A C T A A L I M E N T A R I A P O L O N I C A

Vol. IV (XXVIII), No. 1 1978

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COMPOSITION AND FUNCTIONAL PROPERTIES OF SCP FROM MIXED CULTURES OF YEASTS GROWN ON N-PARAFFIN COMPARED WITH THOSE OF SOME COMMERCIAL SCP SAMPLES *

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Key words: SCP, Candida lipolytica, Candida tropicalis, n-paraffin.

The composition and functional properties of SCP obtained from mixed cultures *Candida lipolytica* and *Candida tropicalis* grown on n-paraffin medium was compared with samples obtained form different firms in the United States and Japan. It was found that SCP from mixed cultures did not differ significantly in its chemical composition from other samples, however, its functional characteristics did not make it possible to apply them in the food industry. SCP from mixed cultures grown on n-paraffin medium can be used as fodder.

INTRODUCTION

The present level of technology enables production of SCP on the basis of various sources of carbon in the medium without much difficulty. Almost every raw material containing either carbohydrates or hydrocarbons can be processed into microbial protein by specially selected microorganisms and a proper technological process. In the professional literature one can find a multitude of publications and patents dealing with this subject [8]. The direct application of manufactured SCP in the human diet faces many obstacles. High level of nucleic acids, the difficulty to digest cell walls, and the poor acceptability by consumers are the main factors limiting the use of this product for human consumption. On the other hand, the economical aspects, as well as the high nutritional value due to the high level of protein, call for the widening of the scope of research in order to increase the application of SCP.

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The present economic situation has restricted the production of SCP from hydrocarbons in countries where the crude oil is expensive. This does not limit, however, the immense possibilities of producing microbial protein on hydrocarbon substrates. For this reason basic papers concerning this problem continue to be frequently published in scientific literature [9, 15]. Investigations dealing with 3,4-benzophyrene, substance of carcinogenic properties, show that in many food products, mainly in smoked ones, it occurs in considerably higher amounts than in SCP from hydrocarbons [12].

Various authors deal also very often with the problem of functionality of SCP. There is a growing need for comparative studies of this problem. This kind of research should contribute to a broader and more rational application of this valuable source of protein in the food industry. The results presented below, refer to the functionality of American and Japanese samples obtained from different raw materials compared with SCP from mixed cultures grown on the n-paraffin medium [1].

The objective of this work was to determine the functional characteristics of the analysed samples as well as to suggest the most efficient use of SCP in the food or feed industry.

MATERIALS AND METHODS

MATERIALS

Six powdery Single Cell Protein (SCP) samples obtained from various American and Japanese companies, available on the American market in 1974, were used for analysis. One sample was declared by the producer for feed, one for food, the others were not specified. Sample number 7 was taken from own experimental mixed cultures *Candida lipolytica* and *Candida tropicalis* grown on the n-paraffin medium [1]. The comparison of this sample with those designed for food and fodder purposes allowed to evaluate it better and assign to its proper usage. Soy protein isolate Supro 350, Ralston Purina Co., St. Louis, Mo., USA, was used for comparison of the functional properties.

METHODS

Methods described by Kosikowski [10] were adopted for the determination of total solids, pH and soluble protein.

The total protein content was calculated from the amount of nitrogen multiplied by 6.25 where the nitrogen content was determined by the Kjeldahl method [2].

Ash was determined according to the AOAC method [2]. Solubility of SCP in water was assayed by Cone and Ashworth [5] method. The fat

determination was made according to the method described by Meloan and Pomeranz [13].

Amino acids analyses were conducted on a Beckman Model 120 C amino acid analyzer (Beckman Instruments, Palo Alto, Cal., USA). The determination of tryptophan in SCP was made separately using the procedure of Speies and Chambers [18, 19].

Before analysing the total amount of nucleic acids, the samples were prepared using homogenization and purification according to Schneider [17]. They were determined according to the method recommended by PAG (Protein Advisory Group UN) and reported by Munro and Fleck [14].

The extraction of protein from SCP samples was made according to Huang and Rha [6] by using 0.05 n NaOH solution. The extracted protein was freeze-dried to confirm storage and testing stability. The freeze-dried protein isolate from SCP samples was used in the next experiments. Emulsifying properties (expressed by the emulsifying activity) and the emulsion stability were determined by methods described by Yasumatsu et al. [21].

The surface tension was determined in 5% SCP protein isolate solution in distilled water. Roller-Smith Balance with a Wilhelmy Plate Tensiometer (Biolar Corp., Northgrafon, Mass., USA) was used. The results were calculated as follows:

$$\gamma = \frac{F \times 0.98}{W}$$

$$\gamma = \frac{F \times 0.98}{5} = 0.196 \times F$$

where γ — surface tension in dynes/cm
F — force in Mg
W — perimeter of plate (5 cm)

RESULTS AND DISCUSSION

1. CHEMICAL ANALYSIS

The results of the chemical analysis of SCP samples are shown in Table I. The pH of the SCP samples in 6% water solution was contained within the limits of pH 5.15-6.30. The water content ranged from 4.42 to 6.93 percent.

The total protein content, calculated by the Kjeldahl method was 49.27-57.68 percent, which represented a fairly high nutritional value both for food and as for feed purposes. Particularly valuable were samples No. 1 and 3, where the protein content was about 57%. Yeasts obtained from own cultivation (sample 7) contained 49,5% protein which

was only 3-5% less than in samples No. 2,5 and 6. For the sake of comparison, we may note that the protein content in SCP produced from n-paraffins by BP Protein Ltd. was 63%, calculated with regard to dry substance [3].

The soluble protein content for different samples ranged from 6.68 to 20.51 percent. A higher content of soluble parts is important in extracting proteins from cells. The amount of soluble protein in the sample from own cultivation was the second greaters from all investigated samples.

Table 1. Chemical analysis of SCP samples

Number of SCP Samples	Trade name	pH in 6 % H_2O solution	Moisture %	Total protein (N × 6,25) %	Soluble protein %	Solubility in water %	Ash %	Fat %
1	Viton (Japan)	5.51	4.50	57.46	11.51	23.89	9.996	0.13
2	Kanepron (Japan)	5.68	5.91	55.82	8.79	21.19	11.02	1.49
3	Food wheast (Knudsen-USA)	5.55	6.12	57.68	9.67	14.83	7.45	1.18
4	Food wheast (Knudsen-USA)	5.15	6.93	49.27	10.51	46.05	22.11	0.063
5	Fragilis yeast (Knudsen-USA)	5.55	4.42	52.52	9.98	19.84	7.46	1.21
6	Sulphate liquor yeasts (USA)	6.30	5.01	54.07	6.68	18.95	6.43	0.023
7	Yeast from n-paraffin (Achremowicz et al.)	5.27	5.38	49.50	12.13	24.27	8.74	1.34

Solubility in water allows to define more exactly the characteristics of individual samples of SCP. Beside proteins, the solubility index is influenced by soluble organic and mineral substances. Solubility in water varied from 14.83 to 46.05 percent, the latter value being far removed from other values obtained. The majority of SCP samples show a solubility index of around 20%. The result obtained for sample No. 4, which was strikingly different from other results, was probably caused by the high content of minerals in the sample (22.11%). Sample No. 4 represented the product designed for feedstuff use, enriched by mineral salts addition.

The fat content in SCP samples was relatively low, 0.02-1.34% and did not perceptibly contribute to the nutritional value of the samples.

Amino acids content in SCP samples is one of the most important characteristics of the biological protein value. The average amino acids

content of SCP is given in Table 2. The SCP samples were defficient in sulphur amino acids, and rich in acidic amino acids. A comparison of essential amino acids of SCP protein with FAO standard and other publications [20], revealed that the SCP proteins should be made nutritionally adequate by supplementation of the lacking amino acids.

Table 2. Contents of amino acids, g/16 g nitrogen

	Number of sample						
	1	2	3	4	5	6	7
	contents of amino acids						
Alanine	6.13	6.94	8.29	5.30	7.17	6.47	5.60
Arginine	4.70	5.37	5.06	3.71	5.59	4.98	4.98
Aspartic Acid	12.62	10.96	11.39	9.80	11.27	8.52	8.43
Glutamic Acid	18.62	15.99	18.11	15.68	18.87	14.84	16.74
Glycine	5.56	5.72	4.62	3.44	5.38	4.51	4.07
Half Cystine	trace	0.74	1.36	1.72	1.41	1.05	1.05
Histidine	1.80	2.56	2.14	2.08	2.39	2.01	1.83
Isoleucine	5.71	5.67	5.61	5.56	6.25	4.64	4.40
Leucine	7.94	8.34	10.18	8.71	8.71	7.19	5.98
Lysine	7.42	8.34	9.85	8.65	10.72	7.15	6.37
Methionine	1.40	1.55	2.19	1.87	1.67	1.21	1.06
Phenylalanine	4.39	4.53	4.61	3.81	4.82	4.02	3.33
Proline	3.71	4.11	4.60	4.15	4.49	3.22	2.99
Serine	3.55	3.56	3.46	3.34	4.03	4.44	4.62
Theronine	4.64	4.95	4.69	4.18	4.81	4.77	5.18
Tryptophan	1.11	1.13	1.32	1.64	1.40	1.20	1.27
Tyrosine	3.92	3.78	4.31	3.62	4.17	3.52	3.14
Valine	5.82	6.42	6.41	5.29	6.62	5.26	4.56

The total content of nucleic acids in the analyzed SCP samples ranged on the average from 7.09 to 9.28 percent calculated on the cell dry weight (Fig. 1). These results are in accordance with the data published by other

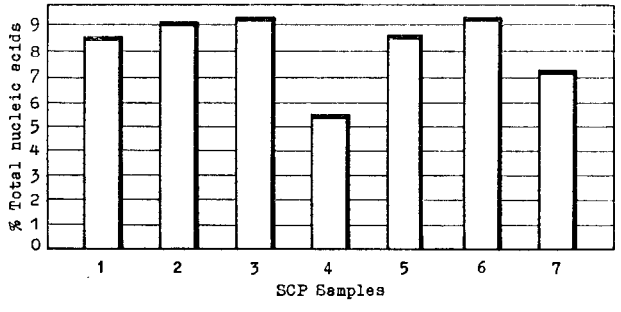

Fig. 1. Total nucleic acids content in SCP samples based on cell dry weight

authors [4, 7]. The lower amount of nucleic acids in the fodder yeast samples produced in Polish factories was observed by Prończuk [16]. The examined yeasts contained nucleic acids from 5.18 to 5.46 g/100 g of dry substance. In our work only sample no. 4 had a total nucleic acids content of 5.36 percent. The lower content of nucleic acids was probably due to the way in which this SCP type was produced. It was designed as feedstuff and was evidenced by the addition of other, supplementary nutritive components.

2. EXTRACTION OF PROTEINS

The extraction of proteins from SCP samples was performed with the use of an 0.05 n solution of NaOH. Although an application of a stronger concentration of NaOH can result in a higher degree of extraction, the technological value of samples obtained would be lower due to the undesirable influences of the alkaline solution. The extracted proteins were freeze-dried. The highest degree of extraction — above 25 percent was obtained from samples No. 3, 5 and 7 (Fig. 2). Samples No. 1, 2

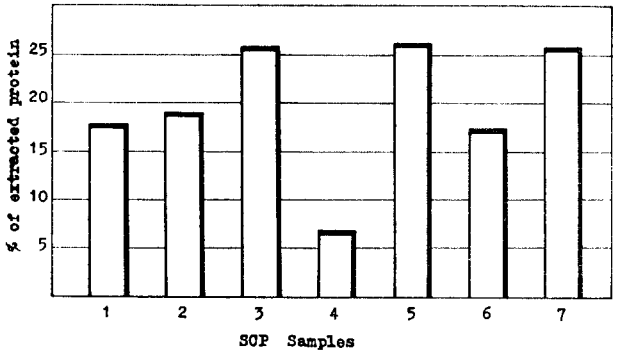

Fig. 2. Percent of extracted protein from SCP samples

and 6 showed similar and lower characteristics in their suitability for the extraction of proteins. The percentage of extracted proteins for these samples was about 17%. Sample No. 4 represents material which has practically no extraction value and for this reason investigation of this sample was discontinued. The results obtained by other authors show extraction of protein from SCP with the use of 0.05 n NaOH amounting to 25 percent [6].

3. FUNCTIONALITY OF PROTEIN EXTRACTED FROM SCP

Emulsifying properties of protein solution are important for the food industry. Because of its appropriate emulsifying capacity the addition of the SCP protein extract could be used in meat products instead of soy

protein. These possibilities should be checked by appropriate investigations on the emulsifying properties of protein extracts from SCP as was done with the soy protein preparations [11].

The emulsifying properties of SCP protein isolates are shown in Table 3. The soy isolate was used for comparison. Only the samples No. 1 and 2 had good emulsifying properties close to soy isolate. They can be used for the production of emulsified food products like meat products or mayonnaise or can be added to other products for enrichment in protein.

Table 3. Emulsifying properties of protein isolates from SCP samples

Sample No.	Emulsifying activity %	Emulsifying stability %
1	57.95	50.42
2	46.99	37.75
3	15.88	10.90
4	—	—
5	15.88	10.26
6	15.56	8.13
7	16.10	14.44
Soy protein isolate	49.73	45.38

Then, the surface tension of the water solutions of extracted proteins was analysed. All SCP protein isolates had lower surface tension than pure water (Tab. 4). This agrees with the fact that proteins in solution reduce the surface tension of water. The reduction of surface tension

Table 4. Comparison of surface tension of SCP protein isolates with soy protein isolate and distillated water

Sample No.	Surface tension dynes/cm
1	53.47
2	53.01
3	54.00
4	—
5	53.52
6	52.98
7	53.91
Soy protein isolate	52.60
Water	68.15

aids in the formation of foam. The protein isolates from samples No. 2 and 6 had respectively 53.01 and 52.98 dynes/cm surface tension. Soy isolate exerted lower surface tension than all the investigated SCP protein isolates.

CONCLUSIONS

1. The SCP from mixed cultures *Candida lipolytica* and *Candida tropicalis* grown on the n-paraffin medium did not differ essentialy in its chemical composition from SCP produced commercially by different firms in the United States and Japan. As a result of the alkaline extraction of SCP from mixed cultures a 25 percent protein was extracted.

2. Unfavourable functional characteristics, especially emulsifying properties of the protein extracted from mixed cultures make it useless for food applications.

3. On the basis of carried out investigations it can be assumed that the SCP from mixed cultures grown on the n-paraffin medium could be used as a fodder.

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Manuscript received: January 1977
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SKŁAD I WŁAŚCIWOŚCI FUNKCJONALNE BIAŁKA DROBNOUSTROJÓW Z ŁĄCZNYCH HODOWLI DROŻDŻY NA PODŁOŻU N-PARAFIN W PORÓWNANIU Z CHARAKTERYSTYKĄ BIAŁKA DROBNOUSTROJÓW PRODUKOWANYCH PRZEMYSŁOWO

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Streszczenie

Porównano skład chemiczny i niektóre cechy użytkowe białka drobnoustrojów otrzymanego z łącznych hodowli *Candida lipolytica* i *Candida tropicalis* prowadzonych na podłożu zawierającym n-parafiny z próbkami białka drobnoustrojów wyprodukowanych przemysłowo przez kilka firm USA i Japonii. Stwierdzono, że próbka otrzymana z hodowli łącznych nie różniła się istotnie swoim składem chemicznym od próbek pochodzących z produkcji przemysłowej. Białko badanych próbek odznaczało się niską zawartością aminokwasów siarkowych przy jednoczesnej wysokiej zawartości aminokwasów kwaśnych. Ogólna zawartość kwasów nukleinowych w badanych próbkach kształtowała się średnio w granicach 7,09 do 9,28% w stosunku do suchej masy komórek.

Analizując cechy użytkowe badanych próbek przeprowadzono ekstrakcję białka z komórek drobnoustrojów przy użyciu 0,05 n NaOH. Najwyższa wydajność ekstrakcji wynosiła 25% białka. W wodnych roztworach wyekstrahowanego białka badano właściwości emulgacyjne ekstraktów białka. Uzyskana z mieszanych hodowli próbka wykazała niskie zdolności emulgacyjne, natomiast dwie spośród handlowych próbek porównawczych wykazały bardzo dobre właściwości emulgacyjne zbliżone do izolatu białka soi.

Z powyższych względów białko drobnoustrojów otrzymane z hodowli łącznych na n-parafinach nie wykazało możliwości zastosowania w produkcji żywności, istnieje natomiast możliwość przeznaczenia go na cele paszowe.