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EFFECT OF ULTRAFILTRATION OF BAKERS' AND BREWERS' YEAST EXTRACTS ON THEIR NITROGEN CONTENT AND TURBIDITY

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Five commercial yeast extracts (YE) were fractionated by ultrafiltration (UF) with 10 000, 3000 and 1000 Da molecular weight cutoff membranes in the aim of evaluating the effect of UF on the turbidity and total nitrogen content of YE. Membrane pore size had much more influence on UF permeation rates than the source of the YE. UF filtration rates were on the average 4 times lower when the YE were treated with the 3000 Da membrane as compared to the 10 000 Da filter, and the 1000 Da unit gave rates approximately 40% lower than those observed with the 3000 Da pore size membrane. Pre-filtration with a 8 µm membrane reduced between 47 and 96% the original YE turbidities, while UF with a 1000 to10 000 Da membranes gave filtrates having between 80 and 99.9% less turbidity than the original YE. On the average, UF with the 10 000 Da unit removed 12% of total solids, while UF with 3000 and 1000 Da cutoff membranes generated the retention of 20 and 23% of solids, respectively. Brewers' YE had lower total nitrogen content than bakers' YE, and UF increased the total nitrogen content of the dried yeast extract filtrates (YEF) obtained. The powders obtained after freeze-drying of brewers' YEF tended to have higher moisture contents than bakers', and this was quite significant with the YEF powders obtained with the filtrates generated with the 1000 Da membrane.

Keywords: amino acids, peptides, membrane pore size, bakers', brewers', yeast

Yeast extracts (YE) are used as flavouring ingredients in sauces, soups and various other food products (DZIEZAK, 1987; NAGODAWITHANA, 1992). They are also used as fermentation nutrients in many growth media destined for the production of food-related cultures, such as lactic acid bacteria used in cheese, yoghurt, sauerkraut or dry sausage manufacture.

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In analytical studies of YE, ultrafiltration (UF) has been used to remove salts from the products (HALÁSZ & SZAKÁCS-DOBOZI, 1993). Industrially, the technological steps that lead to the production of YE may include filtration (PEPPLER, 1982; SCHOENBERG, 1993), especially in instances where clear YE solutions are required. Although filtration is carried out commercially in some YE manufacturing processes, the technological data regarding the effect of this processing step on characteristics of YE seems to be proprietary. There is information on the filtration of brewers' yeasts (YOSHIKAWA et al., 1994), but no comparative data are found on the UF of bakers' and brewers' YE.

The aim of this study is to examine the effects of UF with three pore size membranes (1000, 3000 and 10 000 Da) on the physical (turbidity) and chemical (solids, nitrogen) characteristics of bakers' and brewers' YE.

1. Materials and methods

1.1. Yeast extracts

Five commercial YE were obtained from the following suppliers : Bio Springer (Maisons-Alfort, France), Difco (Detroit, MI, USA), Lallemand (Montréal, QC, Canada), and Red Star (Juneau, WI, USA). Since variability between lots has been reported (POTVIN et al., 1997) two lots of each source were used. The products were coded A to E so as to prevent any prejudice to the companies. Three YE were from bakers' yeasts (A, B, E) while two were from brewers' yeasts (C, D).

1.2. Ultrafiltration of yeast extracts

YE were suspended in deionized water to obtain a solution containing 10% (w/v) solids. This solution was pre-filtered on a 8 μm Whatman (No. 2 filter paper) membrane. The filtrate was further processed by UF, using a tangential filtration system (Minitan Filter plates, Millipore, Bedford, USA) with membranes having molecular cutoffs of 10 000, 3000 or 1000 Da. The system enabled the use of four 30 cm^2 membranes for a total filtration surface of 120 cm^2. A 500 ml solution of 10% YE was used, and the UF process was stopped after the recovery of 300 ml of filtrate. The yeast extracts filtrates (YEF) were lyophilized in a LyoTech (Lyo San Inc, Lachute, Canada) at 24 °C for 72 h and stored at –20 °C until used. Total nitrogen and water contents of the powders as well as total solids and turbidity of YE and YEF solutions were evaluated. All chemical analyses were done in duplicate for each lot tested and the results presented are the means of the two values obtained.

1.3. Chemical analyses of YE and YEF

The total nitrogen determination was done using a FP-428 LECO apparatus (LECO Corporation, Saint Joseph, MI), operated under the following conditions: sample size, 150 mg; oxidation Furnace temperature, 900 °C; oxidation standby temperature, 650 °C; purge cycles, 3; minimum timeout, 30 s; comparator level, 1.00; loop select low range, flow constants at high; gases, oxygen 99.99% and helium 99.99%. The calibration standard was composed of 150 mg EDTA (No 502–092, 9.56± 0.03% Nitrogen, LECO Corporation, Saint Joseph, MI).

Turbidity of YE and YEF solutions were determined with a Orbico-Hellige turbidimeter (Model 965; Farmingdale USA). Hydrazine sulfate standards (VWR; West Chester PA, USA) were used to calibrate the turbidimeter.

Water content of the YE, filtrates and YEF powders were obtained by dry weights after an incubation at 105 °C for 16 h.

1.4. Statistical analyses

Statistical analyses (variance and *t*-tests) were carried out on InStat (GraphPad, San Diego, CA, USA) software.

2. Results

2.1. Filtration rates

In the time required to obtain 300 ml of filtrate from the original 500 ml solution, filtration rates with 10 000 Da membranes showed only small decreases (Fig. 1). This is related to the high filtration surface (120 cm^2), which enabled completion of the process in less than 10 min. The YE source had an effect, as brewers' YE (products C and D) showed lower filtration rates. The membrane used had the greatest effect on filtration rates (Fig. 2). Filtration rates were on the average 4 times lower when the YE were treated with the 3000 Da membrane as compared to the 10 000 Da filter. However, the difference between filtration rates obtained with the 3000 and 1000 Da membranes were much lower, as the 1000 Da unit gaves rates approximately 40% lower than those observed with the 3000 Da pore size membrane. Therefore, with respect to ultrafiltration rates, the membrane pore size had much more influence than the source of the YE.

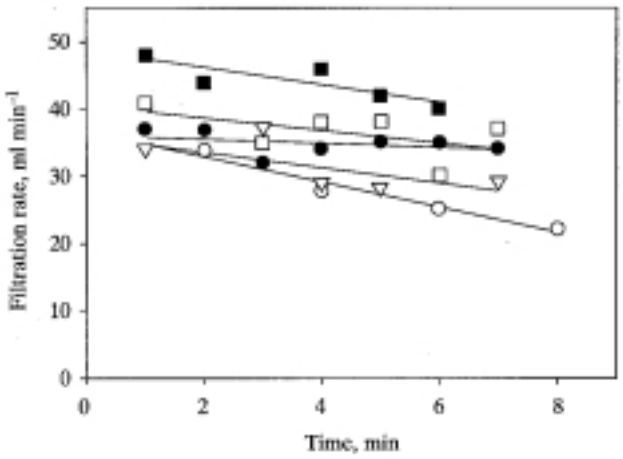

Fig. 1. The effect of yeast extract source on permeation rates during ultrafiltration of yeast extract solutions (10%) with membranes of 10 000 Da cutoff. ■: A-bakers', ●: B-bakers', ❍: C-brewers', ∇: D-brewers', □: E-bakers'

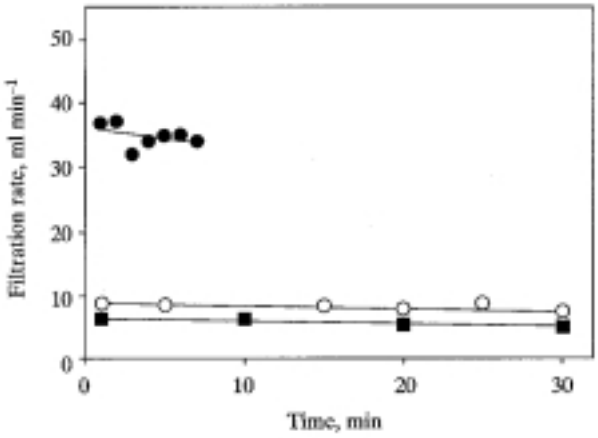

Fig. 2. The effect of membrane pore size on the permeation rates during ultrafiltration of yeast extract B. ●: 10 000 Da, ❍: 3000 Da, ■: 1000 Da

There was no correlation (r of –0.28) between the turbidity of the YE and the initial filtration rates.

Table 1

Chemical composition and turbidity of yeast extracts and yeast extracts fractions

Yeast	Filtration	Turbidity (NTU)	Solid retention by membrane (%)	Total nitrogen (g/100g)
A	None	6.1 c	0 f	10.9 cdef
(Bakers')	8 µm	1.6 c	ND	ND
	10 000 Da	1.2 c	10 de	11.6 bc
	3000 Da	0.9 c	21 bcd	11.0 cde
	1000 Da	0.8 c	22 bcd	10.9 cdef
B	None	87.2 b	0 f	11.9 bc
(Bakers')	8 µm	45.9 be	ND	ND
	10000	0.6 c	5 e	13.4 a
	3000	0.6 c	20 bcd	12.9 ab
	1000	0.6 c	22 bcd	12.7 ab
C	None	60.6 be	0 f	7.7 g
(Brewers')	8 µm	30.2 de	ND	ND
	10 000 Da	0.6 c	24 abc	9.5 f
	3000 Da	0.5 c	32 ab	9.7 ef
	1000 Da	0.7 c	35 a	9.8 ef
D	None	361.3 a	0 f	9.8 def
(Brewers')	8 µm	12.7 d	ND	ND
	10 000 Da	0.4 c	12 de	11.0 cde
	3000 Da	0.5 c	14 cde	10.9 cdef
	1000 Da	0.6 c	19 cd	10.9 cdef
E	None	6.5 cd	0 f	10.8 cdef
(Bakers')	8 µm	1.4 c	ND	ND
	10 000 Da	0.7 c	10 de	11.6 bc
	3000 Da	0.7 c	14 cde	11.3 cd
	1000 Da	0.6 c	20 bcd	11.1 cde

For a given column, means that are followed by the same letter are not significantly different (P>0.05)
ND: not determined

2.2. Effect of filtration on the turbidity of YE

The YE solutions before ultrafiltration had large variations (between 6 to 361 NTU) in turbidity (Table 1). Native YE B, C and D gave visibly turbid solutions. Pre-filtration (8 µm) reduced between 47 and 96% the original YE turbidities, with an average of 74%. UF with a 10 000 Da membrane gave filtrates having between 80 and

99.9% less turbidity than the original YE, with an average of 95%. There were no further gains by using membranes of 3000 of 1000 Da. Thus, filtration of YE solutions with a 10 000 Da membrane cutoff was enough to produce a clear YE solution, and filtration with membranes having lower MW cutoffs were not required for this purpose.

2.3 Effect of filtration on total solids

Ultrafiltration of the YE resulted in significant retention of solids (Table 1). The ultrafiltration of brewers' YE was very difficult and solutions had to be pre-filtered with the 8 μm membranes. On the average, UF with the 10 000 Da membrane removed 12% of total solids, while UF with 3000 and 1000 Da cutoff membranes generated the retention of 20 and 23% of solids, respectively. Although, a variance analysis did not consider the differences in solids retention between 1000 and 3000 Da filtrations as being significant (Table 1), the increased retention of solids with the 1000 Da membrane is systematic, and paired *t* tests of the 1000/3000 data show that the difference is real.

2.4. Effect of filtration on total nitrogen

In all instances, UF with the 10 000 Da membrane resulted in products that had higher total N contents (Table 1). This suggests that the compounds removed by UF at 10 000 Da had little protein content, and were presumably glycan cell wall fractions. However, further filtration with the 3000 and 1000 Da membranes tended to reduce the total N content. Since YE contain amino acids and various peptides (OHLY, 1998) these data suggest that peptides constitute a significant fraction of the YE compounds found in the 1000–10 000 Da range. Consequently, the UF process that enables the production of the YEF powders having the highest total N content is with the 10 000 Da membrane.

The source of YE had an effect, as brewers' YE had lower total N content than bakers' YE (Table 1), confirming results of COHAS and COHAS (1991). UF improved considerably the total N content, and one brewer' YEF became similar to bakers' YEF A and E with respect to total N content.

2.5. Residual humidity in the YEF powders

The water content of the commercial YE powders were not significantly different (Table 2) and averaged 7.6%. The brewers' YEF powders obtained after freeze-drying tended to have higher moisture contents, and this was quite significant with the YEF powders obtained with the filtrates generated with the 1000 Da membrane.

Table 2

Humidity contents (g water/100g powder) of the original yeast extracts and the products obtained after ultrafiltration and freeze-drying

Yeast extract source	Yeast extract fraction				
	Original	0–10 000 Da retentate	0–10 000 Da filtrate	0–3000 Da filtrate	0–1000 Da filtrate
A	6.8 a	6.7 ab	6.6 a	7.9 a	8.0 a
B	7.9 a	7.8 b	9.7 b	8.0 a	8.3 a
C	8.8 a	6.6 ab	12.1 c	11.9 b	11.7 b
D	7.9 a	7.9 b	9.1 b	10.2 c	11.3 c
E	6.8 a	5.1 a	6.6 a	7.2 b	7.1 b

For a given column, means that are followed by the same letter are not significantly different (P>0.05)

Filtration influenced the residual moisture of the products. YEF powders, which contained the low molecular weight compounds of YE, generally had higher water contents than the powders obtained by their retentates. These results are thus in line with those of COHAS and COHAS (1991), who had found that non-fractionated brewers' YE has higher water contents than the equivalent bakers' YE.

The commercial drying of the YEF would probably be carried out by spray drying rather than freeze-drying, and it remains to be determined if these results can extend to this technology. Nevertheless, the data does show that UF changes the properties of YE to drying.

3. Conclusions

UF may be a method of improving the nitrogen content of YEF, particularly in low molecular weight nitrogen compounds such as peptides and amino acids. This can have applications in food technology as well as in fermentation technology. In food technology amino acids such as glutamate enhance the flavour of foods (NAGODAWITHANA, 1992; WARMKE & BELITZ, 1993), and peptides contribute as well to their flavour (KURAMITSU et al., 1996; RAKSAKULTHAI & HAARD, 1992); YE are indeed recognized as useful ingredients for the enhancement of food flavour (DZIEZAK, 1987; LEE et al., 1981). With respect to fermentation technology, amino acids and peptides are also growth factors of many microbial cultures (HOLT et al., 1994). Thus, UF could be used to modify the flavour profiles and biological value of YE. Studies are currently under way in our laboratory to determine the growth-promoting value of the YEF on various lactic acid bacteria destined for food fermentations.

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References

COHAS, P. & COHAS, P. (1991): *Procédé de préparation de lysats de levure*. Demande de brevet Européen #0 390 716, A1.

DZIEZAK, J. (1987): Yeasts and yeast derivatives. *Fd Technol.*, *41*(2), 103–125.

HALÁSZ, A. & SZAKÁCS-DOBOZI, M. (1993): Proteolytic enzyme activity of *S. cerevisiae* baker's yeast and *S. carlsbergensis* brewer's yeast. *Acta Alimentaria*, *22*, 193–209.

HOLT, J. G., KRIEG, N. R., SNEATH, P. H. A., STALEY, J. T. & WILLIAMS, S. T. (1994): *Bergey's manual of determinative bacteriology*, 9th edition. Williams & Wilkins, Baltimore.

KURAMITSU, R., TAKAHASHI, M., TAHARA, K., NAKAMURA, K. & OKAI, H. (1996): Tastes produced by peptides containing ionic groups and by related compounds. *Biosci. Biotechnol. Biochem.*, *60*, 1637–1642.

LEE, C.-H., PARK, C. R. & CHUNG, K. S. (1981): Changes in the chemical composition and flavor of yeast extracts during the autolysis of baker's yeast. *Korean J. Fd Sci. Technol.*, *13*, 181–187.

NAGODAWITHANA, T. (1992): Yeast-derived flavors and flavor enhancers and their probable mode of action. *Fd Technol.*, *46* (11), 138–144.

OHLY (1998): Ohly technical data http://www.ohly.de/sommer.htm.

PEPPLER, H. J. (1982): Yeast extracts. –in: ROSE A. H. (Ed.) *Fermented foods*, Academic Press, London, pp. 293–312.

POTVIN, J., FONCHY, E., CONWAY, J. & CHAMPAGNE, C. P. (1997): An automatic turbidimetric method to screen yeast extracts as fermentation nutrient ingredients. *J. microbiol. Meth.*, *27*, 153–160.

RAKSAKULTHAI, N. & HAARD, N. F. (1992): Correlation between the concentration of peptides and amino acids and the flavour of fish sauce. *ASEAN Fd J.*, *7*, 86–90.

SCHOENBERG, E. (1993): The technology and application of yeast-derived flavour enhancers. *European Food & Drink Rev.*, *Winter*, pp 55–57.

WARMKE, R. & BELITZ, H. D. (1993): Influence of glutamic acid on the bitter taste of various compounds. *Z. Lebensmittelunters. u. -Forsch.*, *197*, 132–133.

YOSHIKAWA, Y., MATSUMOTO, K. & OHKI J. (1994): Membrane filtration characteristics of yeast suspension extracted with solution of ethanol in water. *Nippon Nogeikagaku Kaishi*, *68*, 949–955; -ref: *Fd Sci. Technol. Abst.*, 94-09-B0175.