008 IU	Niacin, 0.55 mg.
Vitamin D_3, 124 ICU	Manganous oxide, 14.81 mg.
D-calcium pantothenate, 0.622 mg.	Zinc oxide, 10.58 mg.
Menadione sodium bisulfite, 0.22 mg.	3-Nitro-4-hydroxy phenylarsonic acid, 5.0 mg.
Riboflavin, 0.70 mg.	
Vitamin B_{12}, 0.0030 mg.	DL-methionine, 50.04 mg.
Choline chloride, 18.80 g.	Penicillin, 1.1 mg.

Chromic oxide indicator was added to provide a level of 0.3% in the assay diets.

The chicks were housed in electrically heated battery brooders with raised wire floors. At the termination of the experiment, the chicks were weighed and killed by chloroform inhalation; the carcasses were stored at −20°F. The frozen carcasses of each group were pooled and passed through a meat grinder; duplicate 100-g. samples were taken and freeze-dried to determine the moisture content. The dried samples were then analyzed for ether extract content by refluxing for 16 hr. with petroleum ether in a Soxhlet apparatus; analysis for protein (N × 6.25) was by a semimicro-Kjeldahl method.

In experiment 2, the protein of the nine wheat by-products was evaluated according to the net protein utilization (NPU) method (12), as modified for assay with chicks (13). Semipurified diets were formu-

TABLE II
COMPOSITION OF DIETS[a] (EXPT. 2)

PROTEIN SOURCE	AMOUNT ADDED	STARCH/ CERELOSE	CORN OIL	SOLKA FLOC	PREMIX[b]
	%	%	%	%	%
Shorts 1	69.1	24.8	1.0		5.16
Shorts 4	69.5	10.1	15.2		5.16
Shorts 3	70.3	21.6	3.0		5.16
Midds 2	76.1		2.0	16.8	5.16
Midds 1	70.0	23.8	1.0		5.16
Shorts 2	59.9	27.0	1.0	7.0	5.16
Bran 2	74.7	8.9	10.5	0.8	5.16
Bran 1	79.8		15.0		5.16
WGM	38.0	37.0	1.0	18.9	5.16
N-free		88.8	3.0	3.0	5.16
Soybean[c]	28.0	66.7			5.16

[a] Calculated to contain 2.50 kcal./g. and 12.2% protein.
[b] The vitamin-mineral premix supplied the following nutrients per 100 g. of diet:
Vitamin A, 500 IU
Vitamin D_3, 59.4 ICU
DL-alpha-tocopherol, 750 IU
Thiamine hydrochloride, 2.0 mg.
Riboflavin, 1.2 mg.
Calcium D-pantothenate, 2.0 mg.
Pyridoxine hydrochloride, 0.6 mg.
Biotin, 0.03 mg.
Menadione bisulfite, 0.4 mg.
Vitamin B_{12}, 0.002 mg.
Ascorbic acid, 15.0 mg.
Niacin, 6.0 mg.
Folic acid, 0.3 mg.
Cobalt chloride, 0.2 mg.
Magnesium sulfate, 250 mg.
Ferric sulfate, 10 mg.
Manganous sulfate, 20 mg.
Potassium iodide, 0.6 mg.
Cupric sulfate, 1.2 mg.
Zinc carbonate, 20 mg.
Sodium molybdate, 1.0 mg.
Dicalcium phosphate, 0.52 g.
Calcium carbonate, 1.25 g.
Sodium chloride, 0.5 g.
Cerelose, 0.226 g.
[c] Supplemented with 0.15% DL-methionine.

lated in which the wheat by-product was the sole source of protein; the levels of dietary protein and metabolizable energy calories were equalized for all treatments by adjustment of the levels of starch/cerelose, corn oil, and solka floc (Table II). A diet essentially nitrogen-free was included to permit correction for nitrogen required for maintenance; a methionine-supplemented soybean meal diet was used for positive control treatment.

The assay rations were cold-pelleted, and each was fed *ad libitum* from 1 through to 3 weeks of age to four replicate groups of ten male White Leghorn chicks, using a randomized complete block design. The chicks were fed from day-old to 1 week of age on commercial chick crumbles and were housed in electrically heated battery brooders with raised wire floors throughout the experiment.

The chicks were weighed at 1 and 3 weeks of age and after the latter weighing were killed by chloroform inhalation. Samples of feed and carcasses were analyzed for water and nitrogen, to permit calculation of NPU (13).

The data from the experiments were analyzed by the method of analysis of variance (14), and tests of significance of treatment effects were made using multiple comparison tests (15).

Results and Discussion

Higher carcass protein content was associated with lower carcass fat content (Table III); the groups of chicks fed on bran 1 and bran 2 and wheat germ meal rations had the highest percentage of carcass protein; those fed on shorts 2 had the lowest. However, when presented as total gain in protein, the ranking of the wheat by-products became the same as for weight gain, except that middlings 2 was inferior to all other products.

TABLE III

WEIGHT GAIN AND CARCASS COMPOSITION OF CHICKS FED RATIONS CONTAINING 50% WHEAT BY-PRODUCTS OR WHEAT GERM MEAL (EXPT. 1)[a]

WHEAT BY-PROCUCT	WEIGHT GAIN (0–4 WEEKS)	PROTEIN GAIN (TOTAL)	CARCASS COMPOSITION		
			Mois-ture	Ether Extract	Protein (N × 6.25)
	g.	*g.*	%	% DM	% DM
Shorts 2	264	160 a	70.8 a	18.6 ab	50.9 a
WGM	244 a	168 a	71.5 b	18.3 ab	58.8 bc
Shorts 1	240 a	157 a	71.0 ac	17.1 bc	56.2 abc
Shorts 3	234 ab	153 ab	71.3 bc	18.0 b	53.8 abc
Shorts 4	224 b	147 abc	71.6 b	17.9 b	54.6 abc
Midds 1	209 c	132 cd	71.2 ac	19.1 ab	53.2 abc
Midds 2	206 c	126 d	69.7	20.3 ab	53.1 a
Bran 2	194 c	134 cd	72.3	15.9 cd	57.6 abc
Bran 1	194 c	136 bcd	72.7	15.0 cd	59.6 c
$S_{\bar{x}}$	6.1	9.5	0.015	0.477	0.30
DF	34	34	34	34	77

[a] Treatments followed by the same letter are not significantly different (P = <0.05).

Previous work has shown that some of the wheat by-products have relatively low metabolizable energy values (11). It is probable that, in this experiment, some of the protein of the wheat by-products may have been utilized for energy purposes, thus limiting the amount of protein available for tissue growth. The evaluation of the protein was probably not as satisfactory for the brans 1 and 2 and shorts 4 treatments as for the others because of their relatively low content of metabolizable energy.

The NPU values of the wheat by-products obtained in experiment 2 (Table IV) compared favorably with that of the methionine-supplemented soybean meal diet; only brans 1 and 2 and wheat germ meal had values significantly lower than those of the control treatment.

Of six protein supplements widely used in poultry nutrition, which Summers and Fisher (13) compared by the NPU method, methionine-supplemented isolated soybean protein and methionine-supplemented soybean meal had the highest NPU values and chicks fed the meal grew faster during the 3-week assay period; thus it is evident that the

TABLE IV

WEIGHT GAIN, FEED INTAKE, CARCASS COMPOSITION, AND NET PROTEIN UTILIZATION OF CHICKS FED ON ISOCALORIC, ISOPROTEIN DIETS IN WHICH WHEAT BY-PRODUCTS OR WHEAT GERM MEAL WERE THE SOLE SOURCE OF PROTEIN (EXPT. 2)[a]

WHEAT BY-PRODUCT	WEIGHT GAIN (1–3 WEEKS)	CARCASS COMPOSITION			NPU
		Moisture	Ether Extract	Protein	
	g.	%	% DM	% DM	
Shorts 1	98.0 a	66.3 ab	35.0 a	51.1 ab	56.3 a
Shorts 4	58.2 bc	66.0 ab	30.0	51.2 ab	54.4 a
Shorts 3	107.3 ad	67.2 a	34.0 a	50.6 ab	54.2 a
Midds 2	63.9 be	66.3 ab	35.0 a	50.0 bc	52.7 a
Midds 1	85.9 f	65.8 ab	36.1 a	52.6 a	52.5 a
Shorts 2	78.6 f	66.4 ab	34.5 a	51.2 ab	49.9 ab
Bran 1	61.8 bce	69.1 c	25.7 b	55.9 d	45.4 bc
Bran 2	71.4 e	69.3 c	23.4 b	54.9 d	43.6 bc
WGM	52.2 c	67.2 a	34.5 a	49.7 c	42.3 c
Soy + 0.15% DL methionine	108.8 d	64.5 b	38.1	47.9 c	54.8 a
$S_{\bar{x}}$	3.4	0.3	0.3	0.7	2.1
DF	27	27	27	27	27

[a] Treatments followed by the same letter are not significantly different (P = <0.05).

control diet used sets a relatively high standard for comparison. The use of equiprotein and equicaloric diets in the second experiment resulted in some changes in the relative values of the proteins. The ranking of the wheat by-products according to weight gain was similar to that of the previous experiment, except that shorts 2 was well below its previous position and wheat germ meal was lowest of all. However, the NPU values showed little correlation with weight gain data (Table IV). Shorts 4 and middlings 2 had relatively high NPU values, although weight gain was low; this can be explained on the basis that the carcass protein content was relatively high. The lowest NPU value was that for wheat germ meal; this product was from a source other than that of the previous experiment. It is probable that the low value of wheat germ protein was due to inadequate or incorrect processing; this aspect will be covered elsewhere.

It was concluded that wheat shorts, wheat middlings, and properly processed wheat germ meal are good sources of protein when included in diets adequate in caloric content.

Acknowledgment

This study was supported by the Robin Hood Flour Mills Ltd., Montreal, whose assistance is gratefully acknowledged.

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