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POULTRY MEAT IN THE UNITED KINGDOM

by

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Introduction

The first census of fowls in England and Wales was recorded in 1884. At that time there were 12 million fowls evenly distributed throughout the country at a density of 250 to 500 birds per 1,000 acres. In only 5 counties was the density smaller, and in only two, Lancashire and Cheshire, was the density greater. In 1966 the population had risen 100 million and virtually all were in Lancashire, Worcestershire and the South and East of England. Whilst the position in Scotland has not been recorded in comparable detail, the pattern of development, towards concentration in selected areas, has been similar.

Until 1955 the population of fowl increased steadily from the 12 million in 1884 to 73 million in 1955, the mean annual rate of increase of approximately 1 million being slowed only in two world wars and the slump of the early thirties. In 1955 the rationing of animal feed in the United Kingdom ceased and the broiler industry began. The census for 1966 shows an increase in the number of fowls over the decade of 27 million, nearly half as much as had been achieved in the previous seventy years. In fact the poultry meat industry in the United Kingdom had been born and the actual number of fowl grown was 386 million, the broiler chicken having so short a growing period that 5 crops could be reared in a year.

The present day poultry meat industry accounts for about 15% of the meat production in the U.K. with an annual value, in 1968/69, equivalent to 15% of the total for meat. The amounts and values of the major components of agricultural output of the United Kingdom for the last 5 years for which complete statistics are available are shown in Table 1 and the contribution from the different classes of poultry meat are shown in Table 2. The small discrepancy in the totals shown for amounts of poultry meat between the two tables arises from differences in the origin of the primary data and the calculations made from it by the Ministry's Statistics Division.

Fowls under 6 months of age are dominantly broiler chicken and these account for the greater part of the poultry meat produced in Britain. Furthermore the organisation of their production is quite different from the traditional pattern of agriculture. Approximately 50% of all broilers are produced by 2 Companies, 75% by 5 Companies and fewer than 100 Companies are concerned with the entire national production.

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The turkey industry, which provides about 10% of all poultry meat, is organised in a similar way, 6 Companies dominating the market and producing turkey meat all the year round.

A single Company accounts for the greater part of the production of duck meat, but this is equivalent to little more than 2% of the national production of poultry meat.

Less than 0.2% of poultry meat comes from geese and there are no large organisations concerned in their production. Of a comparable order in providing meat are game birds, but unlike geese, their numbers are inreasing and a growing proportion are reared by intensive methods.

Agricultural Production.

Biely (1971) has reviewed the progress of the past 25 years and its magnitude is dramatically illustrated in Table 3, where the results of the first and last of the Maine Production and Broiler Tests (1945 - 1947 and 1966) have been compared. During the 20 years the methods of agricultural production, utilizing advances in genetics, husbandry and nutrition, made possible an overall improvement of more than 43%. In the last of these tests the average feed conversion ratio (feed eaten : live weight gained) was 1.98. The nutritional principles which make possible this high animal performance have been summarised by the research group at Cornell (Broiler Rations, 1967) and quoted by Biely (1971) as follows :

Age (weeks)	Energy : Protein (ME : P*)
0 - 6	60 - 62
6 - killing	70 - 74

"The consequences of changes in protein levels to give higher or lower energy : protein ratios than those shown in the previous table are :

(1) Higher protein levels (lower ratios) reduce efficiency because such diets are lower in energy content. They also reduce body fat content and carcass finish, forcing the animal to use the excess protein as a source of energy - a wasteful process.

(2) Lower protein levels (higher ratios) reduce efficiency because the animal consumes insufficient protein, and therefore cannot grow at a normal rate. Fat content of the carcass is increased and there is a greater tendency toward ragged feathering and picking. "

* ME : P metabolizable energy (Kcal.) per pound divided by crude protein (%)

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Whilst the principles so summarised are clear, their quantitative application is more complex depending upon a variable relation for different classes of raw materials between the energy metabolized and that used for productive purposes and between the content of crude protein and the amounts of limiting essential amino acids available for synthesising protein in the bird. A discussion of these principles in relation to the production of poultry meat has been made by Shrimpton (1968). Moreover, the actual performance achieved within the genetic potential of the bird will be determined by the environment and management conditions under which the birds are kept. Hence, if a stocking density of 1 bird per 0.07 sq. m. is increased by 50 %, the yield of poultry meat will increase by 75% to 0.70 Kg. of meat per sq. m. of floor space even though the mean performance of individuals will be depressed by 7% (Welch 1970).

In the U.K. the production of broilers in the past 10 years has shown a progressive improvement in efficiency, as measured by the Feed Conversion Ratio. The extent of this, involving the application to broiler production of genetics, nutrition and husbandry, including control of health, is shown in Table 4 which reproduces data of Laursen-Jones (1970) from costings of up to 9 million broilers throughout the U.K. per year. Comparable statistics for 1971 indicate that the trend of improved efficiency is continuing with a mean feed conversion tending to 2.20 ranging from 1.98 upwards.

In broad terms the principles of raising turkeys and ducks for meat production are similar and Clayton and Draper (1971) have recently published a study of the skeletal development and related meat content of ducks.

Nutritive value of Roasting Chickens (Broilers).

In the human dietary the role of chicken meat is to supply first quality protein. There is no published evidence that this function is influenced in any way by methods of husbandry or nutrition. Of course, the amounts of fat, pigmentation and also of vitamins can be influenced by dietary means, but none is of importance in the diet of the population of Western Europe and North America, there being ample supply in these diets common to these populations.
Shrimpton (1967) has calculated the contents of the major nutrients in the meats of raw and cooked chicken from published data of Watt and Merrill (1963) and these are quoted in Table 5.

It can be seen that the major differences between the nutritive values of raw and cooked meat are accounted for by loss of water in cooking and the presence of vegetable oil after frying. The latter is responsible for doubling the energy value of the cooked meat compared with raw meat.

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Physical and Chemical Characteristics of Poultry Meat.

The diameters of the muscle fibres in the breast and leg meats of chicken are shown in Table 6 where they are compared with equivalent data for mature sheep, cattle and pigs (Lawrie, 1966).

The breast muscle of the chicken and turkey differs most obviously from that of other meats by its near whiteness caused by its low content of myoglobin. The chemical characteristics and their significance in relation to quality of the meat have been recently discussed by Shrimpton (1970) and the principle features are summarised in Table 7. Of especial interest is the relatively high content of the dipeptides anserine and carnosine which Davey (1960 a, b) has shown are capable of buffering at pH 6.8 - 7.0 and so making possible prolonged glycolytic activity.

Qualitatively the structure of the muscles of birds is similar to that of mammals. The major skeletal proteins are actin and myosin which are interdigitated and account for 60 - 65% of the crude protein of the muscle. As in mammals, the contents of the major nitrogenous fractions of the muscle change with age and data of Scharpf and Marion (1964) for turkeys is shown in Table 8.

The course of rigor mortis is similar but quantitatively different because of the small content of glycogen, about 1%, in poultry muscle and because of the death struggle which, as in trawl fish, generally results in the exhaustion of the muscle soon after death. The terminal pH for breast muscle is of the order of 5.6 and that for leg muscle, 6.0.

Food Characteristics of Poultry Meat.

The main attributes of food associated with human preferance are not primarily nutritional but those which affect the senses, namely colour, odour and taste and texture. Johnson (1970) recently reviewed these factors in relation to poultry meat in a private report to the C.S.I.R.O. Division of Food Preservation, Ryde, N.S.W., Australia.

Colour Yellowness in the skin results from the presence of xanthophylls in the diet and recent evidence (Bartor & Bornstein 1969) indicates that feeding a relatively high level of xanthophyll throughout life is necessary if the carcass is to attain a uniform and deep yellow hue. However, whilst this is of preferance for the greater part of the North American population, white skinned birds are preferred in the U.K.

In France the north of the country similarly prefers white skinned birds whilst the remainder of the country has a preferance for yellow skins. Apart from diet, the degree of yellowness is influenced by genetic strain and by the presence of coccidia (parasitic protozoa - Eimeria spp.- of the intestine) which can depigment the skin.

Texture. The subject has been recently reviewed by Shrimpton (1970) and only the more salient points will be mentioned here.

Poultry meat is characteristically tender and relatively small differences cause it to be unacceptable to the consumer. Like other meats major differences result from variation in composition whilst the degree of tenderness within each class is primarily influenced by the course, and especially the rate, of onset of rigor mortis. Thus White et al (1964) found in turkeys that it was only when shear values exceeded 25 lb that there was any consistent downgrading of the meat by the panel and this occurred in only 10% of the 693 samples that they studied. Whilst differences in intra muscular structure, and especially the location of collagen, may account for some of these differences there is, as yet, no published evidence demonstrating how this may occur.

The pattern of change in the proteins of muscle after death, as measured by their increasing solubility in water, is qualitatively similar to that for beef and pork, but the rate of change is more rapid. The order of difference is shown in Table 8 where the results of a comparative study of beef, pork and chicken by McIntosh, (1969) is tabulated. However, there may well be discontinuities in the apparent relation between increasing water-solubility and increasing tenderness and a direct quantitative prediction of tenderness cannot be made at this time from a knowledge of protein-solubility.

Freezing and storage at temperatures of 0°F and lower result in only small changes compared with those in red meats. For example, Khan and van den Berg (1964) found that ATPase activity only decreased slightly after storage for 8 months at -20°C, from 180 to 170 expressed as μg of P released per mg of N per minute.

Changes in texture immediately after death are influenced primarily by the rate of disappearance of ATP (de Fremery and Pool, 1963). However, because the reserve of glycogen in the skeletal muscles is small post mortem glycolysis is virtually complete within 30 minutes of slaughter (Shrimpton 1960) and so in chickens it has become common practice in the U.K. to freeze birds immediately after evisceration so making possible a continuous "on-line" process from slaughter to packing of the frozen oven-ready product.

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At least in turkeys it seems probable that in a small percentage of birds (1 - 3%) the breast muscle remains relatively tough irrespective of the interval allowed between death and the start of freezing (Ranken and Shrimpton).

Flavour. Poultry meat is characteristically bland and little if any progress has been made towards identifying the chemcial basis of its flavour since the review of the subject published by Lineweaver and Pippen (1961).

Summary.

The production of poultry meat is organised on an industrial basis in most of Western Europe and North America. The major sources are young chicken, 6 - 8 weeks of age, and young turkeys 10 - 16 weeks of age. The efficiency of feed conversion is high, of the order of 2 to 1 but its potential as a new source of protein is limited by the absolute requirement of the bird for the same range of essential amino acids as the human. Its contribution to the human dietary is thus primarily as a cheap source of acceptable high quality protein.

A substantial amount of information has been published on all aspects of the food science of poultry meat and these have been briefly reviewed. In essence poultry meat is qualitatively similar to other meats but the chemical changes which take place in the avian muscle on death differ quantitatively from those which occur in the mammal.

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OUTPUT AND UTILISATION OF FARM PRODUCE IN THE UNITED KINGDOM

1964/65 to 1968/69

TABLE 1.

(Statistics Division, Ministry of Agriculture, Fihseries and Food, Whitehall Place West, London S.W.1)

Quantity (thousands of tons) and Vlaue (£ million) of Output at Current Prices (June/May years) Agricultural Holdings, United Kingdom

	1964/5		1965/6		1966/7		1967/8		1968/9(provis)	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value
Total Farm Crops	20,074	338.4	22,020	360.5	20,945	376.4	22,367	381.9	21,310	358.7
Beef [2]	869	263.3	872	267.8	882	269.6	957	309.6	893	307.6
Veal [2]	9	2.7	9	3.3	13	4.4	13	4.5	11	4.0
Mutton & Lamb [2,3]	260	86.4	258	84.9	272	87.8	261	87.5	243	87.4
Pigment [2]	838	197.7	897	210.8	809	203.2	796	203.5	839	214.4
Poultry Meat	327	78.9	356	82.5	389	90.1	431	97.5	476	108.1
Eggs (doz c 10^6)	(1,009)	159.2	(963)	170.9	(993)	163.4	(1,034)	168.4	(1,045)	187.6
Milk & Milk Products (gal x 10^6)	(2,480)	397.4	(2,530)	410.5	(2,528)	420.6	(2,643)	443.4	(2,648)	447.0
Total	-	1,216.6	-	1,261.4	-	1,270.8	-	1,346.1	-	1,387.9
Gross Output (including friutm vegetables and flowers)	-	1,785.9	-	1,826.1	-	1,870.9	-	1,939.4	-	1,983.5

1 Wheat, Barley, Oats, Mixed Corn, Rye, Potatoes, Sugar Beet, Beans, Dried Grass, Straw, Hops, Mustard.

2 Offal, but not tonnage, included in value of meat.

3 Wool, " " " , included in value of Mutton and Lamb.

4 Includes value (about £3 x 10^6) of replacemnt

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TABLE 2

Production of Poultry Meat in the United Kingdom 1964/5 to 1968/9

(Statistics Division, Ministry of Agriculture, Fisheries & Food, Whitehall Place West London S.W.1.)

Meat Produced * (1,000 tons) and Numbers Slaughtered (millions).

	1964/5		1965/6		1966/7		1967/8		(Provis) 1968/9	
Fowls over 6 months	86.1	52.0	77.0	46.6	80.4	49.1	82.0	50.2	81.3	49.9
Fowls under " "	247.9	185.6	279.0	208.6	306.2	226.1	340.0	250.7	378.6	273.8
Total Fowls	334.1	237.7	356.1	255.2	386.6	275.2	421.9	300.9	459.9	323.7
Ducks	9.0	4.8	9.4	4.7	10.8	5.1	11.3	5.3	12.6	5.9
Geese	1.4	0.3	1.4	0.3	1.3	0.3	1.4	0.3	1.3	0.3
Turkeys	32.2	7.6	39.1	9.3	41.4	9.0	46.0	10.1	54.3	12.2
Total Poultry	376.7	250.3	406.0	269.4	440.1	289.5	480.6	316.6	528.1	342.[illegible]

* Dressed carcass weights, oven-ready, presuming oven-ready wt = 75% of live weight.

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TABLE 3

A Comparison of the Results of the 1st and 20th Maine Production and Broiler Tests

	1st Test	20th Test
Age at Killing (weeks)	14	8
Live Weight of Males	–	4.51
Live Weight of Females	–	3.55
Average Live Weight of both sexes	3.96	4.03

TABLE 4

BROILER PERFORMANCE 1961 – 1969

	1961	1962	1963	1964	1965	1966	1967	1968	1969
Total no. of birds (millions)	1.09	2.75	3.47	3.49	3.87	4.39	5.74	8.01	6.08
Average age (days)	71	68	67	67.25	66	65	63	62	61
Stocking Density (sq. m. per bird)	0.069	0.068	0.068	0.067	0.068	0.064	0.062	0.061	0.055
Average Live Weight (Kg)	1.70	1.72	1.73	1.82	1.85	1.86	1.91	1.94	1.97
Mortality (%)	3.41	3.15	3.04	3.12	3.22	3.74	3.64	3.60	3.31
Feed Consumption Per Bird (Kg)	4.45	4.33	4.35	4.55	4.54	4.56	4.58	4.52	4.57
Feed Conversion	2.62	2.52	2.52	2.51	2.45	2.45	2.39	2.32	2.33

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TABLE 5

Nutritive value of roasting chickens (broilers)

Amounts per 100 g

Dietetic characteristic	Units	Raw: Light meat	Raw: Dark meat	Raw: Skin	Raw: Giblets	Cooked (fried in vegetable oil): Light meat	Cooked: Dark meat	Cooked: Skin	Cooked: Giblets
Water	g	77.2	77.3	66.9	73.4	59.5	57.5	32.5	51.7
Ash	g	0.8	0.8	0.5	0.9	1.2	1.3	1.2	1.6
Crude Protein	g	20.5	18.1	16.1	17.5	32.1	30.4	28.3	30.6
Gross energy	kcal	101	112	223	103	197	220	419	103
Carbohydrate	g	0	0	0	0.1	1.1	1.5	9.1	4.7
Fat: Total	g	1.5	3.8	17.1	3.1	6.1	9.3	23.9	11.2
sat. fatty acids	g	-	1.0	5.0	-	-	3.0	9.0	-
oleic acid	g	-	1.0	6.0	-	-	4.0	12.0	-
linoleic acid	g	-	1.0	3.0	-	-	1.0	5.0	-
Calcium	mg	11	13	9	14	12	14	8	18
Phosphorus	mg	218	188	174	220	280	235	186	336
Iron	mg	1.1	1.5	2.4	4.5	1.3	1.8	2.4	6.5
Sodium	mg	50	67	-	-	68	88	-	-
Potassium	mg	320	250	-	-	434	330	-	-
Thiamine	µg	50	60	30	160	50	70	70	170
Riboflavin	µg	170	340	130	1,360	250	450	720	2,180
Niacin	µg	7,600	5,300	2,000	4,900	12,900	6,800	7,000	8,000
Vitamin A	Int. Units	50	120	550	4,530	50	130	490	5,760

Calculated from data of Watt and Merrill (1963)

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Average Diameters (μ) of Muscle Fibres

Source of Meat	Average Diameter
Chicken breast	47.6 ± 13.8
Chicken leg	44.3 ± 20.5
Sheep	50.4
Cattle	73.3
Pig	90.9

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TABLE 7

Chemical characteristics of chicken muscle

Characteristic	Breast muscle	Leg muscle
Total N mg/g	42.3	35.0
Free amino N mg/g	1.56	0.69
Non protein N	5.85	3.65
Anserine & Carnosine (arbit)	72.9	28.7
Thiamine	low	high
Riboflavin	low	high
Niacin	10	5
A.T.P. P mg/g	0.8	0.3

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TABLE 8

Post-mortem changes in extractability of water-soluble nitrogen in beef, pork, and chicken muscle[1]

Time after death	Nitrogen (% of total N)		
	Extractable	Protein	Actomyosin
Beef muscle			
30 min	68	53	23
24 hr	68	54	24
6 days	71	65	34
14	82	82	50
28	82	81	52
Pork muscle			
30 min	76	65	27
24 hr	43	31	3
4 days	50	37	2
6	58	47	18
8	50	47	19
11	70	66	35
14	76	77	50
Chicken muscle			
30 min	55	47	23
5½ hr	40	35	7
24	43	31	4
4 days	72	63	32
6	71	73	43
8	78	78	44

1 From McIntosh (1967)