《Research Notes》

Nutritive Value of New Type of Chlorella for Poultry Feed

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Chlorella, having photo-synthetic mechanism, has been considered as one of the most hopeful future source of food for men and feed for domestic animals and poultry. However, one of the largest disadvantage to use chlorella as feed is low digestibility of nutrients in chlorella, suspected mostly due to hard membrane to protect the cell against penetration of digestive enzymes. The authors reported that digestibility of chlorella protein by rats was 64 %, and metabolizable energy by chicks was 1.99 kcal/g.¹⁾ These findings were supported by recent paper²⁾.

The authors had a chance to examine nutritive value of a sample of chlorella of about 1 kg, which was offered recently by Mr. Junzo Aono of Kurimoto Tekko-sho, 1-12-19, Kita-horie, Nishi-ku, Osaka-shi, Japan. It was informed by him that the dried sample was produced as a pure culture of *Chlorella vulgaris* Al-25, which was isolated in Faculty of Agriculture University of Kagoshima, Japan. This sample of chlorella was characteristic to have thin membrane, so it was suspected to have protein and other nutrients easily digestible. The sample was also characteristic to contain less protein but more carbohydrate than usual type of chlorella did.

Chemical composition and nutritive value of the sample, particularly digestibility of protein and energy are presented in this paper.

Experimental

Moisture, crude protein, crude fat, nitrogen-free extracts, crude fibre, crude ash, calcium and phosphorus were determined by conventional procedures for feed analysis³⁾. Chromic oxide was determined by phosphate reagent³⁾. Gross energy was determined by automatic calorimeter (Shimazu CA-2).

Available energy and gross protein value of the sample were determined by the standard procedures described in the previous papers^{4,5)}. Total 120 8-day-old male White Leghorn chicks were used in these bioassays. The maximum levels of air-dried sample in the experimental diets for bioassay of available energy and for that of gross protein value were 20.0 and 16.33%, respectively. Palatability of the sample was calculated from feed intake in the bioassay of available energy. In the bioassay of gross protein value, 2.0% of DL-methionine was supplemented to crude protein of the sample.

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In the bioassay of available energy, 0.1% of chromic oxide was supplemented to all of the experimental diets as an indicator for digestibility by rats. To 3 adult male rats each of Wister strain, 20 g per day per rat of a diet composed of 20% of the sample of chlorella and 80% of basal parts and of the basal parts alone were fed for 4 days, and the feces of final one day were collected individually for chemical analyses. True digestibility of protein and energy of the sample was calculated by difference of the data of 2 groups of rats. In this calculation, endogenous energy and nitrogen of 2 groups of rats was expected to be the same.

Results and Discussion

Chemical composition of the sample is presented in Table 1. The sample contained 24.38 % of crude protein and 4.565 kcal/g of gross energy, which were much lower than those of chlorlla of usual type, i. e., 51.4% and 5.34 kcal/g, respectively¹⁾. The sample had 52.96% of nitrogen-free extracts and 8.05% of crude fat. The sample was rich in phosphorus but calcium content was as low as 0.11%.

表 1. クロレラの化学的組成
Table 1. Chemical composition of chlorella

		%
水	Moisture	8.80
粗蛋白質	Crude protein	24.38
粗脂肪	Crude fat	8.05
可溶無窒素物	Nitrogen-free extracts	52.96
粗繊維	Crude fibre	1.73
粗灰分	Crude ash	4.08
カルシウム	Calcium	0.11
リン	Phosphorus	1.19
		kcal/g
総エネルギー	Gross energy	4.565

Available energy and gross protein value of the sample by growing chicks are presented in Table 2. Available energy of the sample by chicks was 3.34 kcal/g with availability of 73%, which was significantly higher than that of the previous value of 1.99 kcal/g with availability of 37% for usual type of chlorella¹⁾. Gross protein value by chicks with supplemental DL-methionine was 71. Further study to find the reason of this low gross protein value and to improve the value will be required in future, since digestibility of protein in the sample by chicks was expected to be high enough. Supplemental DL-methionine in this

表 2. クロレラの栄養価
Table 2. Nutritive value of chlorella

		平均 mean	95% 信頼限界 95% fiducial interval
有効エネルギー	Available energy kcal/g	3.34	4.04 ~ 2.99
エネルギー利用率	Availability of energy	73	
蛋白質価	Gross protein value		
メチオニン添加	with methionine	71	88 ~ 54
嗜好性指数	Palatability index	99	

bioassay might be too much, or other amino acid than methionine might be still lacking.

Palatability of the sample was excellent, being 99. During these bioassays, no chick fed the sample died, and all of them grew normally in proportion to dietary levels of energy or protein. The findings indicated no acute toxicity in the sample.

True digestibility of gross energy and crude protein of the sample by adult rats was 80 and 96%, respectively. Digestible energy of the sample was calculated to be 3.63 kcal/g. The difference between digestibility of protein of this new type of chlorella, 96%, and that of the usual type, *i.e.*, 64%¹⁾, was highly significant statistically ($P < 0.001$).

It was concluded that new type of chlorella, *Chlorella vulgaris* Al-25, is highly digestible by rats and chicks. The findings certainly encourage researchers who are trying to use chlorella as future food and feed, but are troubled with low digestibility of dried sample. From the findings of good digestibility, phosphorus in the sample was expected to be highly available by chicks, though this was not confirmed biologically due to the limitation of amount of the sample. Similarly, gross protein value could be improved by proper supplementation of limiting amino acids after the determination of amino acid composition of the sample.

Summary

A sample of new-type of chlorella, *Chlorella vulgaris* Al-25, contained 24.38% of crude protein but 52.96% of nitrogen-free extracts. Available energy of the sample by growing chicks was 3.34 kcal/g with availability of 73%. Gross protein value with supplemental DL-methionine was 71. Palatability was excellent, and no acute toxicity was found in the sample.

True digestibility of gross energy and crude protein of the sample by adult rats was 80 and 96%, respectively. Digestible energy of the sample was calculated to be 3.63 kcal/g.

The sample was characteristic, containing relatively low level of protein and high level of carbohydrate, which were easily digestible and readily available by chicks and rats.

Literature

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新しいタイプのクロレラの養鶏用飼料としての価値

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クロレラは未来の食・飼料資源として期待されているが、消化が悪いという難点がある。著者らは、栗本鉄工所（大阪市西区北堀江 1-12-19）の青野順三氏より、約 1 kg の新しいタイプのクロレラのサンプルの提供をうけ、栄養価を評価する機会をえたので、その結果を報告する。このクロレラは、鹿児島大学において分離した *Chlorella vulgaris* Al-25 を純粋培養した製品で、細胞膜が薄いのが特長であるとのことである。このクロレラは、蛋白質含量が少なく、炭水化物含量が多いのが特長であるとのことである。

既報の生物定量法により、8 日齢の白レグ種雄ヒナ合計 120 羽を用いて、有効エネルギーと蛋白価を測定した。サンプルの配合最大量は、それぞれの生物定量法において、20.0 および 16.33% であった。蛋白価の測定にあたり、クロレラの蛋白質の 2.0% 相当の DL-メチオニンを添加した。有効エネルギーの測定に供試した飼料にはすべて、0.1% の Cr_2O_3 を添加しておき、サンプル 20% と共通部分 80% とからなる飼料と、共通部分のみとを、3 頭ずつのウィスター系雄成ラットに与えて、消化率を測定した。この場合、サンプルのエネルギーおよ

び蛋白質の真の消化率を、2 種類の飼料を与えたときの内因性排泄物が同量であるとの仮定のもとに、差を求めて計算した。

サンプルは、粗蛋白質 24.38%，総エネルギー 4.565 kcal/g を含んでおり、これは、これまでのクロレラの組成に比し著しく低い。サンプルは可溶無窒素物 52.96%，粗脂肪 8.05% を含んでいた。

サンプルの有効エネルギーは 3.34 kcal/g，エネルギー利用率 73% であったが、これは、従来のクロレラの 1.99 kcal/g，利用率 37% に比し著しく高い。DL-メチオニンを 2% 添加した場合のサンプルの蛋白価は 71 であった。嗜好性指数は 99 ですぐれていた。また、この生物定量法の実験において死亡例はなく、サンプルに急性毒性があるとはいえなかった。

ラットによる総エネルギーと粗蛋白質の真の消化率は、それぞれ 80% と 96% であった。これからサンプルの可消化エネルギーは、3.63 kcal/g と計算される。従来のクロレラの消化率 64% と、このサンプルの消化率 96% の差は、危険率 0.1% で有意であった。

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