Economic optimization of feed use in broiler production

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Nigerian Agriculture is gradually being transformed from subsistence to commercial. This, is as a result of various government policies that have been introduced. These includes such policies as input and output subsidies, various mechanization schemes and most recently the various facets of Operation Feed the Nation and the Federal Government Guaranteed Oan Schemes from various commercial banks. This gradual transition, will definitely introduce a major dimension into the agricultural sector of the country, and thus compel farmers to become cautious of the ways in which they use their inputs.

The poultry sector of Nigerian Agriculture has been highly commercia- Feed cost has been identified as forming the major component of the Total Variable Cost in poultry production. For profit maximization, there is need for the combination of the feed ingredients in such a way that the lease cost combination is achieved and technical efficiency also maintained. In economics, this involves the substitution of feed ingredients for each other along an isoquant and choosing an isoquant that satisfies the cost requirement.

For profit maximization, there is the need for the knowledge of the technical relationships between inputs and outputs; the various prices of the inputs and outputs and a knowledge of the most efficient level of inputs.

In this study, the objectives are

1. to determine the variation in weight gains of roilers under different carbohydrates and protein regimes.
2. to compare weight gains when different percentage of protein and carbohydrates are used in feeding broilers.
3. to estimate the optimum combinations of carbohydrates and proteins when the price of broiler is held fixed.
4. to investigate the variation of profit with various assumed levels of broiler prices.

For the purpose of achieving the above specific objectives the paper is divided into the following major sections:

1. The Theory of Economic Optimization
2. Data Collection and Experimental Design
3. Methodology and Choice of Algebraic forms
4. Empirical Equations
5. Results and Discussion

The theory of economic optimization

In any production process, inputs are converted into output. The relationship between input and output is referred to as the production function. This is a mathematical relationship describing the way in which a particular product depends upon quantities of particular inputs.

The kind of product and the amount of it which is to be obtained depends upon the kind and quantity of inputs used (Heady and Dillon, 1956).

Broiler production results from the use of numerous categoires of inputs. In this study, there are two variable categories of feed that are of interest: Corn and Groundnut Cake. Weight gained by a broiler is a function of the quantities of Corn and Groundnut Cake that are fed to it. Other inputs such as supplement are assumed to be fixed. This relationship can be expressed mathematically as in equation 1.1.

$$G = F(C, GN) \quad \ldots\ldots 1.1$$

In the above equation

G = weight gained in grams per bird
C = corn intake in grams per bird
GN = groundnut cake intake in grams per bird

This equation can be re-expressed as shown in equation 1.2.

$$G = F(R) \quad \ldots\ldots 1.2$$

where

R = type of ration

Thus, as expressed, if the quantity of ration fed is known, weight gains can be expressed as a function of the quantities of ration fed. This equation enables one to predict the total weight gain per bird associated with various amounts of a given ration and the most profitable marketing weight. This optimum marketing weight can however only be determined if there is diminishing returns to increases in weight gain to particular ration (Heady, Stanley & Dean, 1956).

An optimum marketing weight is achieved when the following mathematical relationships hold.

$$\frac{dG}{dR} + \frac{Pr}{Pg} \quad \ldots\ldots 1.3$$

where

Pr = price per gram of ration
Pg = prcie per gram of broiler

or

$$dG\,Pg = dRPr \quad \ldots\ldots 1.4$$

Indicating that the optimum marketing weight is achieved when marginal product is equal to the price ratio.

When the marginal product is greater than the price ratio as in equation 1.5, the value of the added gain is greater than the value of the added feed.

$$\frac{dG}{dR} > \frac{Pr}{Pg} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.5$$

Profit can be increased per bird by feeding the bird to greater weight until marginal product is forced down to be equal to the price ratio. The opposite of this relationship is however obtained when the sign of the inequality is reversed as shown in equation 1.6. By this equation, birds should be sold at lighter weights.

$$\frac{dG}{dR} < \frac{Pr}{Pg} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.6$$

In production function analysis, once the specific forms of the production function have been expressed and determined, various derivatives of these functions such as marginal products, isoquant, marginal rates of substitution allows us to determine the characteristics of these functions (All and Adepetu, 1978).

For the determination of optimum marketing weight for any type of ration, there is the need to determine the least cost combination for particular gain levels. This involves the derivation of a family of isoquants for the gain surface. This isoquant shows the possible combinations of the two ingredients which will permit the attainment of a given level of gain. A general form of the gain isoquant is as shown in equation 1.7.

$$C = f(GN) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots)$$

The least cost ration for a particular gain level is the one which results in the attainment of the condition expressed by equation 1.8.

$$\frac{-dC}{dGN} = \frac{GN}{PC} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.8$$

or

$$(-dC)(Pc) = (-dGN)(P\,GN) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.9$$

The equation 1.8 defines the marginal rates of substitution of groundnut cake for corn as being equal to the ratio of the price of groundnut cake to corn. If these two are equal the minimum cost ration* is determined. If the marginal rates of substitution of groundnut cake for corn is greater than the price ratio, as expressed in equation 1.10 the value of corn replaced will be greater than the value of groundnut cake added. Cost therefore, can be decreased by substituting groundnut cae for corn.

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.10$$

or $-(dC)(Pc) \quad -(dGN)(\ GN) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.11$

until the equality of equation 1.8 is attained. If the marginal rate of substitution of groundnut cake for corn is less than the price ratio as in equations 1.12 and 1.13 the value of the corn replaced is less than the value of the groundnut cake added, cost can therefore be decreased by increasing the proportion of corn relative to groundnut cake until the substitution ratio is increased to the level at which equality as expressed in equation 1.8 is attained.

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.12$$

$$\text{or} \qquad -(dC)\,(Pc) \qquad -(dGN)\;\; GN \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.13$$

Data collection and experimental design

The data was collected from an experiment conducted by a graduate student in the Department of Animal Science of the University of Ife. The experiment although purely designed for particular purpose of evaluating the efficiency of four different types of feeds, can be subjected to economic analysis and appraisal. Four different types of feeds, were subjected to economic analysis and appraisal. Four different types of feeds or rations of 22.10%, 22.05% and two of 22.00% protein levels were used in the experiment. The composition of each of the rations is as shown in Table 1.

TABLE 1 FEED RATIONS FOR BROILERS (% Components g of ration)

INGREDIENTS	R (22.10% Protein)	R (22.05% Protein)	R (22.00% Protein)	R (22.00% Protein)
Maize	64.72	60.60	56.00	[illegible]
Groundnut cake	24.00	22'65	21.25	20.25
Fish meal	8.00	8.00	8.00	8.00
Stylosanthes		5.00	10.00	15.00
D.C.P.	0.90	0.90	0.90	0.90
O.S	0.90	0.60	0.10	0.30
ADDITIVE (Agri care)	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	[illegible]
Amprolium	0.05	0.05	[illegible]	[illegible]
Lysine	0.35	0.30	[illegible]	[illegible]
Mathionire	0.08			
Oil		0.90	2.10	[illegible]

* *Ration refers to feeds with specific percentages of the two types of ingredients, corn and groundnut cake.*

One hundred and twenty eight day-old Indian River Chicks were used. The chicks were randomly grouped into twelve, each group being mad up of ten birds and each group assigned a pen. There were therefore twelve experimental pens. The birds were red ad-libitum using feeding troughs. A weighed quantity of the ration was placed in a trough for each group of ten. The following day, weights of the feed remaining was determined and the quantity of feed remaining was determined and quantity of feed consumed by each group was obtained by difference. The quantity of feed consumed by each bird was assumed to be equal. This was obtained by dividing the total amount of feed consumed in each pen by the number of birds in each pen. Their weights were recorded and the total weight of feed consumed per bird during the entire period of the experiment was determined by adding the daily consumptions for eleven weeks. Casualities occurred during the experiment and adequate cognisance was given this in the calculations. Each group member was weighed at the end of each week to determine the weight gained as a result of the feed consumed during the week. The total quantities of feed consumed and the total weight gained by each bird during the entire experiment were determined. The amount in weights of Corn, Groundnut Cake were calculated as percentages of the total feed consumed. Each ration had three replicates, each with ten birds. Hence each bird had a set of observations namely, weight gained, weight of feed consumed, weight of Corn of ration and weight of Groundnut Cake in ration.

Various forms of production functions exists for the study of this type. Four have been chosen for this work. They are the Quadratic, Root, Cobb-Douglas and the Resistance Function. They are represented respectively as in equations 2.1, 2.2, 2.3 and 2.4 respectively.

2.1 $G = a_0 + a_1 C + a_2 GN - a_3 C^2 - a_4 GN^2 - a_5 CGN$

2.2 $G = a_0 - a_1 C - a_2 - a_3\sqrt{C} + a_4\sqrt{GN} - a_5\sqrt{CGN}$

2.3 $G = a_1 C^X GN^{Y2GN}$

2.4 $G^{-1} = a_0 + a_1 C^{-1} - a_{2GN^{-1}}$

where

G = weight gain
a_i = constants
C = weight of corn in ration
GN = weight of groundnut cake in ration

Although Fish meal was another source of protein in ration. The amount in the various rations were the same.

X and Y are exponents and the other letters (i.e. a_0, a_1) are coefficients of the various generalized forms.

The fundamental consideration in selecting production functions is the suitability and the biological fitness of these functions. In production function analysis, that is related to livestock, evidence has shown that as birds increase in size, a greater percentage of the feed consumed goes into maintenance while a small percentage goes into growth. Body composition also changes as size increases which further compounds the problem of feed substitution between feed components. Biologically, the structural portions of the broilers body develops first followed by the development of the muscle, tissue and consequently the fatty layers. Hence production functions should first allow decreasing productivity to each unit of feed input. Secondly, there must be allowance for diminishing marginal rates of substitution between carbohydrates and protein. This is because it is known that as more protein is included in the ration, each gram of protein replaces less of carbohydrates. It is also logical to say that as birds increase in age in the earlier weeks of growth, they require a greater percentage of protein in the ration than do older birds. Thirdly, as a consequence of the earlier reason production functions in broiler-feed analysis should allow substitution rates between feeds which changes as the birds gain weight and must result in isoclines which either are curves or which are linear or do not pass through the origin (Heady and Dillon, 1956; Olayide and Ogunfowora, 1970).

Quadratic (2.1) and Root (2.2) equations satisfy all the requirements stated above. Cobb-Douglas (2.3) and the Resistance Equations (2.4) do not permit substitution along a ration line to change as broilers increase in size. This implies that they do not account for the fact that protein in relation to carbohydrate is of greater value to the young birds than older birds. They introduce the relationship that the rate of substitution must be constant along a ration line, which is definitely not the case.

Despite this limitation, some general principles and characteristics of some of these functions allow for a greater understanding of their uses in applied economics. Some of these principles or characteristics are the isoquant, isoclines, marginal product, marginal rates of substitution and the elasticity of substitution (Bishop and Toussant, 1958).

Empirical forms of the equations

The least squares regression technique was applied to the data and the generalized form of equations 4.1, 4.2, 4.3 and 4.4 were quantified. The following equations were obtained:

$$3.1 \quad G = 1697.58 + 5.02C - 17.84GN - 0.09C^2 + 0.18GN^2 + .10CGN^2$$
$$(10.88) \quad (23.43) \quad (0.12) \quad (0.22) \quad (0.12)$$

$$R^2 = .728$$

$$3.2 \quad G = 2485.56 - 3.19C + 29.57GN - 1,.67\sqrt{C} - 375.51\sqrt{GN} + 9.68\sqrt{GNC}$$
$$(12.07) \quad (34.38) \quad (185.43) \quad (478.97) \quad (16.11)$$

$$R^2 = .658$$

$$3.3 \quad G^{-1} = 1690.64 - \underset{(775.58)}{406.87C^{-1}} - \underset{(1285.10)}{1375.91GN^{-1}}$$

$$R^2 = .206$$

$$3.4 \quad G = 3.10\underset{(.02)}{C^{0.0051}} \quad \underset{(0.03)}{GN^{0.0598}}$$

$$R^2 = .310$$

TABLE 2 CHARACTERISTICS OF VARIOUS EQUATIONS

	ISOQUANT	ISOCLINE
EQ. 3.1	$C = \frac{5.02+0.1GN}{0.18} + \frac{1697.58-17.84GN+0.18GN^2-G}{0.09} + \left(\frac{5.02+10.1GN}{0.18}\right)^2$	$\frac{0.1+\frac{1}{4}}{0.18} \quad \frac{-17.84+3.6GN+2}{0.09}\left(\frac{5.02+0.1GN}{0.18}\right)\left(\frac{0.1}{0.18}\right)$ $\frac{1697.85-17.84GN+0.18GN^2-G+}{0.09}\left(\frac{5.02+0.1GN}{0.18}\right)^2 = K$
EQ. 3.3	$C = \frac{406.87GN}{16>0.64GN-1375.41-GGN}$	$-\frac{5.6002 \times 10^{6}}{(1690.64-G)\,GN - 1375.41^2} = K$
EQ. 3.4	$C = \frac{\log G - 0.0598\log GN - \log 3.10}{0.0051}$	$-11.7255\left(\frac{G}{3.10}\right) 196.08\ GN^{-12.7255} = K$

EQ. 3.1. $G = 1057.58 + 5.02 - 17.84GN - 0.09C^2 + 0.18GN^2 + 0.1C\,GN.$

EQ. 3.3 $G = 1690.64 - 406.87C^{-1} - 1375.91GN^{-1}$

EQ. 3.4 $G = 3.10C^{0.0051}\ GN^{0.0598}$

	MARGINAL PRODUCT	MARGINAL RATES OF SUBSTITUTION	ELASTICITY OF SUBSTITUTION
EQ. 9.1	$\frac{dG}{dC} = 5.02 - 0.18C + 0.10GN$ $\frac{dG}{dGN} = 0.36GN + 0.10C - 17.84$	$-\left(\frac{dGN}{dC}\right) = -\left(\frac{5.02-0.18C+0.10GN}{0.36GN+0.10C-17.84}\right)$	$E_{GN/C} = -\left(\frac{5.02-0.18C+0.10GN}{0.36GN+0.10C-17.84}\right)\left(\frac{C}{GN}\right)$
EQ. 5.3	$\frac{dG}{dC} = 406.87C^{-2}$ $\frac{dG}{dGN} = 1375.91GN^{-2}$	$-\left(\frac{dGN}{dC}\right) = -\left(\frac{406.87C^{-2}}{1375.91GN-2}\right)$	$GN/C = -\left(\frac{406.87C^{-2}}{1375.91GN-2}\right)\frac{C}{GN}$
EQ. 5.4	$\frac{dG}{dC} = 0.0158GN^{0.0598}C^{-0.9949}$ $\frac{dG}{dGN} = 0.1854C^{0.0051}GN^{0.9402}$	$-\left(\frac{dGN}{dC}\right) = -\left(\frac{0.0158GN^{0.0598}C^{-0.9949}}{0.1854C^{0.0051}GN^{0.9402}}\right)$	$E_{GN/C} = -\left(\frac{0.0158GN^{0.0598}C^{-0.9949}}{0.1854C^{0.0051}GN^{-0.9402}}\right)\frac{C}{GN}$

The equations are of the Quadratic Root, Resistance and the Cobb-Douglas types. The standard errors of each coefficient are show below it.

Table 3 shows the R and the t values for each of the a coefficients. Most coefficients are significant at the 0.4 level. For each equation the degrees of freedom is different, thus t(.4, 10) is for equations 3.1 and 3.2 and t(.4, 3) is for equations 3.3 and 3.4. The specific values of these t's are show below the table. The calculated t's shown in the table (i.e. .4615 under b for equation 3.1) was obtained from the equation 3.5 expressed below.

1 For the various characteristics of these equations (i.e. Marginal product, marginal rates of substitution) see Table 2.

$$t = \frac{bi}{se} \qquad \text{..}(3.5)$$

where

bi = **is the value of the coefficient**
se = the standard error of the coefficient.

This t value obtained is referred to as the calculated t and is compared with the tabulated t values at a specific level of significance and appropriate degree of freedom.

The R obtained for equations 3.1 and 3.2 are relatively high indicating that approximately 73 percent and 66 percent of the variation in the two equations is explained. Equations 3.3 and 3.4 have very low R showing that approximately 20 and 30 percent of the variations were explained in these equations.

Results and discussion

The generated equations 3.1 to 3.4 were used to estimate some sets of predicted weight gains as levels of corn and groundnut cake were varied. This amounted to varying the carbohydrate and protein levels in the ration from 16 percent to 22.5 percent. Table 4 shows the predicted weight gains when the levels of protein and carbohydrates are varied in the ration. The figures are those obtained when the various carbohydrate and protein requirements are substituted into equation 3.1. Thus for a ration that contains 16 percent protein and 16.5 percent carbohydrate the weight gain predicted from equation 3.1 is 1533.88 grams. Diminishing returns to weight gain results as the protein and carbohydrate levels are increased holding either of the two constant. The highest weight gain in the table is at a lower level of protein and carbohydrates.

If the level of protein is held constant and that of carbohydrate is gradually increased there is a corresponding gradual decrease in weight

TABLE 3. VALUES OF CALCULATED t AND R FOR REGRESSION COEFFICIENTS IN ORDER SHOWN IN EQUATION

Equation	R	b	b	b	b	b	b	b	b	b	b
3.1	0.72833		0.4615	0.7619	-	0.8143	0.8487	-	0.8747	-	
3.2	0.65823	-	0.2641	0.8599	-	0.0953	0.7840	-	0.6009	-	
3.3	0.20596	-	0.5247	1.0707	-	-	-	-		-	
3.4	0.30965	-	0.0255	1.8744	-	-	-	-		-	

** The tabulated t's are as show below:

Eq. 3.1 t(0.4, 10) = 0.260
3.2 t(0.4, 10) = 0.260
3.3 t(0.4, 3) = 0.277
3.4 t(0.4, 3) = 0.277

TABLE 4. GAIN IN WTS (g) AT DIFFERENT LEVELS OF PROTEIN AND CARBOHYDRATE

G = 1697.58 + 5.02C - 17.84GN - 0.09C + 0.18GN + 0 10C GN

%	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5
16.0	1534.37	1533.27	1531.84	1530.06	1527.95	1525.52	1522.71	1519.58	1516.10	1512.30	1508.16	1503.65	1498.84	1493.64
16.5	1533.88	1532.79	1531.37	1529.61	1527.51	1525.08	1522.29	1519.18	1515.71	1511.92	1507.79	1503.29	1498.50	1493.31
17.0	1527.16	1526.25	1525.01	1523.43	1521.51	1519.26	1516.65	1513.71	1510.42	1506.81	1502.86	1498.54	1493.93	1488.92
17.5	1523.79	1522.98	1521.83	1520.35	1518.52	1516.37	1513.85	1511.01	1507.82	1504.31	1500.45	1496.23	1491.71	1486.80
18.0	1520.64	1519.93	1518.87	1517.49	1515.75	1513.70	1511.27	1508.53	1505.43	1502.01	1498.25	1494.12	1489.70	1484.88
18.5	1517.63	1517.01	1516.05	1514.76	1513.13	1511.17	1508.84	1506.19	1503.19	1499.89	1496.20	1492.17	1487.84	1483.12
19.0	1514.83	1514.31	1513.45	1512.25	1510.71	1508.85	1506.61	1504.06	1501.16	1497.91	1494.35	1490.42	1486.18	1481.56
19.5	1512.20	1511.77	1511.00	1509.90	1508.45	1506.69	1504.55	1502.09	1499.28	1496.14	1492.66	1488.82	1484.69	1480.16
20.0	1609.71	1509.37	1508.70	1507.70	1506.35	1504.68	1502.63	1500.27	1497.54	1494.52	1491.13	1487.39	1483.35	1478.92
20.5	1507.41	1507.16	1506.58	1505.68	1504.42	1502.84	1500.90	1498.63	1496.01	1493.07	1489.78	1486.14	1482.19	1477.85
21.0	1505.28	1505.14	1504.66	1503.84	1502.68	1501.20	1499.35	1497.18	1494.66	1491.81	1488.62	1485.06	1481.21	1476.97
21.5	1503.31	1503.26	1502.88	1502.16	1501.10	1499.71	1497.96	1495.88	1493.46	1490.70	1487.61	1484.15	1480.39	1476.25
22.0	1501.54	1501.59	1501.30	1500.68	1499.71	1498.42	1496.76	1494.78	1492.45	1489.79	1486.79	1483.43	1479.76	1475.72
22.5	1499.95	1500.07	1499.88	1499.36	1498.48	1497.29	1495.72	1493.84	1491.61	1489.04	1486.14	1482.87	1479.31	1475.36

gain as the ratio of protein to carbohydrate increases. The converse is also true. This could however mean that much of the carbohydrate is burnt off in respiration and weight gain is low due to the low level of protein used. Also, when the level of carbohydrate is kept constant and protein increased, the gradual increase in weight gain, might be explained by the fact that at higher weights, increasing levels of protein will not give economic weight gains because birds of higher weights need higher levels of carbohydrate relative to protein. The converse is true for younger birds. It is an established fact that the corn/protein (c/p) ratio is important in poultry nutrition (Ewing, 1963; Morrison, 1964; Biely and March, 1967).

Table 5 contains information on price variation as they affect the profit level and the associated level of gains, corn and groundnut cake as obtained from equation 3.1. In the table as shown in column 1, the ratio of the prices per gram of both groundnut cake and corn are held fixed The prices of groundnut cake and corn per kilogram were also fixed throughout the table. Whilst that of broiler per gram was varied from

TABLE 5. PROFIT MARGINS WITH PRICE OF BROILDER VARIED

$\frac{PGN}{PCH}$	$\frac{PGN}{PCH}$	$\frac{PC}{PCH}$	$\frac{PCH}{K/G}$	G (g)	C (g)	GN (g)	₦ (K)
1.00	0.033	0.033	0.90	1680.54	11.48	214.16	1502.76
1.00	0.038	0.038	0.80	1679.55	104.16	191.55	1334.77
1.00	0.043	0.043	0.70	1678.78	97.44	179.18	1166.85
1.00	0.050	0.050	0.60	1677.84	90.21	165.89	999.01
1.00	0.060	0.060	0.50	1676.61	32.35	151.42	831.30
1.00	0.075	0.075	0.40	1674.96	73.65	135.45	663 71
1.00	0.100	0.100	0.20	1672.53	63.79	117.30	496.33
1.00	0.150	0.150	0.20	1668.46	52.08	95.77	329.26
1.00	0.300	0.300	0.10	1659.27	36.83	67.72	162.80
1.00	0.600	0.600	0.05	1646.29	26.04	47.89	80.09

Consider

Price per gram of broilder. PCH = 0.30k
Price per gram of groundnut cake, PGN = 0.03k
Price per gram of corn. PC = 0.03k

90 kobo per gram down to .05 per gram. Increasing the price of broiler per gram helps to indicate the net effect of price change on the most profitable levels of groundnut cake and corn.

As expected, profit levels as shown in column 8 of table 4 increases as the price of broiler per gram increases. Levels of inputs carbohydrates and groundnut cake also increases. This process constitutes a movement from one isoquant to the other. This is so, because of the various levels of groundnut cake, corn, gain and profits that results when the price levels of broiler is changed (Abaelu, 1964; Aina, Stratman and Topkins, 1968; Ikpi, 1970).

Table 6 shows the marginal products, the marginal rates of substitution and the various elasticities of substitution as obtained from equation

TABLE 6. MARGINAL PRODUCTS, MARGINAL RATES OF SUBSTITUTION AND ELASTICITY OF SUBSTITUTION OF GN FOR C

C (g)	GN (g)	MP (C) $\frac{dG}{dG}$	MP_{GN} $\frac{dG}{dGN}$	MRS (GN/ C) (dgN) (dC)	$ES_{GN/C}$ (dGN)C (dC)GN
110.48	214.16	0.0333	0.0299	11.1137	- 0.5745
104.16	191.55	0.0375	0.0375	-1.0000	- 0.5438
97.44	179.18	0.0429	0.0429	-1.0000	- 0.5438
90.21	165.89	0.0499	0.0499	-1.0000	- 0.5438
82.35	151.43	0.0599	0.0600	-0.9983	0.5429
73.65	135.45	0.0750	0.0749	-1.0013	0.5444
63.79	117.30	0.0999	0.0999	-1.0000	- 0.5438
52.08	95.77	0.1497	0.1500	-0.9980	- 0.5427
36.83	67.72	0.2999	0.3000	-0.9997	- 0.5437
26.04	47.89	0.6000	0.5999	-1.0001	- 0.5438

3.1. The marginal product of corn and groundnut cake are highest a. 26.04 grams of corn and 47.89 grams of groundnut cake respectively. there is a decrease as the levels of both inputs are increased. This is an indication that the production function allows for diminishing marginal productivity. The negative nature of the marginal rates of substitution of corn for groundnut cake indicates that the isoquant is negatively sloped.

The elasticity of substitution of groundnut cake for corn is also negative. It indicates the percentage change in groundnut cake needed to maintain the same level of weight gain if corn is changed by 1 percent. The values obtained does not seem to vary along the isoquant indicating 'hat the isocline must be of the linear form. Likewise, it must be negatively sloped.

Various deductions can be made from the above analysis. It can be observed that variations do exist in weight gains given different types of ration formulations. It can also be seen from table 4 that various combinations of nutrients can yield the same level of weight gain. therefore for efficient utilization of feed in broiler production there is need for a careful evaluation of cost and returns.

The optimum levels of combination of feed must be determined by each producer in order to maximize the profit from his enterprise. Price variation of ingredients, of broiler affects the weight at which the maximum profit is attained. Thus, cognisance should be taken of the effects of these factors in an enterprise of this type.

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