Zusammenfassung

Erhitzen von Erdnußöl auf 205° während 18 Stunden führte zu keinen merklichen Veränderungen der Fettsäurezusammensetzung. Wiederholte Kartoffelzubereitung in auf 180° erhitztem Erdnußöl bewirkte einen deutlichen Rückgang des Linolsäuregehaltes. In 80tägigen Fütterungsversuchen ließen solche Ölgaben im Ausmaß von 10 und 20% einer normalen Diät zugefügt bei wachsenden Ratten keine signifikanten Veränderungen der Gewichtszunahmen erkennen.

Literatur

1. Morris, H. P., Larsen, C. D., and Lippincott J. W., J. National Cancer Inst. **4** 285 (1943). — 2. Crampton, E. W., Farner, F. A., and Berryhill F. M., J. Nutrition **43** 431 (1951). — Crampton, E. W. Common, R. H., Farner, F. A., Wells, A. F., and Crawford, D., J. Nutrition **49**, 333 (1953). — 3. Schürch, A. F., Gegenwartsprobleme der Ernährungsforschung, Experientia Supplementum **1**, 143, (Basel 1953). — 4. Poling, C. E., Warner, W. D., Mone, P. E., and Rice, E. E., J. Amer. Oil Chem. Soc. **39**, 315 (1962). — Rice, E. E., Poling, C. E., Mone, P. E., and Warner, W. D., J. Amer. Oil Chem. Soc. **37**, 607 (1960).

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Biological Value and Chemical Score

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With 2 figures and 2 tables

(Received October 29. 1962)

The value of food proteins may be represented by various coefficients, the most employed one being the biological value, which has become synonymous to protein value. This term was created by Thomas (1909) and completed by Mitchell (1924); it corresponds to the following definition: Biological Value =

$$100 \times \frac{N\text{ingested} - (N_{\text{faeces}} - N_{\text{metabolic}}) - (N_{\text{urine}} - N_{\text{endogenous}})}{N\text{ingested} - (N_{\text{faeces}} - N_{\text{metabolic}})}$$

The biological value is determined by means of the balance technique. This supposes that, in the course of an experiment period, the quantity of ingested food is measured as well as the quantity of secreted faeces and urine; there the nitrogen should be dosed.

Further it is necessary either to have determined in another experiment the metabolic and the endogenous nitrogen or to calculate these figures from generally available data. Since it concerns a biological experiment, it ought to be repeated several times in order to obtain reliable results. This explains the fact that the determining of the biological value is a difficult and delicate method. It is evident that many research-workers have tried to introduce a coefficient which is easier to be found.

BLOCK and MITCHELL (1946) proposed to represent the protein value by chemical score. This calculation is based on the determining of the amino acid composition of both the examined protein and of a reference protein, in this case the whole egg.

The chemical score of the examined protein is the procentual proportion of the amount of the limiting amino acid in the protein to that of the reference protein.

If the biological value of a protein only depends on its amino acid composition, the chemical score would then be numerically equivalent to the biological value. BLOCK and MITCHELL (1946) have from literature, composed a list of about 40 proteins, the biological value of which is determined by nitrogen balances on growing rats. They determined the amino acid composition and the chemical score of 22 proteins. For the relation chemical score/biological value these authors found a correlation coefficient of + 0.86 and a regression equation $BV = 39 + 0.63\,CS$. This equation shows that the chimecal score cannot be expressed directly as biological value.

BENDER (1954) however warned for three serious mistakes in the result given by BLOCK and MITCHEL (1946):

1. The reference protein

BENDER (1954) showed that the essential amino acid composition in the whole egg as determined by BLOCK and MITCHELL (1946) was too high for most of the essential amino acids. BENDERS reference basis were the result from the analysis of the whole egg published by the RUTGERS BUREAU (1950). For the relation biological value/chemical score, he obtained a correlation coefficient of + 0.82 and a regression equation $BV = 24 + 0.74\,CS$. This study approached us to the desired equation. Still BENDER (1954) would conclude his work. "In conclusion it might almost be claimed that the biological measurement of the nutritive value of proteins can be carried out more rapidly and more accurately than the estimations of amino acids."

Table 1. Composition of the reference protein
(g. of amino acid/16 g. of nitrogen)

Amino acid	Whole egg BLOCK and MITCHELL (1946)	Whole egg RUTGERS (1950)	Target values BENDER (1958)
Histidine	2.1	2.1	1.8
Lysine	7.2	6.1	5.2
Phenylalanine	6.3	5.6	3.8
Tryptophane	1.5	1.1	0.7
Cystine	2.4	2.3	2.0
Methionine	4.1	3.2	2.7
Cystine+Methionine	6.5	5.5	4.7
Threonine	4.9	4.9	4.1
Leucine	9.2	9.0	7.5
Isoleucine	8.0	6.2	4.3
Valine	7.3	7.0	5.0

In later papers BENDER (1960a and b) showed that for growing rats the whole egg contains more than their need of some essential amino acids. In a

first approximation an over-estimation of 15% for the whole egg could be pointed out. Basing on experimental investigation BENDER (1958 and 1960a) could calculate the amino acid needed by the growing rat as the procentual composition of the ideal protein. This hypothetical protein then completely corresponds to the actual needs and has a chemical score and a biological value equal to 100.

Table 1 is a comparative table of the various reference proteins used when calculating the chemical score. We based on BENDERS target values (1958) for recalculating the chemical score.

2. Analysis of the proteins

The amino acid analyses of the food proteins by BLOCK and MITCHELL (1946) were undertaken by microbiological and chemical methods. This leads to a serious error. The considerable progress made during the last years as far as the amino acid analysis is concerned, especially the perfectioned resin chromatographic technique, assures a greater exactness. That is why, when calculating the chemical score, we neglected the figures given by BLOCK and MITCHELL (1946) as much as possible. The analytical figures were borrowed from the following works: DE MAN and ZWIEP (1955), HARVEY (1956), OR and WATT (1957) and DE VUYST et al. (1958).

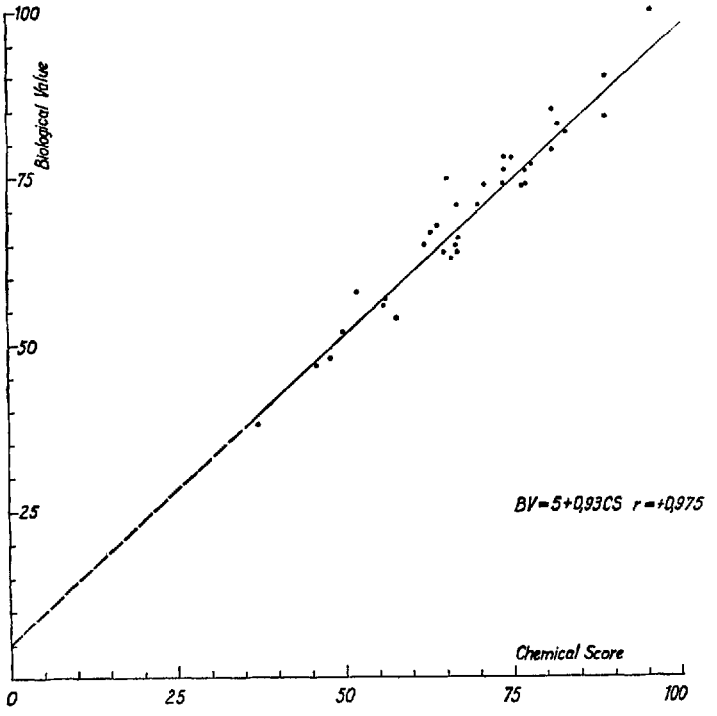

Fig. 1. Proposed revision biological value chemical score.

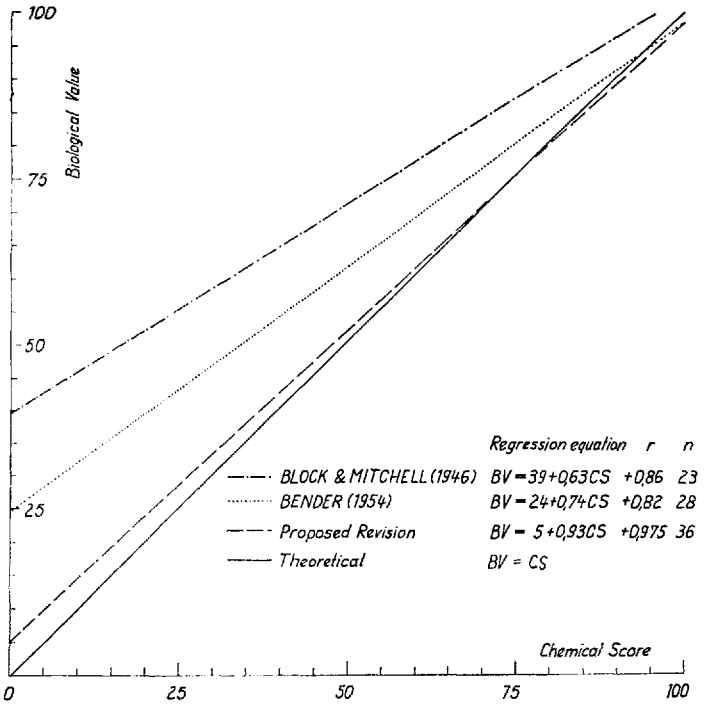

Fig. 2. Relation biological value/chemical score.

3. Estimation of the biological value

We have been maintaining the figures of the biological value that were gathered by BLOCK and MITCHELL (1946). Although these figures were obtained by several research workers and although the experimental circumstances are surely not comparable, yet, for want of more recent and better data, they remain the best reference list.

The new reference basis and the other analytical figures lead to a regression equation $BV = 5.3 + 0.93\ CS$ and a correlation coefficient + 0.975 (see fig. 1).

The value of the chemical score and that of the biological value are represented in table 2. This new regression equation is a much better approximation of the numerical equivalent $BV = CS$. Figure 2 gives a precise idea of the obtained improvement. In a later thesis BENDER (1961) affirms the numerical equivalence of biological value and chemical score. We may conclude:

1. The calculation of the chemical score with regard to the actual need of a growing rat corresponds much better to the biological value. Although the total egg presented many advantages as a reference protein, the fact remains that it does not possess any physiological relation to the growing rat. To determine the biological value means to estimate to which extent a feed protein covers the need of a given physiological condition. That is why a better result will be obtained from an equation with regard to this physiological need. This

implies also that for each species of animals and for each physiological condition (growing, gestation, lactation, production), another reference basis ought to be used.

Table 2. Biological Values and Chemical Scores

Protein	Biological value BLOCK and MITCHELL (1946)	Chemical score BLOCK and MITCHELL (1946)	Chemical score BENDER (1954)	Chemical score Proposed revision	Limiting amino-acid *) Proposed revision
Egg, whole	96	100	100	100	—
Milk, fresh	90	68	80	89	C + M
Lactalbumin	85	66	84	81	M
Milk, dried	84	—	—	89	C + M
Egg albumin	83	69	78	82	PHEN
Pork tenderloin	79	—	—	81	C + M
Flaxseed	78	35	41	75	L
Maize germ	78	39	50	74	M
Beef kidney	77	65	76	74	M
Beef liver	77	70	84	78	C + M
Beef muscle	76	71	83	77	C + M
Cabbage	76	—	—	74	M
Rice, white	75	44	53	73	L
Wheat germ	75	38	49	74	M
Beef heart	74	65	80	79	C + M
Pork, ham	74	—	—	77	C + M
Wheat bran	74	—	—	71	L
Potato sweet	72	—	—	72	C + M
Potato tuberin	71	—	—	70	C + M
Sesame seed	71	39	46	67	L
Coconut meal	70	—	—	67	L
Casein	69	58	69	64	C + M
Wheat, whole	67	37	44	63	L
Oats, rolled	66	46	54	67	L
Sunflower seed	65	53	62	62	L
Barley	64	—	—	65	L
Cottonseed	64	37	44	67	M
Yeast	63	45	53	66	C + M
Groundnut	58	24	31	52	M
Soya beans	57	49	—	56	M
Millet	56	—	—	56	L
Maize, whole	54	28	33	58	L
Flour, white	52	28	33	50	L
Pea	48	—	—	48	M
Bread, white	47	—	—	46	L
Beans, navy	38	—	—	37	M

*) Limiting amino acid: C + M = cystine and methionine; L = lysine; M = methionine; PHEN = phenylalanine.

2. The biological value of a protein can be calculated very accurately on the basis of its amino acid composition. This is also assumed by BENDER since 1959.

3. As in most feeding proteins the first limiting amino acids is lysine or sulphur containing amino acids the calculation of the chemical score can be reduced to an estimation of these amino acids, as BENDER proposed (1961).

Although the numerical equivalence $BV = CS$ was almost approximated, we must not forget that this ideal relation is based on the supposition that the biological value would exclusively depend on the amino acid composition. No other factors, such as digestibility, biological availability are taken into account then. If these factors prove to be important, we shall have to be careful when converting chemical score to biological value.

Summary

Basing on the amount of essential amino acids needed by the growing rat and on recent analytical figures, the chemical score of 36 proteins was recalculated. A regression equation was calculated: Biological value = 5,3 + 0,93. Chemical Score with $r = + 0{,}975$. Two facts were demonstrated: 1. for determining the chemical score, the best reference figures result from the need of essential amino acids; 2. it is possible, on the basis of analytical figures, to calculate the biological value of a protein.

Zusammenfassung

Auf Grund des Bedarfs an essentiellen Aminosäuren bei wachsenden Ratten und an Hand rezenter Analysezahlen wurde die Chemical Score für 36 Proteine neu berechnet. Wir berechneten ebenfalls eine Regressionsgleichung: Biologische Wertigkeit = 5,3 + 0,93. Chemical Score $R = + 0{,}975$.

Zwei Tatsachen wurden dargelegt: 1. die besten Referenzzahlen zum Bestimmen der Chemical Score ergeben sich aus dem Bedarf an essentiellen Aminosäuren; 2. an Hand der Analysezahlen ist es möglich, die Biologische Wertigkeit eines Proteins zu berechnen.

References

Bender: J. Sci. Food Agric. 7, 305 (1954). — Bender: Proc. Nutr. Soc. 17, XXXIX (1958). — Bender: Clin. Chim. Acta 5, 1 (1960a). — Bender: Protides of the biological fluids. Proc. 7 Colloq. 219. (1960b). Bender: Protides of the biological fluids Proc. 8 Colloq. 155 (1961). Block and Mitchell: Nutr. Abstr. Rev. 16, 249 (1946). — De Man en Zwiep: Voeding 16, 2 (1955). — De Vuyst, Vanbelle, Arnould, Vervack en Moreels: Agricultura 6, 5 (1958). — Harvey: Tables of the Amino acids in foods and feedingstuffs, Commonwealth Bureau of Animal Nutrition, Tech. Communication N° 19 (1956). — Mitchell: J. Biol. Chem. 58, 873 (1924). — Orr and Watt: Amino acid content of foods. Inst. Home Econ. US. Dept. Agric. (1957). — Rutgers, Cooperative determination of the amino acid content and of the nutritive value of six selected protein found sources (New Brunswick 1950). — Thomas: Arch. Physiol. 219 (1909).

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