Enzyme-Related Changes in the Nutritional Value of Beer

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Much research has been carried out on the use of enzyme preparations such as α-amylase, protease and β-glucanase as hydrolyzing agents of unmalted cereal compounds (13,14). The breakdown of phospholipids or glycerides is the first in the sequence of enzymatic reactions, followed by the formation of free fatty acids (9,16).

The colloidal system is destroyed by the fatty acids and glycerides and decreases the foam stability of the final product (35). The levels of nitrogen, polyphenols and glycerol are altered by enzymatic reactions occurring during the preparation of the beer and influences the nutrient value of the final product (25).

Knowledge of one alcoholic beverage leads to better understanding of the science and technology of another. White wine and beer production have several common features (31).

While it is known that beer and wine contain many important nutrients, knowledge of the nutritional and metabolic value of these beverages in the diet is very limited at present. Recent studies (15,22,28) have indicated that both beer and wine may be nutritionally beneficial.

An examination of the nutrient content of beer and wine reveals that they have somewhat different compositions. The caloric level of wine is twice that of beer but its influence on the diet may be similar since it is usually consumed in smaller quantities than beer. Both beverages contain consistent but differing amounts of protein, vitamins and minerals which also may be of significance nutritionally (6, 17). There are also suggestions in the literature (12, 33) that beer and wine may have an effect on fat metabolism by stimulating its uptake and transport in the blood and lymph systems (1,10).

Since beer and wine are more or less significant components of the diets of a large percentage of the population, it is important to understand the nutritional and metabolic influences of these beverages (19,20). Such information may also be of value in improving the nutritional value of these and other alcoholic beverages (21,26,27).

In the present study, different types of Israeli beer were tested for their nutrient composition and metabolic influence after enzymatic treatment. The results

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Table I
Composition of Wort, Beer and Wine Samples

Beers	Control I	Control II	Test I	Test II	Test III	Dry White Wine
Lyophilized weight (g/100 mL)	2.90	3.70	3.50	3.50	3.50	1.90
Alcohol (% weight)	3.17	4.01	3.17	3.17	3.17	9.11
Alcohol (% volume)	4.05	5.13	4.05	4.05	4.05	11.34
Chill haze (formazin units) (warm/cold)	17/20	11/15	10/14	13/16	10/12	—
Diacetyl (ppm)	0.21	0.16	0.26	0.15	0.15	—
Sigma (foam stability)	98.5	121.0	122.0	108.0	126.0	—
Polyphenols (mg/L)	167.3	177.1	166.5	146.8	152.5	305.0
Glycerol (mg/100 mL)	9	7	19	16	14	—
% Weight (d.b.)						
Carbon	26.69	40.19	40.04	39.63	40.12	32.33
Hydrogen	4.70	6.54	6.52	6.45	6.52	6.78
% Weight (d.b.) Worts						
Carbon	38.35	37.85	38.32	39.71	39.10	—
Hydrogen	6.57	6.40	6.63	6.68	6.68	—

Table II
Nitrogen Content of Commercial Worts, Beers and Dry White Wine

Indices	Wort					Beer							Dry White Wine
	Control I	Control II	Test I	Test II	Test III	Control I	Control II	Test I	Test II	Test III	Golds	OK	
Total nitrogen*	1.79	2.03	1.59	1.43	1.85	0.85	1.00	0.70	0.58	0.96	1.00	1.03	1.16
Protein*	11.19	12.69	9.94	8.94	11.56	5.31	6.25	4.38	3.63	5.97	6.25	6.41	7.50
Nitrogen Total soluble**	58.1	123.2	55.3	50.4	51.6	38.5	44.8	30.8	29.4	35.6	45.2	44.8	–
Free amino**	12.20	14.70	11.10	11.50	13.50	2.74	3.68	1.90	1.47	2.98	3.09	3.47	7.00
Coagulable**	8.54	12.70	4.48	3.10	4.06	3.50	3.45	1.68	2.80	3.08	2.52	1.82	
Albumose**	12.60	14.00	11.48	10.64	10.08	6.72	8.80	5.04	5.28	7.28	8.96	7.84	

*As a percent of weight (dry basis) of lyophilized sample.
**In mg/100mL.

were compared with a South African dry white wine. Rats were fed beer and wine supplemented diets and food consumption and weight gain were measured. Serum samples were taken at the end of the experimental period and analyzed.

Materials and Methods

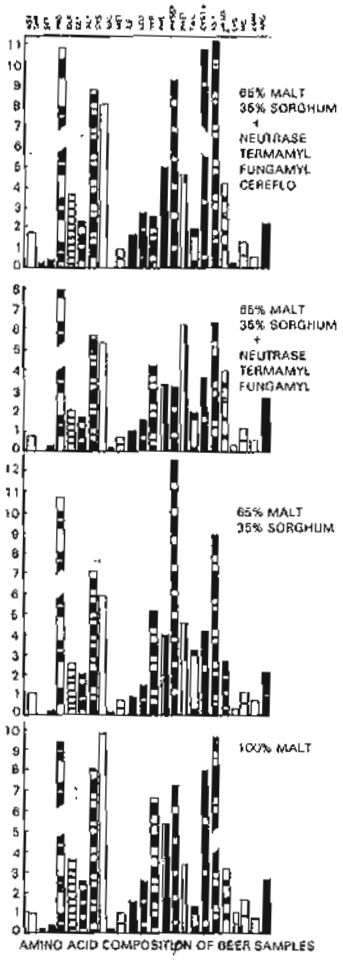
Experiments were carried out using five Israeli Lager beers produced under conditions used at the National Brewery Ltd., Nathanya, Israel. The dry white wine was supplied by the Stellenbosch Farmers' Wineries. Two control beers were used in these experiements. Control Beer I was produced using 65% malt and 35% sorghum and Control Beer II contained 100% malt.

Three test samples were also used. Test Sample I contained 50% malt and 50% sorghum and was produced using 0.1% Convertase 70SC* and 0.05% Convertase BGA*. Test Sample II contained 50% malt and 50% sorghum and was produced using 0.1% Convertase SA* and 0.05% Convertase BGA*. Finally, Test Sample III contained 50% malt and 50% sorghum and was produced using 0.1% Termamyl**, 0.025% Cereflo**, 0.1% Neutrase**, 0.3g/hL Fungamyl 1** in 800 l/hL of wort (16).

Analytical Procedures

The beer and wine samples were analyzed either without treatment or after evaporation and lyophilization (32.) Wine samples were analyzed for their carbon and hydrogen composition, polyphenols, nitrogen, amino acids and free amino nitrogen, by conventional methods (2).

The analysis of malt, wort and beer were carried out using EBC methods (11) and by the methods of Bausch (3), Kruger and Bielig (18) and Moll *et al.* (23). The nitrogen content of all samples was determined by the Kjeldahl method and albumins and coagulable nitrogen by the methods of Kolbach and Wilharm (4) and de Clerck (8). Free amino nitrogen was determined spectrophotometrically using a Varian Techtron Model 635 spectrophotometer. Carbon and hydrogen levels were obtained by elemental analysis. Mineral content was determined by atomic absorption spectroscopy. A Beckman model 119 automatic amino acid analyzer was used to determine amino acids after hydrolysis of the samples for 24 hours at 110°C with 6*M* HCl in evacuated tubes. Chill haze (physical stability) was measured with an EBC hazemeter after one day at 40°C, followed by chilling to 0°C for 24 hours. The foam stability was determined by the modified Carlsberg method.



AMINO ACID COMPOSITION OF BEER SAMPLES

Male Wistar rats (120 g) were housed individually in stainless steel metabolism cages and fed on diet consisting of 70.5% starch, 18.0 ovalbumin, 5.0% salt-mix, 5.0% sunflower oil, 1.0% cod liver oil, 0.3% choline chloride and 0.25% vitamins. Beer-supplemented animals were fed the same diet supplemented with lyophilized beer at a concentration corresponding to an intake of 6.0 mL original beer/day/rat. Wine supplemented animals were fed 2.0 mL wine/day/rat. All animals received the alcohol equivalent of this beverage intake at a rate of 1.0 mL of 24% ethanol per day by stomach intubation. Food consumption and body weight were monitored. After four weeks on these diets, the animals were sacrificed and blood samples withdrawn from the heart.

The molecular weight distribution of the serum proteins was determined by SDS electrophoresis using 5% polyacrylamide gels with 0.1% SDS, according to the method used for human serum proteins (5,7,24). Prior to electrophoresis, the samples were boiled for five minutes in 0.01 *M* sodium phosphate buffer containing 1% SDS and 1% mercaptoethanol. Coomassie Brilliant Blue R250 was used as a protein stain.

Results and Discussion

Table I gives the chemical composition of worts, beers and dry white wine. Analysis of Test Beer III shows the indices of this sample to be the same as Control Beer I.

Table II gives the nitrogen content of worts, beers and wine. All forms of nitrogen were highest in Test Beer III. Albumoses, low molecular weight compounds, are decisive in determining such functional changes in proteins as solubility, coagulability, foamability, viscosity and nutrient value.

Although the content of total nitrogen, albumose and α-amino nitrogen was different in each sample, there was a tendency towards increases in these substances for all-malt beer (Control

Table III
Amino Acid Composition of Beer and Dry White Wine Hydrolyzates*

Amino Acid	Control I	Control II	Test I	Test II	Test III	Dry White Wine
Valine	0.30	0.31	0.25	0.25	0.37	0.24
Methionine	0.050	0.060	0.034	0.0230	0.050	0.013
Isoleucine	0.130	0.150	0.100	0.080	0.130	0.165
Leucine	0.200	0.230	0.150	0.130	0.170	0.233
Tyrosine	0.110	0.110	0.080	0.060	0.100	0.114
Phenylalanine	0.110	0.123	0.080	0.060	0.120	0.121
Histidine	0.110	0.124	0.090	0.070	0.110	0.242
Lysine	0.180	0.210	0.150	0.110	0.180	0.255
Arginine	0.190	0.170	0.100	0.080	0.150	0.347

*In g amino acid/100g freeze dried sample.

highest, then Control Beer I (without enzymes); the lowest values were found in samples produced with Convertases (Test Beer I and Test Beer II).

In **Table III** the amino acid composition of beer and wine samples is shown. The amounts of all amino-acids in Test beers I and II are less than in Test beer III, which is similar to Control beer II (**Figure 1**).

In **Tables I, II** and **III**, the nutrient composition of different types of beer samples is shown, together with a comparison with a South African dry white wine. As can be seen, the beer samples were similar in composition (in elemental organic analysis, protein, nitrogen and amino acids), but they differed markedly from the wine. The alcohol content of the beer samples varied between 4 and 5% (by volume) whereas that of wine was 11.3%.

Body weight gains and food consumption are shown in **Table IV**. Three of the beer-supplemented diets had little effect on body weight gain while the other two (Control Beer I and Test Beer I) resulted in a reduced body weight gain during the experimental period when compared with the controls. Animals fed the wine-supplemented diet showed an increase in weight gain which was probably due to increased food consumption.

Figure 2 shows the electrophoretic patterns of the albumin and globulin fractions of the serum of rats fed the beer and wine supplemented diets.

The patterns of the beer samples were all similar with some slight differences. The band of molecular weight 17,000 is the strongest in Test Beer III and Control Beer II. In Control Beer II, the 28,000 band is weaker than in the other four beers, and, at 32,000, the band is much stronger. The other four beer samples have an additional band at 37,000. Wine is similar to these four beer samples in the region between 28,000 and 41,000, but different from all beers between 80,000 and 141,000. Both wine and Control Beer II have a subunit present at 100,700; wine, however, has an additional subunit of 118,000, which is not present in any of the beers.

Wine has less material at 169,800 than beers. All samples have the same main protein fractions as normal serum except for the lowest molecular weight subunit which normal serum lacks.

Figure 2: *SDS-PAGE (5%) of rat serum proteins (5 μ g serum) of samples (E= molecular marker, CR_W= rat control for wine; W= dry white wine; N= normal; CR_B= rat control for beer; C_2= control II; T_3= test III; T_2= test II; T_1= test I; C_1= control I).*

Summary

In beer samples, changes were detected in the nitrogenous, polyphenolic and fatty substances after the addition of different enzymes during the brewing process. The highest protein solubility, coagulability and foam stability was achieved in beer samples prepared using Novo Industries enzymes.

While the nutrient content of beer is well documented, the nutritional value of this beverage in the diet is not well understood. There is also limited data on the relative nutritional merits of beer when compared with wine. In the present study, the contents of certain nutrients in five different types of Israeli beer and a South African dry white wine were determined. Rats were fed controlled-diets supplemented with beer or wine (equivalent to 3L beer/day or 1L wine/day for a 70 kg man). All animals, including controls, were given alcohol at a level of 1 mL of 24% ethanol per day. After four weeks, the food consumption and body weight gain was determined

Table IV
Body Weight Gains and Food Consumption of Rats Fed Different Types of Beer and Wine

	Control for Rats	Types of Beer					
		Control I	Control II	Test I	Test II	Test III	Dry White Wine
Food consumption (g)	354.4	339.2	351.5	335.3	381.0	354.4	405.4
Weight gain (g)	95.4	72.8*	100.7	66.6*	98.3	98.1	112.8*

*Significant at 99% level.

and blood samples were taken for serum analysis.

Growth of rats fed beer diets was not significantly different from that of control animals. However, the wine supplemented diet appeared to stimulate growth during the experimental period.

Electrophoresis of serum revealed very slight differences in beer samples after brewing with different enzymes. All beer and wine samples have the same main protein fractions with some differences in minor bands; in beer samples, differences appeared in the low molecular weight fractions. Comparing beer with wine, the main differences were in higher molecular weight subunits.

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Literature Cited

(1) Ahlquist, J., Nyholm, M., Salaspuro, M., and Wallgren, H. *Acta Physiol. Scand. 74:* 15A (1968).
(2) Amerine, M.A. The Technology of Wine Making. Avi Publishing Co., Westport, CT, 1972.
(3) Bausch, H.A., Arbeitsvorschriften zur chemisch-brautechnischen Betriebskontrolle, (4th ed), Paul Parsey: Berlin, 1963, p. 44.
(4) Bulgakov, N., Prozvodstvennyy i Laboratornyy Kontrol' Solodorashcheniya i Pivovareniya, Pish chepromizdat, Moscow. 36:214, 264, 304 (1959).
(5) Cooper, T.G. The Tools of Biochemistry. John Wiley & Sons, New York, 1972. p 219.
(6) Coppola, V. *Riv. Vitic. Enol 30*(6): 248, 1977.
(7) Davis, B.J. Gel Electrophoresis, Annals of the New York Academy of Science 409, 1954.
(8) De-Clerck, J. Lehrbuch der Brauerei (2nd ed) Versuchs-und Lehranstalt fur Brauerei: Berlin, I, 1964; II, 1965.
(9) Dominguez, X.A., and Canales, A.M. *Brewers Digest 49*(7): 40 (1974).
(10) Eriksson, K. 28th International Congress on Alcohol and Alcoholism, Washington, 1968.
(11) European Brewery Convention, Analytica-EBC (3rd ed), Schweizer Brauerei-Rundschau, Zurich, Switzerland, 1975.
(12) Garfinkel, L. *Proc. S.A. Nutr. Soc. 3:* 140, 1966.
(13) Gorinstein, S., Kitov, S., Sarel, S., Berman, O., Berliner, M., Popovich, G., and Vermus, Ya. *J. Am. Soc. Brew. Chem. 38* (1): 23, 1980.
(14) Gorinstein, S., Deutsch, J., Kitov, S., Sarel, S., Berman, O., Berliner, M., and Popovich, G. *MBAA Tech. Quart. 17*(2): 98, 1980.
(15) Gorinstein, S., Duncan, J.R. Phillips, A.M., and Quicke, G. *J. Agr. Food Chem.* (In press).
(16) Gorinstein, S., Kitov, S., and Deutsch, J. *MBAA Tech. Quart. 17*(3): 156, (1980).
(17) Helbert, J.R. *J. Am. Soc. Brew. Chem. 36*(2): 66, 1979.
(18) Kruger, E. and Bielig, H.I. Betriels-und Qualitelts kontrolle in Brauerei und alkoholfreier Getranke-industrie. Paul Pakey, Berlin, 1976.
(19) Lucia, S.P. Wine as Food and Medicine. Blakiston, New York, 1954.
(20) Lucia, S.P. Wine and Your Well-Being, Popular Library, New York, 1971.
(21) Masquelier, J. *Ann. Technol. Agric. 27*(1): 427 (1978).
(22) McDonald, J.T., and Morgen, S. *Am. J. Clin. Nutr. 29:* 1093 (1976).
(23) Moll, M., That, V., Schmitt, A., and Parisot, M. *J. Am. Soc. Brew. Chem. 34:* 187 (1976).
(24) Mutch, P.B., and Hurley, L.S. *J. Nutr. 104:* 828 (1974).
(25) Narziss, L. *Brauwelt 118 (20):* 688 (1978).
(26) Niizawa, N. *Hakko to Kogyo 37*(6): 550 (1979).
(27) Nutritional Properties of Beer—a little known aspect of the beverage of moderation. *Brewers Digest 50*(10), 38, (1975).
(28) Pollack, J.R.A. *Brew. Guild. J. 49*: 14 (1963).
(29) Q.A. Analytical Methods, John Labatt's: London, Ontario 92, 1972.
(30) Ross, S., and Clark, G.L. *Wallerstein Lab. Commun. 6:* 46 (1939).
(31) Singleton, V.L. *MBAA Tech. Quart. 11*(2): 135 (1974).
(32) Sorensen, S.B., and Ottesen, M. *Carlsberg Res. Commun. 43:* 133 (1978).
(33) Vogel, G. *Brauwissenschaft 19:* 307 (1964).
(34) Weber, K.J.R., Pringle and Osborne, M. Methods in Enzymology, C.H.W. Hisch S.N. Timasheff eds. Academic Press, New York 26: 3 (1972).
(35) Woodward, J.D. *Brewers Digest 53*(5): 38 (1978).