THE NUTRITIVE VALUE OF YEAST *SACCHAROMYCES CEREVISIAE* ENRICHED IN COPPER, IRON AND MANGANESE

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SUMMARY

Dietary yeast enriched in bioelements like Cu, Fe and Mn was produced on the basis of *Saccharomyces cerevisiae* and whey. Optimal conditions of incubation, temperature and the concentrations of whey, salts (cupric acetate, manganic sulfate and ferric sulfate) were determined. The content of proteins, fat, fibre, ash and the concentrations of macroelements and 47 trace elements were determined in dry matter of copper, iron and manganese yeast. Moreover, the content of bacteria and fungi in yeast were examined after 3 months of their storage. There were very effective bioavailability of Cu and Mn both for young fatteners and laying hens.

Keywords: *Saccharomyces cerevisiae*, dietary yeast, nutritive value, copper, iron, manganese

INTRODUCTION

From the beginning of the last century, yeast has been used in animal feeding as a rich source of well digested protein as well as vitamin B and some important bioelements. The significance of yeast, as a feed additive for farm animals, rapidly increase when the use of animal meals and also antibiotics were strictly forbidden. Active dry yeasts (95% of dry matter), living yeast culture in the form of prebiotics or products of yeast origin are often used [2,7]. The bakery yeast, *Saccharomyces cerevisiae*, are produced on industrial scale from molasses but also from whey and from waste of starch, fat and other organic raw materials. Many scientific researches proves, that it is possible to enrich yeast in macroelements or even trace elements, that could be useful in reduction or even in elimination of mineral premixes (inorganic form of elements) from animal feeding [3,10,11,14].

The waste-free technology production of dietary yeast enriched in selenium, zinc and chromium was elaborated in Poland in last years. In defined incubation conditions it is possible to enrich yeast in many bio elements [4,12].

The aim of this work was to estimate the chemical composition of yeast *Saccharomyces cerevisiae* enriched in Cu, Fe and Mn as well as their nutritive value, especially taking into consideration the content of macro and micro elements.

MATERIALS AND METHODS

Detailed description of the investigated yeast production method was presented in previous publication [5] and patented in Patent Office RP.

The samples of the yeast Saccharomyces cerevisiae enriched in copper (Y-Cu), iron (Y-Fe) and manganese (Y-Mn) were analyzed to determine:

- the content of water, crude protein, crude fat, crude ash, crude fibre – with the use of the generally accepted procedures [1],
- the content of amino acids – with the use of the automatic amino acids analyser AAA-400 (Ingos – Czech Republic),
- the content of the micro and macroelements – with the use of mass spectrometry with inductively coupled plasma (ICP-MS) by instrument Varian UltraMass-700 (prod. Australia)[8],

the content of bacteria and fungi in the fresh yeast and after 3 months of storage in room temperature – according to polish norms (PN-R-64791 and PN-ISO-7954).

Statistical assessment of the results was performed with the use of "Statistica for Windows 5.1" (StatSoft Inc. 1997).

RESULTS AND DISCUSSION

The composition of the examined yeast Y-Cu, Y-Fe and Y-Mn generally meet the requirements defined in PN-81/A-79006 or described by Smulikowska and Rutkowski [13], only the content of crude protein and crude ash were lower than in standards (tab.1). Whereas the amino acids composition was different from the standards but it was easy to explain when we consider the differences in yeast's technology production. The highest concentrations of amino acids were determined for aspartic acid, glutamic acid, lysine and the lowest for cysteine and methionine (tab. 2). Taking into consideration the physiology of digestion, the highest lysine content was a very good result, because this essential amino acid is limiting the value and quality of protein in animal feeding [9].

The microbiological tests of examined yeast showed very low contamination, the content of micro organisms were below the limits defined in the standards (PN-R-64791). The content of bacteria (aerobic mesophiles) were between 2×10^2 and $3{,}4 \times 10^3$ cfu/g in the fresh material and between 3×10^3 and $4{,}4 \times 10^5$ cfu/g in the material after storage in the room temperature (3 months). The fungi were not detected both in the fresh material and in the yeast after storage.

The table 3 presents that the dominant macroelements were phosphorus and magnesium and the lowest concentration was found for sodium. Total concentration of macroelements was the highest for Y-Fe and the lowest for Y-Cu.

The content of the most important microelements in the examined yeast show tables 1 and 4. The highest concentrations were determined for Fe, Mn and Cu (maximal ca. 2%), that proves that the use of the enriched yeast for the premix production or for the production of biopreparations (supplements of diet) could be very good opportunity. The highest concentrations, except for Fe, Mn and Cu, were detected for zinc (ca. 200 mg/kg), silicon, boron, aluminium and rubidium. The concentrations of Cr, Se, Co, Cs, Ga, Ge, Mo, Sb, Ti, V and Zr were detected under the level of 1 mg/kg, the lowest concentrations were determined for nickel, bismuth, tin and lithium (under the detection threshold).

It was found that from the trace elements the highest concentrations were determined for uranium (Y-Cu), indium (Y-Fe), thorium (Y-Fe) and lanthanum (Y-Cu) and the concentrations of Be, Hf, Nb, Os, Pt and Re were under the level of 5 μg/kg. It was interesting that the composition of trace elements in each group of yeast (Y-Fe, Y-Cu, and Y-Mn) were different from each other despite the fact that the substrate for the yeast production (whey) was the same.

It is also worth to say that the concentrations of toxic metals (As, Cd, Hg, F, and Pb) in the examined yeast were under acceptable levels. The highest concentrations of lead and cadmium were determined, respectively, in Y-Fe and Y-Mn.

The obtained results concerning the composition of the yeast were very difficult to compare with the results of other authors because the technology of production and the substrates were different. However, the results of Fernandes et al. [6] showed that the fodder yeast, obtained in the process of the ethanol production from the sugar cane, had very high concentrations of macro and micro elements especially of sodium, potassium and zinc. The investigation of the Biocer® yeast (enriched in Se, Zn, Cr) composition showed that, except of the enriching elements, the highest concentrations were determined for P, Na, Ca, Mg and Fe. Besides, the presence of 30 micro and trace elements were detected, the concentrations of some of the elements were similar to the concentrations of elements which were determined for Y-Cu, Y-Mn and Y-Fe [4].

The nutritional examination made on young fatteners and laying hens showed very good bioavailability of Cu and Mn, worse of Fe, from Y-Cu, Y-Mn and Y-Fe. The results of the bioavailability researches will be published in the separate publication in the next future.

CONCLUSIONS

The yeast *Saccharomyces cerevisiae* enriched in Fe, Mn and Cu were characterized by very good chemical properties, high content of protein, beneficial composition of amino acids and elements. Therefore, the investigated yeast could be very useful in feeding (feed additives) for monogastric animals

ACKNOWLEDGEMENTS

The work was financed by Ministry of Science and Higher Education (scientific project no. 3 T09B 09328).

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Table 1. The basic composition of the yeast *Saccharomyces* cerevisiae enriched with Fe, Mn and Cu

Item	**Y-Fe**	**Y-Mn**	**Y-Cu**
Dry matter [%]	96,2	95,3	95,2
Crude ash [%]	6,62	6,81	5,09
Crude protein [%]	38,0	39,75	39,32
Crude fat [%]	1,01	0,93	0,83
Crude fibre [%]	trace	trace	trace
Metabolic Energy [MJ/kg]	10.33	10.48	10.16
Bioelements (g/kg)			
Fe	1,44–26,45*	0,07	0,026
Mn	0,012	5,33–19,96*	0,011
Cu	0,004	0,004	0,43–18,49*

*maximal values

Table 2. The amino acid composition (g/kg) of the yeast *Saccharomyces cerevisiae* enriched with Fe, Mn and Cu

Amino acid	Y-Fe	Y-Mn	Y-Cu
Asp	40,05	39,56	37,54
Thr	19,27	18,95	19,00
Ser	18,48	17,89	19,18
Glu	46,18	47,02	45,47
Pro	15,76	17,23	15,18
Gly	17,61	18,61	17,70
Ala	22,68	24,27	23,55
Val	22,06	23,15	21,86
Ile	18,59	19,61	18,13
Leu	27,12	29,14	27,80
Tyr	13,11	13,05	10,69
Phe	16,17	16,89	16,19
His	12,06	11,54	10,99
Lys	31,84	31,31	34,48
Arg	21,63	23,51	21,74
Cys	4,23	3,98	4,40
Met	4,57	4,75	4,73

Table 3. The content of macroelements (%) of the yeast *Saccharomyces cerevisiae* enriched with Fe, Mn and Cu

element	Y-Fe	Y-Mn	Y-Cu
Ca	0,210	0,245	0,130
P	1,052	0,990	0,653
Mg	0,873	1,042	0,329
K	0,757	0,659	0,641
Na	0,044	0,003	0,002
S	0,402	0,218	0,196
Total	3.338	3,157	1,951

Table 4. The content of microelements (mg/kg) of the yeast *Saccharomyces cerevisiae* enriched with Fe, Mn and Cu

element	**Y-Fe**	**Y-Mn**	**Y-Cu**
Cr	0,86	6,0	0,29
Zn	221	193	213
I	1,91	0,67	0,082
Se	0,14	0,20	<0,10
Ag	0,069	0,65	0,23
Al	7,6	10,7	8,03
B	25,0	24,6	22,6
Ba	0,88	1,28	0,582
Bi	<0,0005	<0,0005	0,027
Co	0,12	0,205	0,162
Cs	0,030	0,038	0,035
Ga	0,12	0,23	0,17
Ge	0,78	0,08	0,12
Li	<0,27	<0,27	<0,27
Mo	0,095	0,092	0,035
Ni	<0,01	1,20	<0,01
Sb	0,025	0,013	0,020
Sc	1,52	1,50	2,44
Si	52,4	52.0	47,5
Sn	<0,004	<0,004	1,46
Sr	5,6	6,4	3,0
Rb	8,8	9,3	8,5
Ti	0,71	0,93	0,55
V	0,290	0,311	0,168
Zr	0,053	0,075	0,071