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Assessment of *Dioscorea dumetorum* as Alternative Raw Material for Weaning Formular using Analysis of Covariance

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Abstract: Comparative analysis of protein quality of raw materials using standard laboratory and biological methods is both cumbersome and expensive. Analysis of covariance is in this study proposed as an alternative comparative technique. Using both initial and final weights of Wistar albino rats fed with *Dioscorea dumetorum*, maize and rice, this statistical method was used to show that as raw materials for the production of weaning formula, there is no significant difference between the three foodstuffs. The result showed that yam (*Dioscorea dumetorum*) can be used as alternative raw material for the production of weaning formula using analysis of covariance thereby reducing the cost and cumbersomeness faced with analytical methods.

Key words: Analysis of covariance, *Dioscorea dumetorum*, protein quality, conconmitant variable, experimental error variance

INTRODUCTION

Cereal production in the African rain forest is both hectic and highly capital intensive as a result of the activities of pests. This is one reason that accounts for the high cost of weaning formulas where cereals are the principal raw materials. Most families are unable to properly wean their children thereby exposing them to diet-related diseases and infant mortality.

Cereals forms the primary basis for most of weaning foods in West Africa. In Nigeria, the usual first weaning food is called pap, akamu, ogi or koko and is made from maize (*Zea mays*), millet (*Pennisetum americanum*), or guinea corn (*Sorghum* sp.) (King and Ashworth, 1987; Longhurst, 1984; Cherian, 1981; Osuhor, 1980). From the nutritional stand point, protein content of cereals is of poor quality, low in lysine and tryptophan which are indispensable in growth of the young child (Oyenuga, 1968).

Since, a balanced protein preparation which can provide essential amino acids can be formulated through mixing proteins from vegetable sources, a number of alternatives have been developed for infant weaning foods (Plahar and Hoyle, 1991; Takyi *et al*., 1991; Fashakin *et al*., 1986; Ketiku and Ayoku, 1984; Fashakin and Ogunsola, 1982). Flour from *Dioscorea dumetorum* have been developed and nutrient bioavailability studies on laboratory animals and school age children carried out coupled with amino acid composition of *Dioscorea dumetorum* (Alozie *et al*., 2008, 2009; Mbome *et al*., 1995; Mbome and Treche, 1994; Treche *et al*., 1984). It was observed that *D. dumetorum* flour has a high protein content which was quite balanced in essential amino acid (with slight deficiency in lysine, methionine and cystine) and comparable to cereals (maize and rice). The feeding of *D. dumetorum* based diet was observed to result in high protein utilization parameters and comparable to cereal based diet.

However, the procedure for determination of protein quality and amino acid analysis which are important indices of food quality to elucidate authenticity of the food product or raw material for food manufacture is cumbersome and capital intensive. Ratio based nutritional indices as useful as they are, have probable unrealistic assumption of an isometric relationship between denominator and numerator variables (Raubeheimer and Simpson, 1992).

From the foregoing, this study sought to develop a statistical technique for assessing protein quality of a given foodstuff thereby reducing cost of analysis. The study sought to do this using data obtained from an experiment on the feeding of groups of albino rats using maize, rice and *Dioscorea dumetorum*, steamed flours conducted in an earlier study (Alozie *et al*., 2008). Both the initial and final weights of all the rats were taken. These weights constitute the data upon which the analysis of covariance was applied. This comparative statistical technique is used to determine the quality of

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the nutritional value of maize, rice and *Dioscorea dumetorum*. The validity of the method draws from the existence of a linear relationship between the original weights and the final weights.

Analysis of covariance is employed when concomitant (extraneous) variables cannot be held fixed but can be measured (Johnson, 2004). It is an experimental situation for which we cannot block the extraneous variables. The linear statistical model for the analysis of covariance is given by:

$$y_{ij} = \mu + \alpha_i + \beta x_{ij} + e_{ij}$$

for $i = 1,2,...,k;\ j = 1,2,...,n$

where μ is the grand mean, α_i is the effect of the ith treatment, β is the slope of the linear regression equation and the e_{ij}'s are independent, normally distributed variables with zero means and common variance σ^2. x_{ij} is the concomitant variable and it is eliminated by estimating β by least squares methods. An analysis of variance is then performed on the adjusted y's, namely:

$$y'_{ij} = y_{ij} - \hat{\beta} x_{ij}$$

Let S, T and E denote sums of squares, cross products for total treatments and error respectively. Then (Montgomery, 1978):

$$S_{yy} = \sum_{1=1}^{a}\sum_{j=1}^{n} y_{ij}^2 - \frac{y_{..}^2}{an}$$

$$S_{xx} = \sum_{1=1}^{a}\sum_{j=1}^{n} x_{ij}^2 - \frac{x_{..}^2}{an}$$

$$S_{xy} = \sum_{1=1}^{a}\sum_{j=1}^{n} x_{ij} y_{ij}^2 - \frac{(x_{..})(y_{..})}{an}$$

$$T_{yy} = \sum_{1=1}^{a} \frac{y_{i.}^2}{n} - \frac{y_{..}^2}{an}$$

$$T_{xx} = \sum_{1=1}^{a} \frac{x_{i.}^2}{n} - \frac{x_{..}^2}{an}$$

$$T_{xy} = \sum_{1=1}^{a} \frac{(x_{i.})(y_{i.})}{n} - \frac{(x_{..})(y_{..})}{an}$$

$$E_{yy} = S_{yy} - T_{yy}$$

$$E_{xx} = S_{xx} - T_{xx}$$

$$E_{xy} = S_{xy} - T_{xy}$$

The least squares estimator for β is:

$$\hat{\beta} = E_{xy}/E_{xy}$$

The error sum of squares:

$$SSE = E_{yy} - (E_{xx})^2/E_{xx}$$

The experimental error variance is estimated by:

$$MSE = \frac{SSE}{a(n-1)-1}$$

If there is no treatment effect (i.e., $\alpha_i = 0$) we obtain a reduced model whose error sum of squares is:

$$SS_E^1 = S_{yy} - (S_{xy})^2/S_{xx}$$

with a -2 degrees of freedom.

To test the hypothesis of no treatment effects

H_0: $T_i = 0$, we compute

$$F_0 = \frac{(SS_E^1 - SSE)/a-1}{SSE/[a(n-1)-1]}$$

which is distributed as $F_{a-1,}$ a(n-1)-1 if the null hypothesis is true.

The hypothesis of no linear relationship between the response variable and the concomitant variable stated as H_0: $\beta = 0$ was tested by using the test statistic:

$$F_0 = \frac{(E_{xx})^2/E_{xx}}{MS_E}$$

and comparing it with F_1, a(n-1)-1

RESULTS AND DISCUSSION

The original weights of 21 weanling albino rats were taken before they were randomly assigned to three of carbohydrate foodstuffs, namely rice, maize and *Dioscorea dumetorum* (trifoliate yam). The carbohydrate types were steamed. The data is captured in the Table 1.

Table 1: Body weights of albino Wistar rats fed cereals (maize and rice) and *Dioscorea dumetorum*

Diets	Weight category	Values of weight of 21 wistar rats						
Rice (A)	X Original wt.	65.8	65.4	65.5	67.0	66.1	65.9	65.3
	Y Final wt.	71.8	70.3	70.7	73.0	72	71.5	71.3
Maize (B)	X Original wt.	66.0	64.5	60.8	70.4	65.4	67.0	63.5
	Y Final wt	72.3	70.3	66.6	76.0	71.4	75.0	68.7
Dioscorea	X Original wt.	65.9	65.4	70.0	60.3	66.3	64.4	65.4
dumetorum	Y Final wt.	71.5	71.7	70.9	72.1	70.9	71.7	71.4

Under the null hypothesis, H_0: $\alpha_i = 0$; the result of the analysis of covariance performed on the data shows:

$$F_{cal} = \frac{(SSE^1 - SSE)/(a-1)}{SSE/[a(n-1)-1]}$$

$$\frac{0.17/2}{44.75/17} = \frac{0.085}{2.63} = 0.0323$$

$$F_{2,18} = 3.59$$

$$F_{calculated} < F_{2,18}$$

Thus, the null hypothesis that there is no significance difference between the three carbohydrate types is accepted.

Under the null hypothesis H_0:$\beta = 0$:

$$F_{cal} = 10.47$$

$$F_{1,18} = 3.59$$

$$F_{cal} > F_{1,17}$$

This implies that there is a linear relationship between the original weights of the rats and the final weights and the adjustment provided by the analysis of covariance is necessary.

Results obtained in this study confirm the result earlier reported by Alozie *et al*. (2008) on the comparative evaluation of protein quality of *Dioscorea dumetorum* varieties and cereals using biological methods. The findings showed the *Dioscorea dumetorum* varieties to be of similar protein quality to the cereals and resulted to higher values for protein utilization parameters in albino wistar rats. Using the analysis of co-variance in this study, the *Dioscorea dumetorum* was not significantly (p<0.05) differed from the cereal fed rats. The establishment of a significant linear relationship between the original and final weights is an indication that the raw material (*Dioscorea dumetorum)* is of good protein quality. This advantage of examining the relationship between original and final weights is a major benefit of using analysis of co-variance rather than analysis of variance. We conclude that *D. dumetorum* is equally good as raw material for the production of infant formula as rice and maize which are currently used by manufacturers and that analysis of covariance of weight gain or loss of animals used in experimental feeding trials may serve as an alternative method for determination of protein quality of foodstuff thereby eliminating or reducing the cost and/or cumbersomeness encountered by using the chemical and biological methods.

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