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EVALUATION OF BAROTHERMALLY PROCESSED CASEIN AS A COMPONENT OF TROUT STARTERS. II. THE EFFECT ON FISH GROWTH

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ABSTRACT. Six experimental trout starters containing 8-40% of processed casein were tested. The experiment lasted 50 days. Rainbow trout fry of average individual body weight 1.5-1.7 g was used. The best results were obtained with the starter containing 32% of caseinate – final fish body weight was 18.07 g/ind., feed conversion rate 0.85, PER – 2.32, and aNPU – 33.50.

Key words: RAINBOW TROUT, FEEDING, FEEDS, CASEIN, EXTRUSION

INTRODUCTION

Commercial success of rainbow trout farming depends on availability of nutritious and cheap artificial feeds, meeting all requirements of the fish. Costs of feeds in Polish trout farming reach up to 50% of total production cost. According to Pitcher (1978), feeds may comprise even 70% of all expenses.

High demand for artificial fish feeds encourages the use of alternative components, such as offal milk proteins, new technologies in feed processing, and utilisation of various by- or waste products (Gongent et al. 1996).

This study was a continuation of earlier studies dealing with the use of fish meal substitutes, such as barothermally processed casein wastes, in trout feed production.

MATERIAL AND METHODS

The experiment was carried out under controlled conditions in tanks of the Department of Inland Fisheries and Aquaculture of the Agricultural Academy in Poznań.

Rainbow trout (*Oncorhynchus mykiss*) fry of average individual body weight 1.5-1.7 g was used; it was purchased from the Trout Farm Mylof.

The fish were reared in 60 dm^3 flow-through tanks supplied with tap water filtered through activated carbon to remove chlorine. Retention tank of 2 m^3 was used to heat and aerate water. Grate distribution system was applied, supplied by greaseless compressor. Water was renewed about 5 times a day (water flow rate was equal to 0.2 dm^3/min.).

During the experiment, physiochemical water parameters were measured daily: temperature (°C), pH, and DO (mg O_2/dm^3). The tanks were cleaned twice a day (morning and evening), faeces and non consumed feed were removed using a rubber hose. The fish were treated with 250 ml/m^3 solution of formaldehyde and methyl blue for 20 minutes, if needed.

Experimental feeds were supplied manually on water surface, hourly from 8 a.m. to 8 p.m. Daily feeding rates were calculated according to Leiritz (1969) recommendations, taking into consideration fish body weight and water temperature. Feed supply was changed every 10 days, according to fish weight increase. Fish were weighed, and growth rate was calculated.

Experimental feeding was carried out in 6 groups (including the control), each in 3 replicates (25 fish in each tank). The tanks were stocked on July 3, and experimental feeding (50 days long) started on July 10, 1996.

The following parameters were calculated:

- Fish survival (%)
- Average final fish weight (g)
- Body weight increase (g)
- Specific growth rate (SGR) (DeSilva, Anderson 1995)
- Average food conversion rate (FCR)

The effect of feed protein on fish growth was evaluated using the following indices:

- Apparent net protein utilisation index (aNPU) (Zeitoun et al. 1973)
- Feed protein efficiency rate (PER) (Steffens 1985)

Before and after the experimental feeding, randomly selected fish were sampled for chemical analyses. The fish were ground and homogenised, and the following components were measured: dry weight, total protein, ether extract, and ash. The results are shown as mean values of 3 replicates.

The results were calculated using a computer program (S-4), licence AR Poznań. Growth rate dynamics was subject to regression analysis using Quattro Pro for Windows package.

Changes of individual body weight of the fish were analysed using exponential relation between the weight and time of rearing. Calculations were done according to

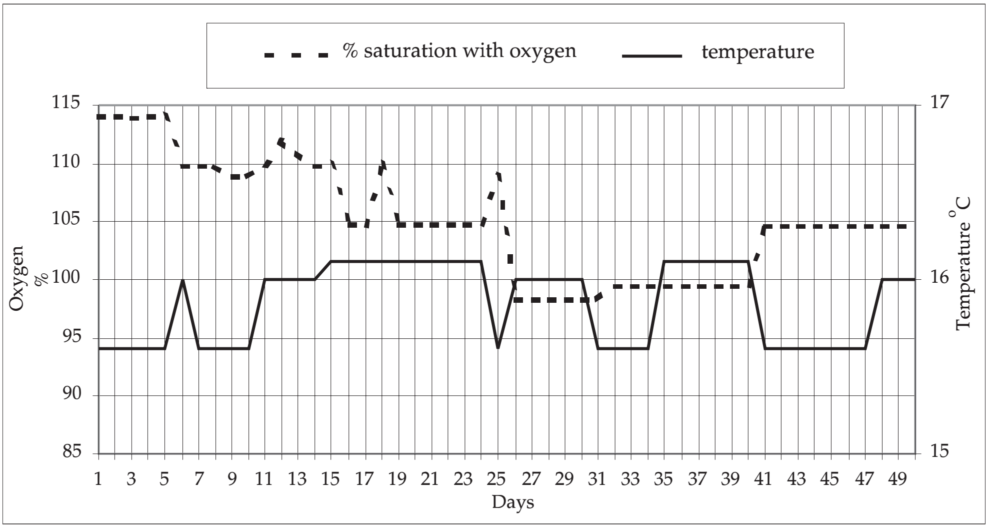

Fig. 1. Dynamics of temperature and saturation with DO during the experiment.

Nair (1986). Final fish body weight was tested with one-way ANOVA, and LSD test . The differences exceeding LSD were considered significant, and standard analysis of variance was done (Martin 1972).

RESULTS

Dynamics of temperature and DO during the experiment is shown in Fig. 1. Average daily temperatures ranged from 15.6 to 16.1°C, and oxygen saturation from 114.1 to 98,3%.

Average final fish body weights ranged from 12.06 (A diet) to 18.07 g (E diet). Fish growth was satisfactory also in D and E groups. The highest specific growth rate (SGR) was observed in groups D (4.69%) and E (4.72%). Trout survival was high, and ranged from 97.3 to 100%.

In experimental animal rearing, growth rate may be described with various types of growth curves in which 3 phases may be distinguished: 1. short period of poor growth, 2 phase of logarithmic growth, and 3. slower growth rate approaching maximum body weight. In our study a logistic curve was obtained (Fig. 2).

Experimental fish rearing is usually limited to the first two phases – of slow and logarithmic growth. In such a case, fish growth may be described with an exponential function:

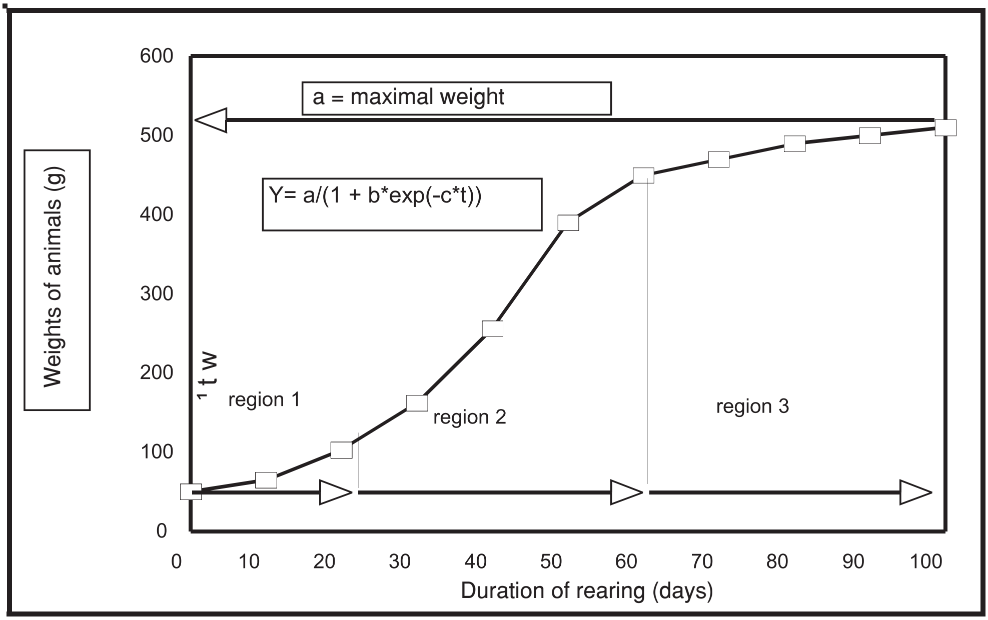

Fig. 2. Fish growth curve

$$Y\,(t) = Y\,(0) * e^{b*t}$$

where:

Y (t) – fish weight after t time of rearing,

Y (0) – initial fish weight,

e – base of natural logarithm = 2.7183...,

b – coefficient describing growth dynamics.

Coefficient „b“ describes dynamics of weight increase over time, and daily fish weight is expressed as natural logarithm. Thus, 1/b is equivalent to the number of days that are necessary to increase fish weight by the factor 2.7183, which means one cycle of natural logarithm. That is a good indicator of rearing efficiency, and it takes into consideration the role of feeding, so it was used in the present study.

The effect of a substitute feed component on b dynamics of Y function was described using 2 models – according to Harris and Gauss (Glasser 1974). Hariss' model is expressed by the formula:

$$Y \quad \frac{1}{(a \quad b \ [\%]^{C})}$$

TABLE 1

The results of rainbow trout feeding on experimental feeds

Parameter	Feeds					
	A	B	C	D	E	F
Initial fish number	75	75	75	75	75	75
Average fish mass (g)	1,55	1,57	1,56	1,68	1,70	1,64
Total fish mass (g)	116,6	118,2	117,0	126,1	128,0	123,2
Final results						
Final fish number	75	74	75	73	75	75
Average final fish mass (g)	12,06	14,98	15,56	17,97	18,07	14,86
Total fish weight (g)	904,6	1108,7	1167,1	1312,4	1355,4	1114,9
Average fish growth (g)	10,51	13,41	14,00	16,29	16.37	13,22
Total fish growth (g)	788,0	990,5	1050,1	1186,3	1227,4	991,7
SGR %	4,10	4,48	4,60	4,69	4,72	4,41
Survival %	100	98,6	100	97,3	100	100

TABLE 2

The effect of caseinate level and time of rearing on fish weight (ANOVA)

Variable	Sum of square	Degrees of freedom	Mean square	Fcalc.	Significance F calc.*
Caseinate level Na	33852,024	5	43212,214	621,079	0,000
Time of rearing	1563902,940	5	14497,622	208,371	0,000
Dodatek x czas	28483,292	25	8121,500	116,728	0,000

****significante level*** *$\alpha < 0,000$*

TABLE 3

Parameters of exponential function for fish weight increase during the experiment.

% of caseinate in feeds	Y(o) – calculated initial mass [g]	B – dynamics of weight increase [(ln(g))]/day	Fitting to logarithmic model R^2	Significance level of logarithmic regression α
0 – control	36,30	0,0420	0,9947	0,000
10	39,28	0,0453	0,9976	0,000
20	40,88	0,0454	0,9790	0,000
30	41,67	0,0474	0,9940	0,000
40	41,52	0,0474	0,9981	0,000
50	40,16	0,0446	0,9928	0,000

and Gauss:

$$Y \quad a \ \exp \frac{1}{\dfrac{x(\quad [\%])^2}{2 \ \ c^2}}$$

In both models [%] means the amount of alternative feed component, and a, b and c are coefficients. In Gauss' model, x coefficient represents percentage of alternative component resulting in maximum Y value, i.e. giving an optimum level.

Data in Tab. 2 show that the analysed variables and their interactions (sodium caseinate addition and time) significantly affected the fish weight. Statistically significant interaction indicates that dynamics of fish weight is different for various levels of sodium caseinate in feed. Thus, time–mass relations should be determined separately for each experimental group (% of additive).

Data in Tab. 3 and Fig. 3 indicate that irrespectively of the amount of caseinate, in all experimental groups the fish grew very fast during the experiment. Slightly higher slope of the curves for fish fed caseinate-supplemented feeds compared to the control indicates somehow higher value of b coefficients – higher growth rate in group E.

Despite lack of statistical significance ($t = 0.221 < t = 2.2776$), the difference between b for the control (0.0422) and average b for all experimental groups (0.0466) shapes the curve indicating optimum level of caseinate in the feed (Fig. 4).

Gauss curve indicates that optimum caseinate level is 30.55%. At this level, b = 0.0472 and the highest growth rates were observed. This was confirmed by the relation between caseinate level and average fish weight (Fig. 5), showing that optimum caseinate level in the feed was 31.52%. This value does not significantly differ from 30.55% (Fig. 4).

Average values of feed conversion rates ranged from 0.85 (group E) to 1.02 (group A). Protein efficiency rate (PER) ranged from 2.32 (E) to 1.97 (A), and apparent NPU from 33.50 (E) to 28.69 (A) (Tab. 4).

Diet composition affected chemical composition of trout body. The highest protein content (14.69%) was found in fish of group B, and lowest (14.34%) in group D (Tab. 5).

Analysis of variance of final fish body weight did not reveal significant differences ($\alpha = 0.05$) between group D and E which, however, significantly differed from A, B, C, and F.

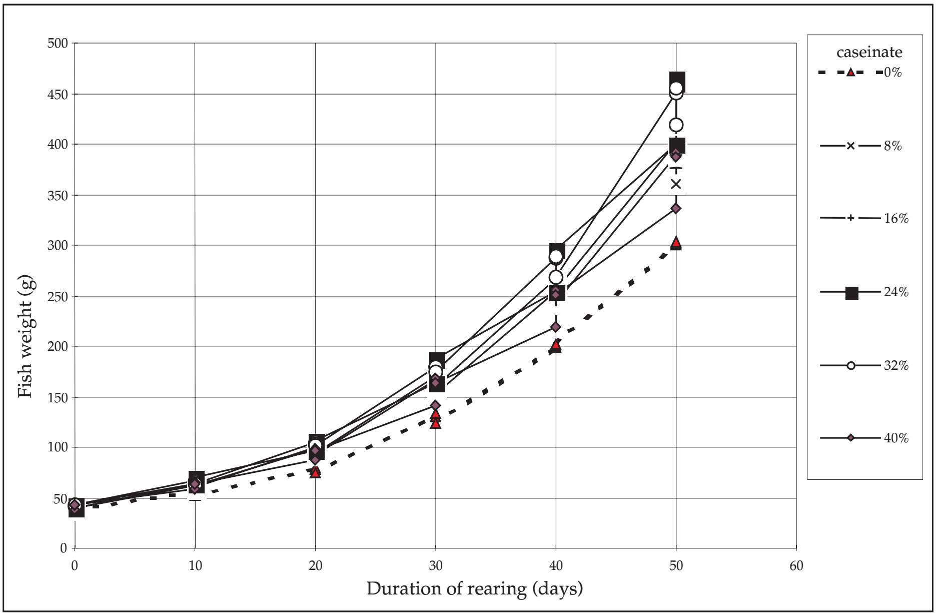

Fig. 3. The effect of sodium caseinate in feed on rainbow trout growth.

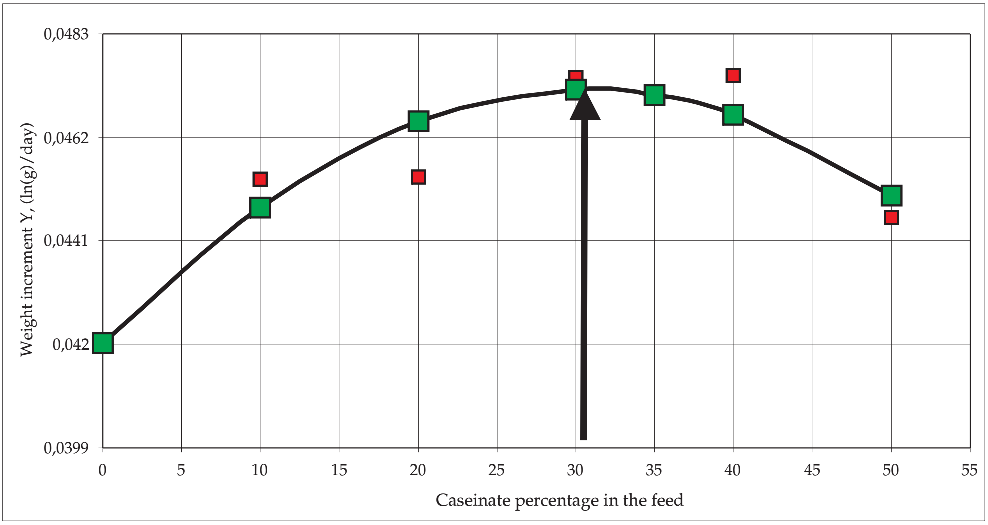

Fig. 4. The effect of sodium caseinate on fish growth rate.

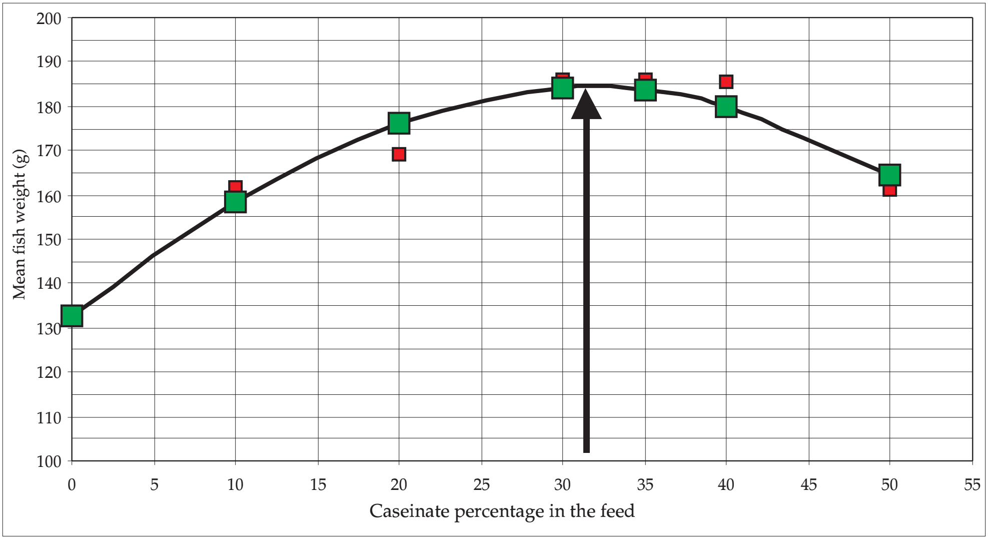

Fig. 5. The effect of sodium caseinate on average rainbow trout body weight.

TABLE 4

Utilisation of feed components.

Index	Feeds					
	A	B	C	D	E	F
FCR	1,02	0,95	0,92	0,89	0,85	0,95
PER	1,97	2,10	2,19	2,25	2,32	2,12
aNPU(%)	28,69	30,90	32,30	32,30	33,50	32,00

TABLE 5

Chemical composition of fish body before and after the experiment (%).

Experimental group	Dry mass	Crude ash	Total protein	Crude fat
Before the experiment	20,76	2,73	14,17	3,75
A	23,44	2,11	14,53	6,54
B	23,57	2,25	14,70	6,49
C	25,01	1,93	14,69	8,09
D	25,37	1,86	14,34	8,98
E	25,26	1,94	14,39	8,82
F	25,00	1,81	15,03	7,97

DISCUSSION

Values of physico-chemical water parameters during the experiment (temperature and dissolved oxygen) were near optimum for rainbow trout: 15°C, and 80-100% (Goryczko 1977).

Fish growth rate and the effects of feed composition indicate that nutritive value of the experimental diets differed. Values of PER and aNPU show that feeds E and D were most efficiently utilised by the trout, and feeds A, and B – least so.

Values of PER and aNPU may vary with the level and quality of nutrients, particularly protein, time of rearing, fish age, and even race or sex. Very high nutritive value of casein (PER 2.36-2.22) was observed by Nose (1971) in trout starters of 35% total protein content. According to Zeitoun et al. (1973), the highest PER value (2.1), and NPU (34%) was obtained in feeding rainbow trout with feeds containing 40% of casein (in relation to total protein).

It was proved (Tiews et al. 1979) that fish protein may be replaced with meat-and-bone and fowl meals supplemented with the lacking amino acids. Steffens (1982) obtained good results feeding trout various offal animal meals with yeast.

In this experiment, PER and NPU values for the best feed E were 2.32, and 33.50% respectively. Other casein-supplemented feeds showed PER values 1.97-2.25, and NPU – 28.69-32.30%.

The aim of the present study was to evaluate the effect of various casein levels on fish growth rate. The results of ANOVA (for the following variables: time of rearing, casein level, interaction time * casein level) indicate that optimum casein level in feed, resulting in the highest growth rate of rainbow trout fry, ranges from 30.55 to 31.52%.

REFERENCES

De Silva S.S. Anderson T.A. 1995 - Fish nutrition in aquaculture. Chapman & Hall, London

Glasser R. 1974 - Biologie einmal andres. Urania Verlag , Leipizig – Jena – Berlin Pozycja dla krzywej wykładniczej oraz Gaussa i Harrisa

Gongnet G.P., Meyerburgdorff K.H., Becker K., Gunther K.D. 1996 - Influence of various protein sources on protein digestion and metabolism of growing mirror carp (*Cyprinus carpio* L.) - Revue de Medicine Veterinaire. 147 (1): 63-68

Goryczko K. 1977 – Jak przygotować budowę nowych obiektów pstrągowych. Gosp Ryb. 4:3-6

Leitritz E. 1969 – die Praxis der Forellenzucht –Verlag Paul Parey, Hamburg ,Berlin

Martin J. 1972 - Podstawy matematyki i statystyki dla biologów, lekarzy i farmaceutów. PZWL W-wa (tł. z języka francuskiego)

Nair K.R. 1986 - The Fitting of Rrowth Curves. In : Kemthorne O.: Statistics and Mathematics in Biology. Iowa State College Press, Ames, Iowa USA.

Nose T. (1971) – Determination of nutritive value of food protein in fish – III Nutritive value of casein, white fish meal and soybean meal in rainbow trout fingerlings – Bull.Freshwat.Fish Res. Lab. 21,(1) : 85-89

Pitcher T. J. 1978 – An energy budget for rainbow trout - Farm. Environmental Conservation, 4 (1):59 – 65.

Steffens W. 1982 – Moglichkeiten des Ersatzes hochwertiger tierischer Eiweissttrager in Mischfuttermittelen fur fische – Z.Binenfisch. DDR 29H (7):204-207

Steffens W. 1985 - Grundlagen der Fischernahrung VEB Gustaw Fisher Verlag, Jena

Tiews K., Koops H.,Groop J., Beck H., 1979 – Compilation of fish meal-free diets obtained in rainbow trout (*Salmo gairdneri*) feeding experiments at Hamburg 1970-1977/78).

Zeitoun I.H., Halver J.E. , Ullrey D.E., Tack P. J.1973 - Influence of salinity on protein requirement of rainbow trout (*Salmo gairdneri*) fingerlings – J. Fish. Res. Board Can. 30(12):1867-1873.

STRESZCZENIE

PRZYDATNOŚĆ MODYFIKOWANEJ BAROTERMICZNIE KAZEINY W MIESZANKACH PASZOWYCH DLA NARYBKU PSTRĄGA TĘCZOWEGO *(Oncorhynchus mykiss).*
II OKREŚLENIE PRZYDATNOŚCI PASZ DOŚWIADCZALNYCH W ŻYWIENIU PSTRĄGA

Doświadczenie wykonano w warunkach kontrolowanych w katedrze Rybactwa Śródlądowego i Akwakultury - Akademii Rolniczej w Poznaniu. Materiał doświadczalny stanowił narybek pstrąga tęczowego *(Oncorhynchus mykiss)* o średniej masie jednostkowej 1,5 - 1,7 g/szt. Do testów wykorzystano akwaria o pojemności 60 l . Pasze doświadczalne podawano rybom w odstępach godzinowych od $8^{\underline{00}}$ do $20^{\underline{00}}$. Dzienne dawki paszy wyliczono według norm podanych przez Leitritza (1969). Badania przeprowadzono w okresie 50 dni na 6 grupach doświadczalnych , w trzech powtórzeniach przy obsadzie 25 sztuk narybku na akwarium. W czasie podchowu średnie dobowe temperatury wahały się od 15,6 do 16,1.

Badaniami objęto sześć mieszanek paszowych uformowanych metodą ekstruzji, w których udział kazeinianu sodu wynosił od 8-40 %. Przeżywalność narybku pstrąga była wysoka i wahała się od 97% do 100% . Ryby żywione paszą zawierającą 32% kazeinianu osiągnęły najwyższą średnią masę końcową 18,07 g/szt., przy współczynniku pokarmowym 0.85. W tym wariancie żywieniowym uzyskano też najlepsze wskaźniki wykorzystania białka PER - 2,32 i aNPU - 33,50 %

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