ENERGY UTILIZATION OF SUPPLEMENTED CEREAL DIETS IN HUMAN VOLUNTEERS

Abrar H. Gilani[1], *Musadiq Asif*[2], *and Saeed Ahmad Nagra*[3]

University of Agriculture, Faisalabad, Pakistan and
University of the Punjab, Lahore-1, Pakistan

SUMMARY

Energy utilization was studied in human volunteers using different diets containing wheat flour supplemented by groundnut *(Arachis hypogaea)*, "masur" *(Lens culinaris)*, mung *(Phaseolus aureus)* and gram *(Cicer arietinum)* flour. Digestible and metabolizable energies were determined for all the experimental diets.

An improved energy digestibility was observed when wheat flour was supplemented with groundnut flour, and groundnut flour plus gram flour, i.e. 93.35 and 89.48% respectively. Percent digestibility of energy for the other two experimental diets was 81.07% when wheat flour was supplemented with groundnut and "masur" flour. It was further depressed to 77.87% when wheat flour was supplemented with groundnut and mung flour.

INTRODUCTION

The nutritional survey of Pakistan as well as the food balance sheets indicate that there is a widespread protein deficiency in the population, due to the low quantity and quality of protein consumed (1). It is therefore necessary that the meager amount of protein present in the diet be available to the body, and not be utilized as an energy source. Food energy exerts a sparing effect on proteins; hence, energy deficiency widens the protein gap, and it is considered that most of the protein deficiency is conditioned by energy deficiency. Therefore, unless the

Manuscrito modificado recibido: 8-1-86.

1 Director of Advanced Studies and Research, University of Agriculture, Faisalabad, Pakistan.

2 Member of the Department of Nutrition of the above-mentioned University.

3 Member of the Division of Biochemistry, Institute of Chemistry, University of the Punjab, Lahore-1, Pakistan. (Requests for reprints should be sent to Dr. Nagra).

energy need is met, increased protein production will not help much to improve the situation, and may be an uneconomical approach to solve the nutritional problem (2). Efforts have been made in the past to utilize vegetable protein sources such as groundnut *(Arachis hypogaea)*, "masur" *(Lens culinaris)*, mung *(Phaseolus aureus)* and gram *(Cicer arietinum)* as a supplement to cereal proteins to improve their quality. Nevertheless, energy availability in such practices has not been estimated, despite its vital importance and recognition as a major deficiency problem in a developing country.

The present comunication pertains to the study of energy utilization of cereal diets supplemented with groundnut *(Arachis hypogaea)*, "masur" *(Lens culinaris)* mung *(Phaseolus aureus)* and gram *(Cicer arietinum)*.

MATERIAL AND METHODS

The composition of experimental diets is given in Table 1. Five male human subjects between 30-35 years of age and weighing 60-70 kg, clinically healthy, were allotted to these diets at random. The experiment was conducted in a 5 x 5 Latin square design (3). The weighed amounts of ingredients of the diets were given as "chappaties", thrice a day, i.e. at morning, at noon and in the evening. Pickles, fresh mango and some onion were provided for variety sake, and to meet vitamins requirements. In addition, one cup of tea in the morning and one in the evening after meals was allowed. Gross energy intake was worked out on the basis of the calorific value of diets. Volunteers were allowed to take the experimental diets up to their fills. However, it must be stated that physical activity in all the individuals under study was almost uniform.

Five trials of four days each were conducted, during which samples of feces and urine were collected on a 24-hour basis from individual subjects. After each trial, a gap of one day was allowed for subjects to consume their routine diet.

The feces collected from each trial and from each subject were weighed as such, and again after drying in an electric oven at 105°C, to work out the fecal energy loss. Similarly, urine excreted during 24 hours by each subject, for each trial, was weighed and measured. Urine samples were dried by mixing in a known quantity of wheat flour in the oven at 80°C. Samples thus obtained were used to work out the urinary loss of energy.

The calorific value of five experimental diets (on a dry basis, and in the form of "chappaties") feces and urine were determined using the Parr Oxygen Bomb Calorimeter (4).

Gross energy intake *per capita*, per day, and losses of energy in feces and urine were also determined. Digestible and metabolizable energies were computed to establish the availability of dietary energy from wheat flour supplemented with vegetable protein sources.

The data were statistically analyzed using the analysis of variance (3). Duncan's Multiple Range Test (5) was applied for significance of mean differences.

TABLE 1

COMPOSITION OF EXPERIMENTAL DIETS (ISONITROGENOUS)

(EXPRESSED IN g °/o)

Ingredients	Experimental diets				
	A	B	C	D	W
Wheat flour	93.413	91.912	91.912	91.912	78.125
Groundnut *(Arachis hypogaea)*	6.587	5.666	5.936	6.016	—
Masur *(Lens culinaris)*	—	2.422	—	—	—
Mung *(Phaseolus aureus)*	—	—	2.152	—	—
Gram *(Cicer arietinum)*	—	—	—	2.072	—
Maize starch	—	—	—	—	21.875
TOTAL	100.00	100.00	100.00	100.00	100.00

RESULTS AND DISCUSSION

The data on energy balance in human volunteers, consuming different experimental diets, are summarized in Table 2.

Maximum energy intake was found in the case of diet "D", (wheat groundnut and mung flour) indicative of the superiority of this combination, and the potentiating effect of including gram in the diet. Statistical analysis of the data, however, did not show any significant difference in regard to gross energy intake derived from the various diets. Results suggested that energy intake may not be affected to a drastic extent by the supplementation of wheat, but there is a fairly good margin to improve it by supplementation, especially through the addition of groundnut flour or gram flour. Factors such as palatibility and energy availability might explain the existing variations in energy intake from supplemented wheat diets.

Gross energy requirements established according to the WHO recommendation (6) for volunteers of the present study, were 2,654 to 3,191 Cal *per capita*, per day, whereas the actual gross energy intake by the volunteers ranged between 2,452.81 to 2,705.33 Cal. Gross energy intake for all individuals was low, as compared to the requirement. This indicated

TABLE 2

AVERAGE ENERGY BALANCE OF EXPERIMENTAL DIETS IN HUMAN VOLUNTEERS

(Calories)

	Experimental diets				
	A	B	C	D	W
Gross energy intake	2681.78	2452.81	2554.16	2705.53	2493.22
Fecal energy loss	178.29	464.14	565.13	284.35	174.77
Urinary energy loss	28.74	20.78	31.56	25.97	29.45
Digestible energy	2503.49	1988.67	1989.03	2420.98	2318.45
Metabolizable energy	2474.75	1967.89	1957.47	2395.01	2280.00
% Digestibility of energy	93.35	81.07	77.87	89.48	92.95

that the diets under study must have some more gross energy to meet the requirements of adults at the same intake level.

Fecal and Urinary Loss of Energy

The fecal energy loss from the experimental diets ranged from 6.65 to 22.13% of the intake (Table 2). The energy loss in case of diet "A" (wheat and gram flour), "W" (wheat flour and maize starch), "B" (wheat, groundnut and "masur" flour) "D" (wheat, groundnut and gram flour) and "C" (wheat, groundnut and mung flour) was 6.56, 7.01, 10.51, 20.15 and 22.13% of the energy intake, respectively.

The analysis of variance indicated a significant ($p < 0.01$) loss of energy in feces in case of diets "D", (wheat, groundnut and gram flour) and "C" (wheat, groundnut and mung flour) than all other diets, whereas other apparent differences were statistically non significant. It may be concluded, therefore, that supplementation of wheat with groundnut flour has no appreciable influence on the fecal loss of energy as compared to wheat alone. Mung, "masur" and gram, however, have in them some factor which depresses energy availability in a descending order. Variations in fecal energy due to individuals, were found to be non significant ($p < 0.01$).

Urinary losses of energy were almost uniform and ranged from 0.85 to 1.18% of the gross energy intake, per day, per individual. These findings are in line with those of Beaton and McHenry (7) who reported a urinary

loss of energy as less than 3% of the energy intake.

Digestible Energy

Diets containing groundnut flour and groundnut flour plus gram along with wheat alone (Diets "A" and "D", respectively) showed significantly ($p < 0.01$) better digestible energy than other combinations (Table 2). This indicated an improvement in digestibility with groundnut flour and groundnut flour plus gram supplementation. The depressed digestibility of individuals fed on diet "B" (wheat, groundnut and "masur" flour) and "C" (wheat, groundnut and mung flour) was perhaps due to the presence of some depressing factors in these pulses.

Metabolizable Energy

The metabolizable energy followed a similar pattern as the digestible energy (Table 2). Uniform loss of urinary energy indicated that the respective diets were uniformly metabolized. Metabolizable energy was also calculated by the prediction formula (8), which turned out to be 2160.65 to 2390.23 Cal *per capita*, per day. However, metabolizable energy of the experimental diets on the basis of human trials ranged from 1957.47 to 2474.75 Cal *per capita*, per day. Thus, it is suggested that the formula for the prediction of metabolizable energy may hold good in the case of children, but that it cannot be applied to adults.

RESUMEN

UTILIZACION DE ENERGIA PROVENIENTE DE DIETAS DE CEREALES SUPLEMENTADAS, EN VOLUNTARIOS HUMANOS

Se estudió la utilización de energía en sujetos voluntarios humanos, utilizando diferentes dietas que contenían harina de trigo suplementada con harina de maní, *(Arachis hypogaea)*, "masur" *(Lens culinaris)*, frijol mungo *(Phaseolus aureus)* y garbanzo *(Cicer arietinum)*. En todas las dietas experimentales se determinó la energía digerible y metabolizable.

Se observó una mejor digestibilidad energética al suplementar la harina de trigo con harina de maní, y la harina de maní con harina de garbanzo, esto es, 93.35 y 89.48%, respectivamente. El por ciento de digestibilidad de energía para las otras dos dietas experimentales fue de 81.07% al suplementar la harina de trigo con harina de maní y "masur". Descendió hasta 77.87% cuando la harina de trigo fue complementada con harina de maní y de frijol mungo.

BIBLIOGRAPHY

1. **Protein Problem of Pakistan.** Islamabad, National Science Council, 1968.
2. Hussain, M. A. A fresh look at the incidence of protein deficiency in Pakistan. **Br. J.Nutr., 29**(2):211-219, 1973.
3. Snedecor, G.W & W.G. Cochran. **Statistical Methods.** Ames, Iowa, The Iowa State University Press, 1967, 237 p.

4. Lorin, E.H. **Nutrition Research Techniques for Domestic and Wild Animals.** Utah, 1970, p. 1901-1903.
5. Duncan, D.B Multiple range and multiple F-test. **Biometrics, 11**:1-42, 1955.
6. **The Health Aspect of Food and Nutrition.** Manila, World Health Organization Regional Office for Western Pacific. 1972, p. 225.
7. Beaton, G. H. & E. W. McHenry. **Nutrition.** Vol. I. London, Academic Press, Inc., 1964, p. 214.
8. Dorthy, S.S., S. T. Ehrlich, C.W. Bedell & B.R. Farthing. Prediction of metabolizable energy in pre-adolescent children. **J. Nutr., 91**(2):348-352, 1967.