RESEARCH ARTICLES

J.Sci.Soc. Thailand 13 (1987) 15- 27

TENTATIVE UTILIZATION OF PHOTOSYNTHETIC BACTERIA AS A MULTI-PURPOSE ANIMAL FEED SUPPLEMENT TO FRESH WATER FISH. I. THE UTILIZATION OF *RHODOPSEUDOMONAS GELATINOSA* FROM CASSAVA SOLID WASTES FOR GOLDFISH, *CARASSIUS AURATUS*

NAPAVARN NOPARATNARAPORN[a], SAVITR TRAKULNALEUMSAI AND SANTANA DUANG-SAWAT[b]

[a] *Department of Microbiology, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand*

[b]*Institute of Inland Fisheries, Ministry of Agriculture, Bangkok 10900, Thailand*

(Received 20 May 1986)

Abstract

R. gelatinosa *cell mass cultivated on cassava solid waste under aerobic - dark condition contained 56% protein, 2.45% fat, 26.42% carbohydrate and 3.21% ash. The protein consisted of appreciable amounts of essential amino acids (methionine, lysine, leucine and phenylalanine) comparable with those of other single cell protein (SCP) sources. The contents of vitamins essential for animal feed were appreciable such as: (mg/kg dry cell) vitamin* B_2, *33.2; vitamin* B_{12}, *33.0; vitamin E, 50.7 and niacin, 135.8. The intracellular content of carotenoid was 0.09 mg/g dry cell.*

The bacterial cell mass was replaced for 50% (w/w dry basis) of the fish meal of the control diet and was fed to 2-month old goldfish, Carassius auratus *in moist pellet form for a 122-day feeding period. There was no mortality and no overt toxicity observed with both isonitrogenous diets. Growth of fish fed with bacterial cell-supplemented diet was significantly superior in terms of specific growth rate and percentage weight gain: the latter was increased by as much as 22.62%. The most significant enhancement was in fecundity as measured by ovary weight, and numbers of total, mature and immature eggs, which showed increase of 8.57%, 41.18%, 68.48% and 34.77% repectively. There was no effect on muscle pigmentation, while the skin pigmentation was slightly increased. The overall positive feeding effects suggest that the bacterial cell mass may be useful as a multipurpose - animal feed supplement. However, costs of production must be decreased and longer term toxicity tests need to be performed.*

Introduction

Rhodopseudomonas gelatinosa was reported by several workers to be a potential source of high quality protein and other physiologically active substances for inclusion in animal feed.[1, 2] For example, Shipman and coworkers[1] reported that the cell mass of *R. gelatinosa* grown on agricultural waste under anaerobic-light conditions contained approximately 65% crude protein consisting of amino acids comparable to those of plant and animal origins. Sasaki and coworkers[2] similarly reported that cell mass of *R. gelatinosa* and *R. gelatinosa* A1 harvested from treatment of soybean waste contained 62% and 63% of crude protein respectively, and in particular, the intracellular contents of vitamin B_{12} and carotenoid pigment were appreciable.

Recently, we cultivated *R. gelatinosa,* the only species of *Rhodopseudomonas* reported to utilize cassava starch directly[3], on cassava solid waste medium, and the cell mass was found to be highly nutritive as a potential animal feed.

The objectives of this study were to observe the nutritional values of *R. gelatinosa* as a replacement for high quality fish meal in the diet of goldfish, *Carassius auratus.* Observations were performed and evaluated in terms of effect on growth, % survival, feed utilization, fecundity including muscle and skin pigmentation.

Materials and Methods

Bacterial cell mass

The purple non-sulfur photosynthetic bacterium *Rhodopseudomonas gelatinosa* (given by Prof. H. Kitamura, Tokyo Metropolitan University) was cultivated in the cassava solid waste medium. The cassava solid waste medium composed of (g/*l* starch solution extracted from cassava solid waste) : total sugar ca. 11-12; $(NH_4)_2HPO_4$, 5.6; KH_2PO_4, 2.8; K_2HPO_4, 2.8; $CaCl_2.2H_20$, 0.3; $MgSO_4.7H_20$, 1.1; nicotinic acid, 11.25 $\times 10^{-3}$; biotin, 4.5×10^{-5}; B_1-HCl, 9.0×10^{-3}; ferric citrate, 1.4×10^{-2}; $MnSO_4.5H_2O$, 6.75×10^{-3} and $CoCl_2.6H_20$, 5.4×10^{-3}. The batch cultivation was carried out in a 2.5-l fermentor (working volume 1.5 l, MD-250 Marubishi Bioeng. Co. Ltd., Tokyo) under aerobic-dark conditions for 30h under pH range of 6.5 to 7.5, agitation speed of 500 rpm, aeration rate of 0.5 vvm and temperature of 40°C.

The cells were harvested by centrifugation of the culture broth at 12,000 rpm for 15 min, washed two times with deionized water and were used in fresh form or stored at −20°C until use.

Experimental fish

The fish used throughout the experiment was two month-old goldfish *Carassius auratus* (Linnaeus) obtained from the stock of the fresh water fish breeding company. The starting fish were graded to be as similar in size and in skin pigmentation pattern as possible.

Diet composition and preparation

The diet composition for goldfish shown in Table 1 was the complete formula of the Institute of Inland Fisheries, Ministry of Agriculture, Thailand.[4] This composition was used as the control diet.

The composition of the experimental diet, the bacterial cell supplemented diet is shown in Table 1. Fresh cells of *R. gelatinosa* was replaced for 50% w/w (dry basis) of fish meal. Proximate analyses of the two diets (Table 1) indicated that they were isonitrogenous and varied slightly only in the fat content. The composed diets were pelletized by the wet extrusion method to obtain 2-mm diameter pellets with approximately 24-27% moisture content. The pellets were air-dried for several hours and stored in freezing conditions during the experiment. The pellets of the bacterial cell supplemented diet appeared to be slightly pinkish.

Feeding experiment

For each feeding diet, 100 fish were used and divided into 5 glass-aquariums of 46×60 cm^2 (20 fish in each). The aquariums were self cleaning and fresh ground water was replaced every week. Cultivation period was 4 months (122 days). The fish was fed at 5% of their body weight and feeding intervals were two times a day. Throughout the feeding period, there was no uneaten diet observed indicating that the fish readily accepted the pellets as their food.

Analyses

Growth interpretation of the test fish were indicated in total length (head to tail length) in centimeters and body weight in grams. Each fish was weighed and measured individually every month, and the values were averaged per aquarium, and the values of three aquariums were then averaged for each group fed with different diet. Fish of two other aquariums fed with each diet were not disturbed during the 4-month cultivation, and growth was determined only at the end of the cultivation.

Fecundity of the female fish was determined at the end of cultivation. The fish was 6 months old. Ten female fish from each diet were randomly sampled and were killed. Ovaries were removed and weighed and then soaked in 6% formalin solution. The numbers of egg were counted by following the method described by Lagler[5] and were divided into two types of eggs based on size and age of maturation.

Proximate analyses of the bacterial cell and the diets were done as follows: crude protein content was estimated from total nitrogen content $\times$ 6.25 (measured by Kjeldahl procedure)[6]. Soluble carbohydrate content of the cells was determined by the method described by Norris and Ribbon[7]. Total fat was determined by ether extraction. Ash was determined by heating in a vacuum at 105°C and combustion in a muffle furnace at 600°C[8]. Moisture content was measured by drying to constant weight over a 48-hr period at 105°C.

Table 1. COMPOSITIONS AND PROXIMATE ANALYSES OF THE CONTROL DIET AND THE BACTERIAL CELL SUPPLEMENTED DIET FOR GOLDFISH.

	Control diet	Bacterial cell supplemented diet
Compositions (%)		
Fish meal	30	15
Rice bran	45	45
Peanut meal	24	24
Pre-mix (all vitamins)[a]	1	1
Fresh cells of *R. gelatinosa*	–	15
Total	100	100
Proximate analyses (g/100 g)		
Crude protein	26.96	27.09
Crude fat	1.74	1.23
Moisture	29.05	29.23
Dry matter	70.95	70.77

[a] Purchased from Better Pharma Company, Samuthprakarn, Thailand.

Table 2. PROXIMATE ANALYSES OF *R. GELATINOSA* CELL MASS COMPARED TO OTHER SCP.

Compositions (g/ 100 g dry cell)	*R. gelatinosa*	*R. gelatinosa*[2]	Esso-Nestle SCP[12] (yeast)	*Chlorella*[13] *vulgaris*	*Paecilomyces*[14] *varioti*
Crude protein	56.00	62.00	54.00	55.52	55.00
Crude fat	2.45	n	10.00	8.07	1.30
Soluble carbohydrate	26.42	n	26.00	21.04	n
Crude fiber	n	n	n	12.09	7.00
Ash	3.21	n	7.00	3.28	6.00

n = Not detected.

Amino acid compositions of the cell were determined by pretreating the fresh cells in 6 N HCl under reflux for 24 hrs. After cooling, the whole aliquot was centrifuged and the clear supernatant was analyzed for amino acid composition in an amino acid analyzer (LKB Biochrom Ltd., United Kingdom).

Carotenoid content of the cell was determined spectrophotometrically by following the method of Hirayama et al[9].

Vitamin compositions of the cell were assayed following the methods described by the Association of Vitamin Chemists[10]. The assayed vitamins were B_2, B_6, B_{12}, E, niacin and folic acid. The analyses were carried by the Laboratory of Department of Science Service, Ministry of Science, Technology and Energy, Bangkok, Thailand.

All statistical analyses were carried by the method described by Duncan[11].

Results and Discussion

Nutritional quality of the cell mass of R. gelatinosa

The proximate analyses of *R. gelatinosa* cell mass cultivated from cassava solid waste medium are shown in Table 2. The cell mass contained 56% crude protein (dry basis) which was equal to those of other SCP sources like yeast; algae and fungus. However, the protein content was slightly lower than those of *R. gelatinosa* previously reported by Shipman *et al.*[1] and Sasaki and coworkers[2]. The cell mass of *R. gelatinosa* reported by Shipman and coworkers[1] was cultivated on agricultural waste under anaerobic-light condition and the protein content obtained was 65%. The cell mass of *R. gelatinosa* and *R. gelatinosa* Al reported by Sasaki *et al.* contained 62 and 63% protein respectively and were cultivated on soybean waste medium under aerobic-dark condition. It thus appears that the protein content of photosynthetic bacteria is partly affected by the culture condition and medium composition.

Analysis of amino acid composition of the protein from *R. gelatinosa* is shown in Table 3. The pattern was comparable to those of other SCP sources. And in particular, the contents of lysine (3.04% dry basis), methionine (1.92% dry basis), leucine (5.84% dry basis) and phenylalanine (3.08% dry basis) which were four essential amino acids were remarkable appeared to be quite high in comparison to those of other SCP and soybean protein[2]. Similar results were previously reported by Sasaki *et al.*[2] with *R. gelatinosa* and *R. gelatinosa* Al and Noparatnaraporn *et al.*[3] with *R. sphaeroides* P47. It was clear that the methionine content of *Rhodopseudomonas* spp. was much higher than that of other SCP and plant derived protein such as soybean. Since methionine was one of the limiting essential amino acids in feedstuff, the cell mass of *R. gelatinosa* may be useful to fulfil the essential amino acid requirement of feeding animals and to lower the raw material cost of the feed. However, *R. gelatinosa* cell mass should be recommended as a supplement to the basic diet for feeding animals rather than as the sole source of protein based on the scoring pattern of FAO and WHO.

Table 3. CELLULAR AMINO ACID COMPOSITIONS OF *R. GELATINOSA* COMPARED TO OTHER SCP.

Amino acid composition (g/100 g dry basis)	*R. gelatinosa*	*R. capsulata*[12]	Esso-Nestle SCP[12] (yeast)	*Chlorella*[13] *vulgaris*	FAO/WHO[15] scoring pattern[b]
Lysine[a]	3.04	2.86	3.76	2.71	5.5
Histidine[a]	1.15	1.25	0.90	1.06	
Threonine[a]	2.04	2.70	2.63	2.28	4.0
Valine[a]	3.44	3.51	3.20	3.02	5.0
Methionine[a]	1.92	1.58	0.51	0.27	1.9
Isoleucine[a]	2.73	2.64	2.63	2.44	4.0
Leucine[a]	5.84	4.50	3.54	4.46	7.0
Phenylalanine[a]	3.08	2.60	2.20	2.65	3.0
Arginine	3.42	3.34		3.24	
Aspartic acid	4.92	4.56		4.74	
Serine	2.10	1.68		2.12	
Glutamic acid	5.84	5.34		4.62	
Proline	2.40	2.80		2.12	
Glycine	2.58	2.41		2.28	
Alanine	4.45	4.65		2.98	
Tyrosine	1.50	1.71		0.96	
Ammonia	3.05	4.01		2.58	3.0

[a] Essential amino acids.

[b] Each value was expressed as g/16 g N.

Besides, the high protein content with balanced essential amino acids, the cell mass of *R. gelatinosa* cultivated on cassava solid waste also contained considerable amounts of several vitamins necessary for feeding animals. Results shown in Table 4 indicated that the cells were rich in vitamin B_2 (33.2 mg/kg dry cell), B_{12} (33 mg/kg dry cell), E (50.7 mg/kg dry cell) and niacin (135.8 mg/kg dry cell). It is noticeable that all three vitamins essential for animal feedstuff (B_{12}, E and niacin) were contained in the cell mass of *R. gelatinosa* in appreciable amounts even though the content of vitamin E was lower than that of *R. sphaeroides* P47 reported by our group[16]

Table 4. VITAMIN AND PIGMENT CONTENTS OF THE CELLS OF *R. GELATINOSA* COMPARED TO OTHER SCP.

	R. gelatinosa	*R. Sphaeroides*[16]	*R. capsulata*[12]	Esso-Nestle SCP[12] (yeast)	*Spirulina*[15]
Vitamin (mg/kg dry cell)					
Thiamine (B_1)	n	n	12	11-13	27.8
Riboflavin (B_2)	33.20	13.0	50	110-130	33.4
Biotin (B_6)	8.28	6.3	65	0.1-1.6	0.06
Cobalamin (B_{12})	33.00	78.85	21	0.11-0.17	2.4
Tocopherol (E)	50.70	210.1			
Niacin	135.80	5.8	125	165-200	
Folic acid	7.24	1.0	60	1.8-2.4	
Pantothenic acid	n	n	30	14-23	
Pyridoxine	n	n	5	4.8-7.6	1.32
Carotenoid pigment (mg/g dry cell)	0.09	0.68			0.5[a]

n = Not analyzed.
a = β-carotene.

In addition, the cells also contained carotenoid (0.094 mg/g dry cell) which is considered to have various biologically important effects on feeding animals.[17] The most important function of carotenoid in aquaculture was recently reported[19] to be to increase the viability and lower the mortality of teleost eggs. Based on the nutritional quality shown in Table 2, 3, 4, the cell mass of *R. gelatinosa* showed a good potential for use as a multipurpose feed supplement for animal feedstuff industry.

Effect on growth, % survival and feed utilization of goldfish

Results of the effects of experimental diets on growth, survival and feed utilization of goldfish starting from 2-month of age are shown in Table 5. There were no mortalities during the 122-day trial indicating that the bacterial cell supplemented diet was readily accepted and utilized, and showed no overt toxicity to the test fish. Growth of the fish fed with bacteria-supplemented diet was found to be superior than that of the control group in terms of percentage weight gain and specific growth rate. The percentage weight gain of the two test groups with different growth determination method (A and B group) were 419.71 and 441.41; this was significantly different from the 355.59 and 349.12 found in the control groups ($P < .05$). The specific growth rates of the two groups fed with bacterial cell-supplemented diet (11.70 and 12.39% per day) were significantly different ($P < .05$) from those of the two groups fed with control diet (9.91 and 9.73%/day). The outcome of growth yielded in an average increase in weight

Table 5. SUMMARY OF GROWTH, % SURVIVAL AND FEED UTILIZATION OF GOLDFISH, *CARASSIUS AURATUS* (2-MONTH OLD) FED WITH CONTROL DIET AND BACTERIAL CELL SUPPLEMENTED DIET FOR 122 DAYS (MARCH TO JUNE).

Mean values	Control diet					Bacterial supplemented diet				
	A	SE	B	SE	Average	A	SE	B	SE	Average
Total number of fish	60		40			60		40		
Initial body weight (g)	3.40	0.152	3.40	0.150	3.40	3.40	0.151	3.40	0.152	3.40
Initial total length (cm)	3.58	0.076	3.58	0.074	3.58	3.58	0.075	3.58	0.076	3.58
Final body weight (g)	15.49	1.482	15.27	1.138	15.38	17.67	2.120	18.51	1.559	18.09
Final total length (cm)	5.30	0.182	5.25	0.155	5.28	5.43	0.239	5.49	0.161	5.46
Weight gain (%)	335.59		349.12		352.36	419.17		444.41		432.06
Weight gain (mg/day)	99.10		97.30		98.20	116.97		123.85		120.41
Feed consumption (mg/day)[a]	364.75		364.75		364.75	395.88		395.88		395.88
Feed conversion ratio (mg/mg)[b]	3.68		3.75		3.72	3.38		3.20		3.29
Specific growth rate (%/day)[c]	9.91		9.73		9.82	11.70		12.39		12.05
Survival (%)	100		100		100	100		100		100
Increase in weight gain (%) = 22.62										

A : Growth was determined monthly
B : Growth was determined only at the end of the 122 day-cultivation
a : Averaged from monthly feed intake basing on 5% of body weight
b : Calculated from feed consumption/weight gain.
c : Calculated from (weight gained/60 days) × 100.
SE : Standard error.

gain of 22.62%.The experimental data show that the cell mass of *R. gelatinosa* was not only effectively utilized as a protein supplement to replace 50% of the fish meal but also enhanced the growth rate and accelerated the increase in body weight. Since the control diet and the bacterial cell supplemented diet were isonitrogenous (27% crude protein), it might be suggested that the increase in weight gain was an effect of the presence of some growth stimulatory substances in the cell mass of *R. gelatinosa*. The analyses of various vitamin contents of the bacterial cell mass (Table 4)supported this assumption. Similarly, Kobayashi and Kurata[13] observed the growth stimulatory effect of photosynthetic bacterial cell mass on test animals and they proposed that this might be an effect of some growth stimulatory hormone or hormone-like substances contained in the cells. In addition, the average feed conversion ratio of the fish fed with bacteria supplemented diet was slightly improved compared to that of the control group (3.29 compared to 3.72).

Effect on fecundity

The effects of diet on fecundity of goldfish were studied in the female fish before the first ovulation in terms of ovary weight, total numbers of eggs including mature-large and immature-small oocytes. Since the important factors related to the fecundity of fish of the same age include total length and nutrition, fish with the same total length were fed with different diets as a comparison. Results shown in Table 6 indicate that the total numbers of egg and the ovary weight of fish fed with the bacterial cell supplemented diet were much higher than those of fish fed with the control diet at the same total length. It is interesting to note that even in the case of fish with lower total length, the number of total, mature and immature eggs were also increased, particularly the numbers of mature eggs. Analysis of the results obtained in Table 6 shown in Table 7 revealed that the percentage increases in fecundity of fish fed with bacterial cell supplemented diet in terms of ovary weight was 8.57; for total number of eggs was 41.18; for immature and small eggs was 34.77 and the highest increase, in the mature eggs, was 68.48%. Moreover, the gonadosomatic index (GSI) increased from 13.60% of the control diet to 17.16%

The experimental data clearly indicated the high effect of *R. gelatinosa* cell mass on fecundity of goldfish, *Carassius auratus*. This result strongly supported the similar effects on red *Tilapia* fed with *R. sphaeroides* P47 supplemented diet previously reported by our group as well as the similar effects observed in egg-laying hens by Kobayashi and Kurata[13]. The cellular content of vitamin E in *R. gelatinosa* (50.70 mg/kg dry cell) might be one of the stimulatory substances. However, it was also reported by Van Der Kraak *et al.*[18] that LH-RH and gonadotropin (GTH) were the two important hormones in acceleration of oocyte maturation and ovulation of salmon. However, based on the present data, it is not possible to conclude the stimulatory source of fecundity enhancement and many interesting points remain to be studied in more detail.

Table 6. COMPARISONS OF FECUNDITY OF 6-MONTH OLD FEMALE GOLDFISH, *CARASSIUS AURATUS* FED WITH CONTROL DIET AND BACTERIAL CELL SUPPLEMENTED DIET

		Control diet						Bacterial cell supplemented diet					
	Length (cm)	Body wt (g)	Ovary wt (g)	GSI (%)	Number of eggs			Body wt (g)	Ovary wt (g)	GSI (%)	Number of eggs		
					M	IM	Total				M	IM	Total
	4.3	10.0	1.77	17.70	1050	5560	6610						
	4.3	10.0	2.06	20.60	1200	5870	7070						
	4.5							10.0	2.66	26.60	1550	4680	6230
	4.6							5.0	0.98	19.60	·670	4770	5440
	4.6							10.0	1.67	16.70	1760	5590	7350
	4.8							10.0	1.34	13.40	1214	3870	5084
	4.9							10.0	2.33	23.30	3700	5730	9430
	5.0	10.0	1.24	12.40	500	5780	6280	10.0	1.32	13.20	1650	5520	7170
	5.0	10.0	1.32	13.20	810	3070	3880	10.0	2.30	23.00	2010	6500	8510
	5.1	15.0	1.69	11.27	910	1840	2750						
	5.2	10.0	1.58	15.80	890	3060	3950						
	5.3	12.5	1.91	15.28	1030	4340	5370	15.0	2.29	15.27	1630	6500	8130
	5.4							20.0	2.19	10.95	860	8130	8990
	5.5							20.0	1.91	9.55	1680	5690	7370
	5.8	20.0	2.59	12.95	1100	1530	2630						
	7.0	15.0	1.74	11.60	1730	5600	7330						
	7.5	30.0	1.56	5.20	710	5630	6340						
Range min	4.3	10.0	1.24	5.20	500	1530	2630	5.0	0.98	9.55	670	3870	5084
max	7.5	30.0	2.59	20.60	1730	5870	7330	20.0	2.66	26.60	3700	8130	9430
Median		20.0	1.92	12.90	1115	3700	4980	12.5	1.82	18.08	2185	6000	7257
Mean		14.25	1.75	13.60	993	4228	5221	12.0	1.90	17.16	1673	5698	7371

M : Mature and large eggs; IM : Immature and small eggs.

GSI : Gonadosomatic Index $= \frac{\text{Ovary wt}}{\text{Body wt}} \times 100\%$.

Effect on muscle and skin pigmentation

The carotenoid content of *R. gelatinosa* cell mass was 0.09 mg/g dry cell which was not as high as that of *R. sphaeroides* P47 previously reported (0.68 mg/g dry cell). As a result, the effect of carotenoid incorporation into muscle pigment could not be observed in the goldfish after 122-day cultivation. However, the color of fish skin from bacteria diet was slightly intensified, particularly in the shade of orange and red and in addition the skin appeared more shiny.

Table 7. ANALYSIS OF PERCENTAGE INCREASES IN FECUNDITY OF GOLDFISH FED WITH BACTERIAL CELL SUPPLEMENTED DIET

Parameters \ Mean Values	Control diet	Bacterial supplemented diet	% Increase
Ovary weight (g)	1.75	1.90	8.57
Total egg numbers	5221	7371	41.18
Mature and large eggs	993	1673	68.48
Immature and small eggs	4228	5698	34.77

Potential application of R. gelatinosa *cell mass in animal feed industry.*

The experimental results suggest that the cell mass of *R. gelatinosa* cultivated on cassava solid waste under aerobic-dark condition can be multiple supplement purpose in feeding animals. Fresh cells can be used to replace up to 50% of fish meal without causing overt toxicity or abnormality, and were accepted and utilized efficiently by the test fish. The results clearly indicated that supplementation of the bacterial cell mass to goldfish not only increased the specific growth rate, feed conversion ratio but also the percentage weight gain. Most strikingly, the fecundity of the test fish was also enhanced.

The potential application of the mixed diet also depends on the production cost of the cell mass. From our preliminary estimates, the raw material cost and manufacturing cost for 1 kg dry cell of *R. gelatinosa* from cassava solid waste medium might be about 250 baht (approx. 9.60 US $) and 680 baht (approx. 26 US $) respectively. However, since the cost of fish meal is only 11-12 baht/kg, the use of the bacterial cell mass as a multipurpose-animal feed supplement to raise the productivity and efficiency of young animals and to improve breeding stocks depends on reducing the production costs of the cell mass. We are exploring ways to achieve this. Moreover, longer term experiments need to be conducted to determine whether this supplementation causes any direct acute or delayed toxicity to the fish themselves or to animals consuming bacteria - supplemented fish.

Acknowledgements

The authors would like to express our sincere thanks to the Government of Australia for the financial support through ASEAN Project on Management and Utilization of Food Waste Materials (1980-88), to Prof. S. Nagai, Hiroshima University, Japan and Prof. Prasert Sitasithi, Institute of Inland Fisheries, Ministry of Agriculture, Bangkok, Thailand, for their valuable comments in preparation of this manuscript. This work was a part of the cooperative research between the JSPS and the NRCT under the Ph.D. Dissertation Programme (RONPAKU).

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บทคัดย่อ

เซลของ *R. gelatinosa* ซึ่งเลี้ยงในอาหารกากมันสำปะหลังภายใต้สภาพมีอากาศไร้แสง ประกอบด้วย โปรตีน 56%, ไขมัน 2.45%, คาร์โบไฮเดรต 26.42%, และเถ้า 3.21% โปรตีนดังกล่าวประกอบด้วยกรดอะมิโน จำเป็นหลายชนิด เช่น เมธิโอนิน, ไลซีน ลูซีน และเฟนนิลอลานีน ในปริมาณสูงเมื่อเทียบกับแหล่งโปรตีนเซลเดียวอื่น ๆ นอกจากนี้ยังอุดมด้วยวิตามินที่จำเป็นต่ออาหารสัตว์ เช่น วิตามินบี 2, 33.2; บี 12, 33; อี, 50.7 และไนอาซีน, 135.8 มิลลิกรัมต่อกิโลกรัมเซลแห้ง รวมทั้งสารคาร์โรทีนในเซลอีก 0.09 มิลลิกรัม ต่อกรัมเซลแห้ง

การทดลองใช้เซลสดของแบคทีเรียนี้แทนที่ปลาป่น 50% โดยน้ำหนักแห้งในสูตรอาหารเลี้ยงปลาทอง *(Carassius auratus)* โดยปรับให้อาหารผสมเซลและอาหารเปรียบเทียบมีปริมาณโปรตีนเท่ากันในการเลี้ยงปลาอายุ 2 เดือน เป็นเวลานาน 122 วัน ผลการทดลองพบว่าอาหารทั้ง 2 ชนิดไม่เป็นพิษและไม่พบการตายเลย การเจริญของปลาที่เลี้ยงด้วยอาหารผสมเซลดีกว่าทั้งในด้านอัตราการเจริญและเปอร์เซ็นต์การเพิ่มของน้ำหนักปลาเฉลี่ยต่อตัวต่อวัน ซึ่งพบว่าอัตราการเพิ่มน้ำหนักของปลาที่เลี้ยงด้วยอาหารผสมมีมากกว่า 22.62% นอกจากนี้ ยังพบว่า น้ำหนักรังไข่ จำนวนไข่ทั้งหมด จำนวนไข่ใบใหญ่และแก่ ตลอดจนจำนวนไข่ใบเล็กและอ่อนของปลาที่เลี้ยงด้วยอาหารผสมเพิ่มขึ้นมากถึง 8.57%, 41.18%, 68.48% และ 34.77% ตามลำดับ สีผิวของปลาเพิ่มขึ้นเล็กน้อย แต่สีเนื้อไม่มีการเปลี่ยนแปลง ผลการทดลองทั้งหมดชี้ให้เห็นถึงศักยภาพในการประยุกต์ใช้เซลแบคทีเรียนี้เป็นอาหารเสริมอเนกประสงค์ในปลา แต่อย่างไรก็ดี ยังคงต้องมีการทดลองเพิ่มเติม เพื่อศึกษาความเป็นพิษของอาหารเสริมนี้ และเพื่อหาวิธีการลดต้นทุนในการผลิตเซลของแบคทีเรียด้วย