Utilization of Potato-Chips Waste for Production of High Economic Value Products: I- Production of Baker's Yeast

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ABSTRACT

The present study aimed to utilize the potato-chips waste as a cheap substitute of molasses for the production of baker's yeast thereby, reduce the cost of baker's yeast production, at the same time eliminates environmental impact of waste via open burning. Investigations proceeded to optimize the conditions for acid hydrolysis of waste, followed by studying the feasibility of producing yeast biomass from the waste hydrolysate. The results revealed that, the optimum conditions for acid hydrolysis were 5 % w/v solid to liquid ratio; 100°C hydrolysis temperature; 4% w/v acid concentration and 25 min for reaction time. The resultant hydrolysate was detoxified by overliming to reduce its content of hydroxy methyl furfural (HMF) and then utilized as a substrate for cultivation of baker's yeast. The maximal cell biomass production was attained at cultivation conditions being: 0.4 % w/v inoculum level; 2 % w/v sugar concentration; 0.05 % w/v nitrogen source (wheat bran) and 9 hr incubation period at 30 °C. The chemical analysis and the activity evaluation of the obtained yeast indicated that it had a high nutritive value and was suitable for bread making.

Keywords: potato chips waste, acid hydrolysis, baker's yeast,bread

INTRODUCTION

Food industries of plant foods usually produce numerous by-products that contain an enormous amount of carbohydrate waste, which increasing disposal costs and environmental challenges. The food processing industry generates approximately 45 % of the total organic industrial pollution (Akerberg *et al.*, 1998, Akerberg & Zacchi, 2000). Bioconversion of carbohydrate waste is receiving increased attention in view of the fact that these waste can act as substrates for the production of useful biomaterials (Jin *et al.*, 2005). Potato-chips industry in Egypt generates many tons of waste per year, while each one-ton raw potato drives around 100 Kgs waste during the preparation and chips industry process. Baker's yeast (*S. cerevisiae*) considered the most intensively cultivated and commercial microorganism that has been used extensively for the production of single-cell protein for human and animal consumption because of its generally regarded as safe status (Solomon *et al.*, 1997, Akinyemi *et al.*, 2003). In addition, it is widely used in leavening of dough because of its ability to produce carbon dioxide and to contribute the aroma and flavour of bread (Chen & Chiger, 1985, Hoek *et al.*, 2000, Jorgensen *et al.* 2002). In Egypt, there is a wide gap between the annual local production figures and the actual consumption (Fadel & Foda, 2001). This is probably attributed to the molasses high price along with its limitation. Such a problem stimulates our attention to search on substitute cheap carbon source.

Baker's yeast is now produced in Egypt by fermentation of cane and beet molasses. The rapid development in sugar industry production caused a decrease in the molasses amount derived from the process, and because of an increase in demand for baker's yeast for both food and feed, there was an urgent need for using potato-chips waste as an alternative substrate for Baker's yeast production. It achieves many targets such as: elimination the environmental pollution and hazards; securing an economic, cheap source of raw materials due to business development and economic growth; strategic provides an alternative way to replace the refined and costly raw materials (i.e. molasses).

The objective of the present study was to reduce the cost of the baker's yeast production by using potato-chips waste in place of molasses as a conventional carbon source thereby, decreasing the environmental hazards. To achieve this target a trial to optimize the acid hydrolysis of waste was carried out, furthermore a study was carried out to verify the optimal conditions for baker's yeast production by using potato-chips waste hydrolysates instead of molasses.

MATERIALS AND METHODS

Potato-chips waste was obtained from a factory for potato-chips industry located in Tanta city. The waste was consists of potato peels and potato tuber pieces. The whole waste was dried at 80 °C to a constant weight then was milled in a kitchen blender to give powder, which was used for further investigation. The starch content was determined according to the method of Kim & Hamdy (1985).

Chemical analysis of waste

The Micro-Kjeldahl method was used to determine the total nitrogen and thereafter its value was multiplied by the factor of 6.25 to get the crude protein content. Ether extract was determined in a Soxhlet apparatus using the petroleum ether as a solvent, and ash content was determined by ashing the samples in an electric muffle at 550°C until constant weight was maintained. (A.O.A.C., 2000). Reducing sugars were estimated by 3, 5 dinitrosalicylic acid method (DNS), according to Miller (1959).

Hydroxy methyl furfural (HMF) was determined using a colorimetric method developed by Meydav & Berk (1978). Accurately 2g of the hydrolysate were weighed in a small beaker and transferred to 50-ml volumetric flask. Four ml of saturated lead acetate solution were thoroughly mixed and then diluted to volume with distilled water. Then, filtered through two-layers Whatman paper No.1 under vacuum using Buchkner funnel. Two ml from the filtrate were pipetted into each of two (18×150 mm) test tubes. Two ml of the distilled water were added to one tube (blank) and 2ml of sample to the other tube. Two ml of 40% tricholoroacetic acid and 1 ml of (0.05 M) thiobarbituric acid were added and mixed well. Then, tubes were placed in water bath at 40°C for 50 min, following by cooling to room temperature. The colour absorbance (A) was measured at 433nm using (Spectrophotometer Jenway 6100). The HMF concentration (mg/g) was calculated by multiplying (A) by 16.7.

Acid hydrolysis

Waste powder was mixed with HCl to desired final concentration ranged between 1 and 8 % (w/v) in 250 Erlenmeyer flask (under or without reflux) with desired solid to liquid ratios varied from 2.5 to 12.5 w/v. Hydrolysis was performed at five temperatures (80, 90,100, 110 and 121°C) for different periods (5 to 30 min). The time of reaction began when the slurries of waste reached the desired reaction temperature; at the end of the reaction, the remaining solids were separated by filtration. The filtrate was then neutralized to pH =7 using Na OH solution (2 N), and examined for both reducing sugars and hydroxy methyl furfural (HMF). Hydrolysis at 80, 90 and 100°C was performed in a boiling water bath and at 110 and 121°C in an autoclave.

Detoxification treatments

The hydrolysate gives 3.2 % reducing sugars and 0.939 % w/v HMF. It was treated by over liming or with active charcoal to reduce its content of inhibiting substances according to the method of Parajo *et al.*, (1997).

Organism

Saccharomyces cerevisiae was isolated from commercial baker's yeast, which is produced by Starch & Yeast Company, Alexandria. Slant potato dextrose agar PDA (PDA, Difco, Detroit, USA) was used for preservation of the strain.

Inoculum preparation

Yeast inoculums were prepared by transferring *Saccharomyces cerevisiae* colonies from the slant agar to identical experimental media followed by incubation at 30°C for 20 min with shaking. Cells were concentrated by centrifugation; pellet was resuspended in appropriate volume of distilled water. From this suspension, an adequate volume was taken to attain the desired inoculum final concentration in experimental media.

Cell dry weight measurement

Cell dry weight was determined according to the method of Roca & Olsson, (2003).

Experimental media and fermentation conditions

Experimental media consists of 3 % w/v carbon source; 0.3 % w/v yeast extract 0.025% w/v nitrogen, was provided from 0.053g urea (urea solution was sterilized by filtration) and 1 % v/v salt solution from both A and B solutions where:

Solution A: 10 % KH_2PO_4 and 10 % K_2HPO_4.

Solution B: 4 % Mg $SO_4.7H_2O$; 0.2% NaCl; 0.2% $MnSO_4.H_2O$ and 0.2 % Fe SO_4.

The media pH was adjusted to 4.5, when the effect of nitrogen source was subjected to study, urea was replaced with various concentrations of nitro-

gen sources. When the effect of sugar concentration was under study, various concentrations of sugar were tested. The media were sterilized by autoclaving at 121°C for 20 min. All experiments were carried out in 250 ml Erlenmeyer flasks containing 100 ml of the fermentation medium. The flasks were inoculated and incubated at 30°C with shaking (200 rpm) for 12hr. Determination of gassing power was done according to Dodic *et al.*, (2004). All experiments were carried out in triplicates and values were calculated on dry weight basis.

Evaluation of fermentative activities of the obtained yeast

The obtained yeast was used for preparing Shamy bread (white pita bread) as a comparison; commercial baker's yeast was applied parallel with the yeast under study. The test was done by kneading 72% extraction-wheat flour, 55-60% tab water, 1.5% table salt and 2.26% obtained yeast or 2% commercial yeast. The kneading was conducted until the dough was smooth, then it was set at 30oC for 2hr to rise, thereafter, it was divided and formed to flat round shapes. The baking was performed at 225°C until the rolls were light golden brown.

The prepared bread was evaluated sensorily applying the described method by American Institute of Baking (1987)

Statistical analysis

Data were analyzed according to Steel & Torrie, (1980). A one way analysis of variance (ANOVA) using the general linear models (GLM) procedure was used to test for main effects where more than two variables being compared. Differences with P values ≤ 0.05 were considered to be statistically significant.

RESULTS AND DISCUSSION

Analysis of potato-chips waste:

The results of chemical analysis of potato-chips waste presented in Table (1) indicate that, it contains 24.11 % dry matter. More than 60% of the dry matter is starch that is easily converted to fermentable sugars and used as cheap carbon source for many microbial industries. Potato-chips waste also contains nitrogen and ash, thereby its hydrolysate might be suitable for using as a fermentation medium.

Table 1: Chemical composition of potato-chips waste

Component	Wet weight (%)	Dry weight (%)
Moisture	75.89	00.00
Starch	14.95	61.49
Crude fiber	05.31	21.84
Ash content	03.72	15.22
Reducing sugars	00.15	0.610
Crude protein	00.20	00.82
Ether extract	00.00	00.00

Acid hydrolysis of potato-chips waste:

1-Effect of solid to liquid ratio on the liberation of reducing sugars

To verify the best concentration of waste powder, which liberates the highest sugar amount during the acid hydrolysis, different solid to liquid ratios varied from 2.5 to 12.5% w/v were subjected to hydrolysis. The results presented in Table (2) indicate that in general the liberation rates of reducing sugars decreased by elevating the solid to liquid ratios.

The optimum hydrolysis time was found to vary according to the ratio of solid to liquid; it was 20 min for the ratio 2.5% and 25 min for the ratios 5 and 7.5%, while that for ratios 10 and 12.5% it was 30 min. The formation of HMF, the dehydration product of glucose, increased with increasing of both the solid to liquid ratio and the hydrolysis time. This could be attributed to the heat effect, since it did not distribute well at high solid to liquid ratio causing sugar decomposition, also heating for long time show the same result. Similar results were reported by Kim & Hamdy (1985). The highest amount of reducing sugars was liberated with solid to liquid ratio 5% at 25 min. Data of ANOVA given in Table (2) show that there was a significant difference at ($P \leq 0.05$) among treatments.

2- Effect of hydrolysis temperature on the liberation of reducing sugars

To findout the favourable temperature at which higher yield of reducing sugars could be liberated with low concentration of HMF, hydrolysis of 5%(w/v) potato-chips waste was performed with 2% HCl at different temperatures (80 – 121°C) for different periods. From the results shown in Table (3), it could be noted that, both reducing sugars and

Table 2: Effect of solid to liquid ratio on the liberation of reducing sugars

Solid to liquid ratio % (w/v)	ANOVA		Hydrolysis time (min)*											
			5		10		15		20		25		30	
	RS	HMF	$RS^{(f)}$	HMF^{f}	$RS^{(e)}$	HMF^{e}	$RS^{(d)}$	HMF^{d}	$RS^{(c)}$	HMF^{c}	$RS^{(a)}$	HMF^{b}	$RS^{(b)}$	HMF^{a}
2.5	B	C	0.199	0.000	0.299	0.011	0.435	0.031	0.460	0.089	0.456	0.175	0.453	0.210
5	A	E	0.196	0.005	0.297	0.021	0.433	0.039	0.466	0.071	0.475	0.088	0.472	0.0169
7.5	C	D	0.188	0.013	0.265	0.031	0.431	0.044	0.453	0.057	0.455	0.113	0.454	0.199
10	C	B	0.178	0.018	0.233	0.033	0.390	0.049	0.399	0.089	0.411	0.212	0.412	0.261
12.5	E	A	0.177	0.022	0.203	0.041	0.371	0.058	0.350	0.132	0.401	0.251	0.411	0.283

RS: Reducing sugars (g/g waste sample). HMF: Hydroxy methyl furfural (g/g waste sample).
Reaction conditions: Temperature: 100±1°C; Acid concentration: 2 % w/v.
(a), (b), (c), (d), (e) and (f): Comparison of means of reducing sugar by hydrolysis time.
a, b, c, d, e and f: Comparison of means of HMF by hydrolysis time.
A, B,C,D and F: Comparison of means of reducing sugar and HMF by solid to liquid ratio %w/v.
*: ($P \leq 0.05$)

Table 3: Effect of reaction temperature on the liberation of reducing sugars

Temperature °C	ANOVA		Hydrolysis time (min)*											
			5		10		15		20		25		30	
	RS	HMF	$RS^{(f)}$	HMF^{f}	$RS^{(e)}$	HMF^{e}	$RS^{(d)}$	HMF^{d}	$RS^{(c)}$	HMF^{c}	$RS^{(a)}$	HMF^{b}	$RS^{(b)}$	HMF^{a}
80 ±1	D	E	0.049	0.000	0.073	0.000	0.121	0.003	0.313	0.015	0.411	0.032	0.454	0.111
90 ±1	C	D	0.149	0.000	0.190	0.011	0.347	0.009	0.455	0.036	0.461	0.045	0.462	0.140
100 ±1	A	C	0.198	0.008	0.298	0.025	0.431	0.041	0.464	0.077	0.474	0.096	0.466	0.178
110 ±1	B	A	0.211	0.110	0.411	0.210	0.401	0.250	0.388	0.271	0.373	0.266	0.380	0.261
121 ±1	CD	B	0.251	0.270	0.400	0.223	0.377	0.233	0.371	0.220	0.367	0.210	0.281	0.198

Reaction conditions: Acid concentration: 2 % w/v; Solid to liquid ratio: 5 % w/v.
RS: Reducing sugars (g/g waste sample). HMF: Hydroxy methyl furfural (g/g waste sample).
(a), (b), (c), (d), (e) and (f): Comparison of means of reducing sugar by hydrolysis time.
a, b, c, d, e and f: Comparison of means of HMF by hydrolysis time.
A, B,C,D and F: Comparison of means of reducing sugar and HMF by temperature.
*: ($P \leq 0.05$)

HMF increased slightly and gradually at temperatures 80 and 90°C. Maximum yield of the reducing sugars (0.474 g/g waste sample) and suitable amount of HMF (0.096 g/g waste sample) were formed at 100°C after 25 min of the hydrolysis thereafter, the yield of the reducing sugars started to decline whereas, the HMF content increased. At temperatures 110 and 121°C, it could be noted that there was a negative interaction between temperature and time which yielded lower amounts at these temperatures for long times. The decrease in reducing sugars yield at these temperatures could be attributed to loss of glucose by recombination to reversion products and dehydration to HMF (Azhar & Hamdy, 1981). The decline of HMF amount at these temperatures for long time of hydrolysis could be attributed to the conversion of HMF to levulinic and formic acids under these conditions (Kerr, 1944).

3- Effect of acid concentration on the liberation of reducing sugars

The effects of different acid concentrations (1-8% w/v) on the hydrolysis of potato-chips waste at 5% solid to liquid ratio and 100°C were investigated. The results in Table (4) show that at acid concentrations from 1-4 % (w/v), the release of reducing sugars during the hydrolysis increased with elongating the hydrolysis time and elevating the concentration of the acid. The highest amount of sugars liberated was 0.532 g/g of sample. This yield was obtained at acid concentration of 4% (w/v) for 25 min at 100°C. After that, a decrease in reducing sugars was observed, probably due to either repolimerization or degraded to by-products such as HMF (Prieto *et al.*, 1986).

Selection the proper method for detoxification

The starch cannot be utilized by yeast because it doesn't contain the appropriate enzyme to hydrolyze this substrate to fermentable sugars, thus starch is first converted to sugars (Kim &Hamedy, 1985). During the acid hydrolysis of starch, the HMF is formed; it has been known to inhibit the yeast growth (Taherazadeh, 1999). In order to verify the hydrolysate toxicity and efficient way to ferment the waste hydrolysate, the hydrolysate was treated with overliming or with charcoal. The treatments effect was evaluated chemically by determining the HMF before and after the treatment and biologically by cultivation the yeast in three different substrates of untreated hydrolysate, hydrolysate treated with charcoal and by overliming. Overliming treatment reduced the HMF in the hydrolysate from 0.939 to 0.029 % (w/v), with efficiency of 96.9 % that is to a value even lower than the threshold of complete S. cerevisiae growth inhibition. Inhibition effects of HMF on baker's yeast were reported by Ingram *et al.*, (1955) at concentration as low as 1 g/L. It is not even entirely clear whether it is the effect of the high pH or the effect of lime causes detoxification of the hydrolysate (Taherazadeh, 1999). Calcium hydroxide is stated to catalyze the concentration reactions of formaldehyde (Niitsu *et al.*, 1992). Possibly it can catalyze the concentration of other kinds of aldehydes in hydrolysates such as furfural and HMF (Taherazadeh, 1999). Data also indicated that char-

Table 4: Effect of acid concentration on the liberation of reducing sugars

Acid concentration% (w/v)	ANOVA		Hydrolysis time (min)*											
			5		10		15		20		25		30	
	RS	HMF	RS$^{(f)}$	HMF^{f}	RS$^{(e)}$	HMF^{d}	RS$^{(c)}$	HMF^{d}	RS$^{(b)}$	HMF^{c}	RS$^{(a)}$	HMF^{a}	RS$^{(d)}$	HMF^{b}
1	D	F	0.019	0.00	0.121	0.015	0.154	0.023	0.202	0.051	0.282	0.070	0.325	0.092
2	A	E	0.196	0.00	0.299	0.023	0.433	0.042	0.468	0.081	0.476	0.092	0.466	0.161
4	C	D	0.300	0.012	0.401	0.042	0.453	0.076	0.486	0.130	0.532	0.153	0.488	0.163
6	B	A	0.393	0.210	0.400	0.222	0.376	0.238	0.355	0.256	0.273	0.300	0.251	0.211
8	B	B	0.421	0.212	0.389	0.231	0.374	0.270	0.333	0.282	0.301	0.210	0.230	0.179

Reaction conditions: Temperature: 100±1°C; Solid to liquid ratio: 5 % w/v.
RS: Reducing sugars (g/g waste sample). HMF: Hydroxy methyl furfural (g/g waste sample).
(a), (b), (c), (d), (e) and (f): Comparison of means of reducing sugar by hydrolysis time.
a, b, c, d, e and f: Comparison of means of HMF by hydrolysis time.
A, B,C,D and F: Comparison of means of reducing sugar and HMF by acid concentration.
*: ($P \leq 0.05$)

coal was effective in removing the HMF with percentage 94.7%. Converti *et al.*, (2000) reported that more than 95% of lignin-derived compounds were reduced by charcoal adsorption. The results in Table (5) reveal that, the lowest cell biomass yield was corresponded to the untreated hydrolysate, however the treated hydrolysates media stimulated production of considerable cell biomass yield. This confirms presence of inhibitor substances in the untreated hydrolysate making the yeast growth difficult. From these results, it can be established that HMF, the main growth inhibitor in the hydrolysate, can be removed by overliming and charcoal treatments.

Effect of cell inoculum level on the yield of biomass production

To explore the appropriate inoculum level that is suitable for growing in overlimed-waste hydrolysate medium, different inoculum levels were tested. The results in Table (6) revealed that the maximum biomass yield was produced at 0.4 % w/v inoculum level, however concentrations above this value produced disproportionate increase in biomass yield. These results could be attributed to the autolysis, which is because the existence of disproportionate amount of nutrients as well as lower conversion efficiency (Reade & Gregory, 1975). On the other hand, use of inoculum size below 0.4 % w/v was corresponded with decrease of biomass productivity. This may be attributed to the adverse effects of HMF on yeast viability and growth as found by Chung & Lee, (1985). Also they suggested that the use of relatively high inocula level could be practical means of overcoming the toxicity of the hydrolysate.

Effect of sugar concentration on the yield of biomass production

To determine the optimum sugar concentration in the hydrolysate, which stimulates maximum biomass production, hydrolysate media with various sugar concentrations were tested. The results presented in Table (7) show that the growth of yeast increased with the increase of sugar concentrations to reach its maximum at 2 % w/v while above this concentration the biomass production started to decline. The decrease in growth at lower sugar concentration can be attributed to exhausting sugar in the medium (Kays & Vanderzant, 1980). On the contrary, the decline of biomass production at higher sugar concentration is due to that S. cerevisiae is Crabtree positive yeast, meaning that fermentative growth can happen even at aerobic conditions (Barford & Hall, 1979; Sonnleitner & Kappeli, 1986). This phenomenon gives a lowered biomass yield as well as an increase the ethanol production (Fiechter & Seghezzi, 1992).

Table 5: Growth of yeast in treated and untreated hydrolysate of potato-chips waste

Treatment	Y %	E %	Remaining sugars (g/100 ml)	Specific growth rate (g/L.h)
Without treatment	0.421 [c]	14.03 [c]	2.55 [c]	0.35 [c]
Over liming	1.25 [a]	41.66 [a]	2.15 [a]	1.04 [a]
Charcoal	1.10 [b]	36.66 [b]	2.21 [b]	0.91 [b]

Y%= Yield %(gram cell biomass/100 ml medium ×100); E%=Efficiency % (gram cell biomass/ gram sugar in the medium ×100). Fermentation conditions: inoculum size: 0.1 % w/v; sugar conc.: 3%; nitrogen source: 0.025% urea w/v; fermentation time: 12 hr; temperature: 30°C; pH: 4.5. Statistical significant differences ($P \leq 0.05$)

Table 6: Effect of cell inoculum level on the biomass yield production

Inoculum size % (w/v)	Y %	E %	Remaining sugars (g/100 ml)
0.2 [a]	1.60	53.33	1.78
0.4 [b]	1.85	61.66	1.58
0.6 [c]	1.83	61.00	1.53
0.8 [c]	1.83	61.00	1.54
1.0 [d]	1.81	60.33	1.55

Fermentation conditions: sugar conc.: 3%; nitrogen source: 0.025% urea w/v.
Y%= Yield %(gram cell biomass/100 ml medium ×100); E%=Efficiency % (gram cell biomass/ gram sugar in the medium ×100).fermentation time: 12 hr; temperature: 30°C pH: 4.5. Statistical significant differences ($P \leq 0.05$)

Table 7: Effect of sugar concentration on cell biomass production

Sugar concentration % (w/v)	Y %	E %	Remaining sugars (g/100 ml)
0.5 [d]	0.371	74.20	0.16
1.0 [c]	0.790	79.00	0.32
1.5 [b]	1.21	80.66	0.41
2.0 [a]	1.62	81.00	0.57
2.5 [b]	1.99	79.60	0.77

Fermentation conditions: inoculums size: 0.4 % (w/v dry weight); nitrogen Source: 0.025% urea w/v; fermentation time: 12 hr; temperature: 30°C; pH: 4.5. Y%=Yield %(gram cell biomass/100 ml medium ×100); E%=Efficiency % (gram cell biomass/ gram sugar in the medium ×100). Statistical significant differences ($P \leq 0.05$)

Effect of nitrogen source and concentration on the yield of biomass production

Nitrogen source is considered as the second contributer of the medium cost thereby investigation of cheap renewable nitrogenous materials like food-processing by-products was considered. Various concentrations of organic and inorganic nitrogen sources were investigated for their stimulating yeast growth. The results in Table (8) reveal that the yeast could utilize all tested nitrogen sources with variable favouration. Ammonium sulfate was found to be the best inorganic nitrogen source; on the other side wheat bran extract was the more favourite organic nitrogen source. This could be attributed to its content of other nutrients such as minerals, vitamins, amino acids etc. Moreover, they maintained the culture pH nearly constant at 4.5–5.5 during the cultivation time. But, in case of inorganic sources, the pH values of the culture increased drastically to reach about pH 8 at the cultivation end; this is possibly attributed to an effect of NH4+, which may be liberated from inorganic nitrogen compounds and thereby raises the pH values and suppress the yeast growth (Jeffries, 1985). The biomass yield which was produced with urea maintained nearly constant at all concentrations under study. It could be also observed that the concentration of nitrogen present was not as important as the nature of the nitrogen source. In general, the organic nitrogen source induced higher biomass production as compared with the inorganic one.

Effect of incubation period on the yield of biomass production:

To verify the cultivation period at which the maximum cell biomass was produced, the yeast was cultivated under the estimated optimal conditions (sugar conc. 2%, nitrogen 0.05% and inoculum size 0.4% w/v). The yeast culture was provided with the best organic nitrogen source (wheat bran extract) and the best inorganic nitrogen source (ammonium sulfate). The results shown in Fig.(1) indicate that,

Table 8: Effect of nitrogen source and concentration on the yeast growth

Nitrogen concentration / source	0.025%		0.05%		0.1%		0.15%	
	Y %	E %	Y %	E %	Y %	E %	Y %	E %
Ammonium sulfatec	1.54	77	1.68	84	1.67	83.6	1.69	84.5
Ammonium phosphatebc	1.51	75.5	1.53	76.5	1.54	77	1.51	75.5
Ammonium chlorided	1.51	75.5	1.55	77.5	1.56	78	1.56	78
Urea	1.63	81.5	1.64	82	1.63	81.5	1.64	81.8
Rice branb	1.61	80.5	1.66	83.1	1.67	83.8	1.67	83.5
Wheat brana	1.68	84	1.79	89.5	1.73	86.5	1.79	89.5
Potato extractab	1.64	82	1.64	82	1.69	84.5	1.64	82
Milk wheye	1.48	74	1.51	75.5	1.53	76.5	1.53	76.5

Y%=Yield %(gram cell biomass/100 ml medium ×100); E%=Efficiency % (gram cell biomass/ gram sugar in the medium ×100). Statistical significant differences *($P \leq 0.05$)
Fermentation conditions: inoculums size: 0.4 % (w/v); sugar conc.:2% w/v; fermentation time: 12 hr; temperature: 28°C; pH: 4.5.

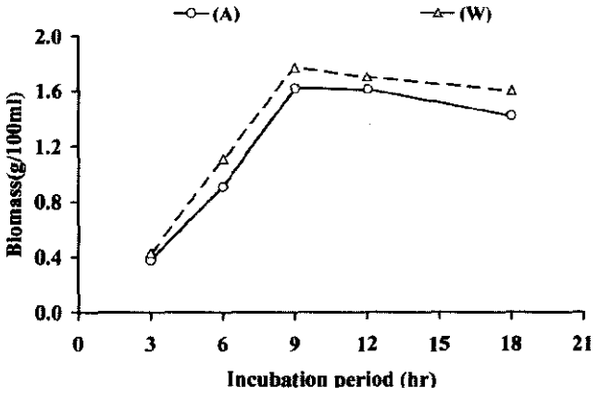

Fig 1: Time course of cell biomass production from optimized media of potato-chips waste hydrolysate (A) = Ammonium sulfate, (W) = Wheat bran

as expected lower cell biomass yield was produced from ammonium sulfate as compared with that from wheat bran at different cultivation time intervals. The yield of biomass accumulated rapidly in both used media to reach their maximum 1.73 with efficiency of 88.6 at 9 hr of cultivation (in case of wheat bran as a nitrogen source) and thereafter declined gradually as time was proceeded. Torija *et al.*, (2003) mentioned that the main variable, which affects the yeast growth might be supplying of nitrogenous substrate. The decrease in growth after 9 hr could be attributed to exhaustion of the nutrients and oxygen in the cultivation media and accumulation of metabolism by-products due to cell autolysis (Kays & Vanderzant, 1980).

Practical and economic considerations

Under optimal hydrolysis conditions (Table 4) each 1g waste sample releases 0.532g reducing sugars, this means that one ton releases 532 kg reducing sugars. From the results of the effect of incubation period on the biomass yield production (Fig.1), the fermentation efficiency of reducing sugars is 88.6% under optimal conditions. Consequently, total yield of yeast biomass from one ton equal 470.8kg (532 × 88.6 %) or each one waste unit (per weight) produced 0.470 unit of yeast biomass.

Table 9: Comparison of chemical composition of obtained and commercial baker's yeast

Parameter %	Produced yeast	Commercial yeast
Moisture	73.12	68.7
Kjeldal protein (N× 6.25)	49.02	50.91
Total carbohydrate	32.25	30.11
Ash	5.15	4.25
Ether extract	4.46	6.12

Chemical composition of the produced yeast as compared with the commercial yeast

The quality of baker's yeast mainly depends on its nutritional value and leavening power, therefore, to evaluate the produced yeast quality, a comparative study between the produced yeast and normal commercial baker's yeast (purchased from local market) was carried out based on the chemical composition. The results in Table (9) show that, the produced yeast contained high protein ratio (49.02 %) nearly similar to that of commercial yeast. The higher protein content points to good assimilation of nitrogen from the medium when the yeast was in the final phase of multiplying as outlined by (Dodic *et al.*, 2004), they also reported that high protein content points to high enzymatic activity of yeast cells and good leavening power. The results also reveal that, the produced yeast contains total carbohydrate higher than the commercial yeast by about 2 %, this carbohydrate in the cells consider as reserve food (Dodic *et al.*, 2004). In regard to the content of minerals and lipids, the produced yeast stands out as compared with the commercial yeast. It can be concluded that the characteristics of produced yeast are nearly similar to those of commercial product which produced from molasses.

Quantitatively evaluation of produced yeast quality as compared with the commercial one

To evaluate the fermentative capacity of produced yeast, fermentative activity test of produced yeast was done in parallel with commercial yeast under the same conditions. The results shown in Fig (2) indicated that, in general the leavening power of

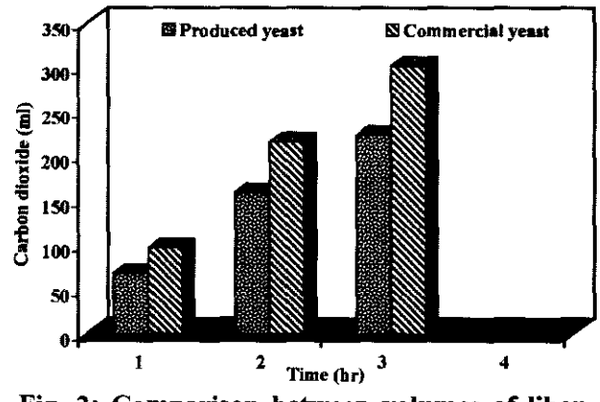

Fig. 2: Comparison between volumes of liberated CO_2 during fermentation of dough

both yeasts was high, while that of commercial yeast was about 26% higher than that of produced yeast. These results could be expected on the basis of the higher protein content of commercial yeast which due to higher enzymatic activity. It can recommend that the amount of produced yeast must increase with 26 % on being it used for bread leavening.

Sensory evaluation of the bread made by using the two yeast strains

Baking test was performed by using the produced yeast parallel with commercial yeast but the used amount of produced yeast was more than that of commercial with 26 % w/v as a substation of its lower leavening power. The final product was sensory evaluated by 24 persons according to the methods of American Institute of Baking, (1987). The results presented in Table (10) indicate that the bread made with the produced yeast was satisfying the criteria for bread. From these results, it can be suggested that the produced yeast from the fermentation of potato-chips waste is suitable for bread making.

Table 10: Evaluation of bread made by using two yeast strains

Evaluated characteristics	Score points of bread	
	Produced strain	Commercial strain
Volume	8/10	9/10
Colour of crust	7/8	8/8
Symmetry of form	3/3	3/3
Evenness of bake	3/3	3/3
Characteristic of crust	3/3	3/3
Break and shred	3/3	3/3
Grain	8/10	8/10
Colour of crumb	7/10	9/10
Aroma	8/10	8/10
Taste	10/10	10/10
Chew ability	8/10	8/10
Texture	13/15	14/15
Appearance	4/5	5/5
Total	85/100	91/100

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الإستفادة من مخلفات صناعة شرائح البطاطس في إنتاج منتجات ذات قيمة اقتصادية عالية: ١- إنتاج خميرة الخباز

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تهدف الدراسة إلى الاستفادة من مخلفات شرائح صناعة البطاطس في إنتاج خميرة الخباز كبديل رخيص للمولاس حتي يمكن خفض تكلفة إنتاج خميرة الخباز وفي نفس الوقت تلافي الأضرار البيئية الناتجة عن حرق هذه المخلفات. اشتملت الدراسة علي دراسة الظروف المثلي لتحلل المخلفات وتحويلها إلى سكريات قابلة الاستفادة بواسطة الخميرة . كذلك دراسة الظروف المثلي لإنتاج الخميرة باستخدام السكريات الناتجة من تحلل المخلفات. أوضحت النتائج الآتي: الظروف المثلي لتحلل المخلفات هي نسبة المادة الصلبة إلى السائلة ٥ ٪وزن/حجم . تركيز الحامض ٤٪ وزن/ حجم، درجة حرارة تحلل ١٠٠ درجة مئوية لمدة ٢٥ دقيقة. كما وجد أن الظروف المثلي لإنتاج الخميرة هي حجم اللقاح ٤.٠٪ وزن/حجم تركيز السكر في بيئة النمو ٢٪ وزن/ حجم ، تركيز مصدر النيتروجين في البيئة ٠.٠٥٪ وزن / حجم وزمن تخمر ٩ ساعات وبتقييم الخميرة الناتجة وجد أنها ذات قيمة غذائية عالية ومناسبة لصناعة الخبز.