

# M altogenase 和 B 淀粉酶制取超高麦芽糖浆的研究

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**摘 要:** 分别研究了液化程度对 M altogenase 和 B 淀粉酶这两种酶的糖化作用的影响以及酶的用量对麦芽糖含量的影响; 研究了制取超高浓度麦芽糖浆时 M altogenase 和 B 淀粉酶并用与脱支酶的协同作用。 研究表明: 液化程度对 M altogenase 和 B 淀粉酶的糖化作用有显著影响; 与 M altogenase 或 B 淀粉酶单独与脱支酶的糖化相比, M altogenase 和 B 淀粉酶共同与脱支酶协同作用时可得到更高纯度的超高麦芽糖浆。

**关键词:** M altogenase; B 淀粉酶; 超高麦芽糖浆

中图分类号: S377

文献标识码: A

文章编号: 100226819(2002)0120126203

根据麦芽糖含量的高低, 麦芽糖浆可分为普通麦芽糖浆、高麦芽糖浆和超高麦芽糖浆。一般麦芽糖含量: 60% 以下的麦芽糖浆为普通麦芽糖浆, 80% 以下的麦芽糖浆为高麦芽糖浆, 80% 以上的麦芽糖浆为超高麦芽糖浆<sup>[1]</sup>。超高麦芽糖浆, 尤其是麦芽糖含量 90% 以上的超高麦芽糖浆, 主要用来提纯高纯度麦芽糖。虽然结晶法、吸附法、膜分离法等分离手段不断引入麦芽糖浆的分离提纯中<sup>[2-4]</sup>, 但由于麦芽糖浆各组分相差比较小, 制取高纯度麦芽糖受到限制。因此, 尽可能提高麦芽糖浆中麦芽糖的含量, 对高纯度麦芽糖的生产有重要意义。

## 1 材料与方 法

### 1.1 试验材料

木薯淀粉: 海南琼中淀粉厂, 优级;

高温液化酶: Tem amy l 120L, NOVO, 丹麦, 酶活力单位为 LU;

B 淀粉酶: SPEZYM E Fred, 杰能科, 美国, 酶活力单位为 DP<sup>0</sup>;

M altogenase: NOVO, 丹麦, 酶活力单位为 MANU;

脱支酶: Promozyme 500 L, NOVO, 丹麦, 酶活力单位为 PUN;

### 1.2 主要仪器和设备

高效液相色谱分析仪 (HPLC): 惠普公司, 美国。

测定条件:

色谱柱: Carbohydrate A nalysis, 惠普公司, 美国; 检测器: Differential Refractometer, 惠普公司, 美国; 柱温: 30 ; 流动相 乙 甯 水 = 70 30 (V ö

V), 流速 1 mL òm in。

### 1.3 试验方法

1) 液化淀粉葡萄糖值测定: 碘量法;

2) 液化方法: 配约 30% 浓度的淀粉乳, 调 pH 值, 加入一定量的液化酶, 不断搅拌加热淀粉乳, 一定时间后升温灭酶;

3) 糖化方法: 液化液冷却至 60 后, 调整浓度至 30%, pH 值 5.2, 加酶, 在 58 恒温水浴中糖化, 一定时间后, 加热灭酶。

### 1.4 麦芽糖浆的生产工艺流程

液化酶

糖化酶

淀粉乳

液化 糖化 脱色精制 浓缩 糖浆

## 2 试验结果与分析

### 2.1 液化程度对糖化的影响的研究

#### 2.1.1 液化程度对 B 淀粉酶 M altogenase 单独糖化的影响研究

木薯淀粉乳液化到不同的 DE 值, 加入糖化酶糖化, M altogenase 的用量为 8MANU ögDS, B 淀粉酶用量 1.5 DP<sup>0</sup> ögDS。不时摇匀, 隔一定时间取样灭酶, 用 HPLC 分析糖化液组成。结果如图 1、图 2 所示。

图 1、图 2 结果显示, 液化 DE 值为 8.6 时, B 淀粉酶糖化一定时间后生成的麦芽糖含量最大; DE 值再升高, 麦芽糖含量反而有所降低。用 M altogenase 糖化一定时间后, 液化 DE 值为 12.5 时麦芽糖含量最高; 液化程度较低或较高时, 麦芽糖含量都降低。液化一方面能增加糖化酶水解的非还原尾端基, 有利于糖化生成麦芽糖; 另一方面增加了生成奇数聚合度低聚糖的机会, 不利于麦芽糖含量的提高。因此要提高麦芽糖含量液化程度应控制在适当范围内。

收稿日期: 2001207216

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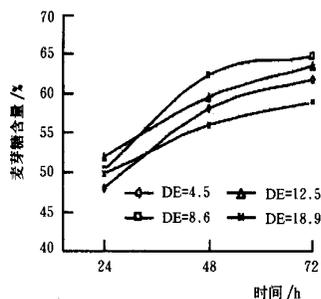


图 1 液化DE 值对 B 淀粉酶糖化的影响

Fig 1 Effect of different DE after liquefaction on the action of B-amylase in saccharification process

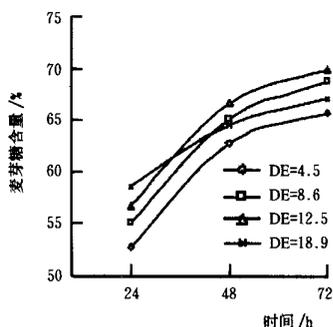


图 2 液化DE 值对 M altogenase 糖化的影响

Fig 2 Effect of different DE after liquefaction on the action of M altogenase in saccharification process

2.1.2 液化程度对 M altogenase 或 B 淀粉酶与脱支酶合并糖化的影响研究

木薯淀粉液化到不同的 DE 值后, 按 2.1.1 的用量分别加入糖化酶和脱支酶, 脱支酶用量为 0.25 PUN ögDS, 糖化一定时间后, 取样灭酶。用 HPLC 分析糖化液组成。结果如图 3、图 4 所示。

图中结果显示, 用 M altogenase 或 B 淀粉酶与脱支酶合并糖化时, 液化程度越低, 麦芽糖浆中麦芽糖的含量越高。但液化程度太低, 液化液粘度高, 不利于后续操作, 因此在不产生凝沉的前提下应尽量降低液化程度。

生产麦芽糖浆的淀粉原料中大多数含有 75%

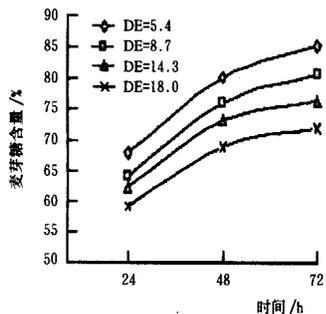


图 3 液化DE 值对 B 淀粉酶和脱支酶协同糖化的影响

Fig 3 Effect of DE after liquefaction on the coaction of B-amylase and promozyme

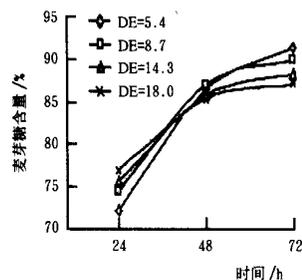


图 4 液化DE 值对 M altogenase 和脱支酶协同糖化的影响

Fig 4 Effect of DE after liquefaction on the coaction of M altogenase and promozyme

~ 85% 的支链淀粉, 一般支链淀粉含有 4% ~ 5% 的 A21, 6 糖苷键<sup>[5]</sup>, 由 2.1.1 和 2.1.2 结果看出脱支酶能显著提高麦芽糖含量, 因此脱支酶是生产超高麦芽糖浆必不可少的。

2.2 M altogenase 和 B 淀粉酶用量对麦芽糖含量的影响研究

根据前面的研究结论, 淀粉液化 DE 值选定在 7.1, 按 0.25 PUN ögDS 的用量加脱支酶和不同用量的糖化酶, 糖化 72 h 后, 加热灭酶, 用 HPLC 分析糖化液组分。结果如表 1、表 2 所示。

表 1 B 淀粉酶用量 (DP<sup>0</sup>ögDS) 对糖化液中麦芽糖含量的影响

Table 1 Effect of B-amylase dosage (DP<sup>0</sup>ögDS) on maltose formation

酶用量	葡萄糖	麦芽糖	麦芽三糖
0.75	0.40	79.89	19.71
1.5	0.61	83.63	15.77
3.0	0.71	81.21	16.29
7.5	1.62	81.71	15.58

表 2 M altogenase 的用量 (MANU ögDS) 对糖化液中麦芽糖含量的影响

Table 2 Effect of M altogenase dosage (MANU ögDS) on maltose formation

酶用量	葡萄糖	麦芽糖	麦芽三糖
4	9.75	86.67	3.58
8	10.23	89.77	—
12	9.51	90.49	—
24	10.26	89.74	—
32	11.48	88.52	—

由表 1、表 2 得, 用不同用量的 B-淀粉酶 M altogenase 与脱支酶协同糖化, 麦芽糖的生成都有一个最高极限。糖化酶用量再增加, 麦芽糖生成量不但不增加, 反而会降低, 用 M altogenase 糖化麦芽糖降低得更多。所以单纯依靠增加酶的用量, 不能提高麦芽糖含量, 甚至还会下降, 且增加了生产成本。

2.3 M altogenase 和 B 淀粉酶并用生产超高麦芽

## 糖浆的研究

淀粉液化至DE 值为 7.1, 脱支酶用量为 0.25 PUNögDS,  $\beta$ 淀粉酶用量 1.5 DP<sup>0</sup>ögDS, Maltogenase 用量 8 MANU ögDS, 并各取  $\beta$ 淀粉酶和 Maltogenase 上述用量的一半并用糖化研究合并糖化的效果。用 HPLC 分析糖化液成分。结果如图 5 所示。

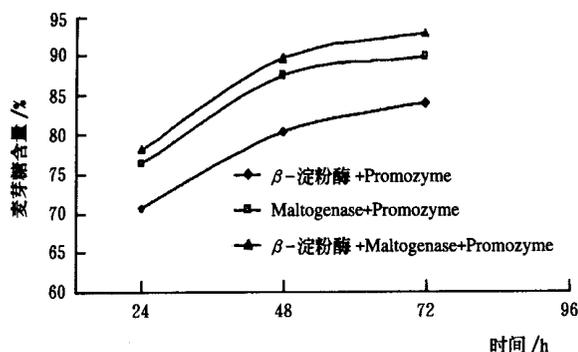


图 5 Maltogenase 和  $\beta$ 淀粉酶协同作用的糖化结果

Fig 5 Result of coaction of  $\beta$ enzyme and Maltogenase on maltose formation

图 5 结果表明,  $\beta$ 淀粉酶和 Maltogenase 两种糖化酶并用与脱支酶一起糖化, 比  $\beta$ 淀粉酶或 Maltogenase 单独与脱支酶糖化时生成的麦芽糖含量高, 可以得到更高纯度的超高麦芽糖浆。

## 3 结论

1) 液化程度对糖化液中麦芽糖含量有重要影响。只用  $\beta$ 淀粉酶或 Maltogenase 糖化时, 液化程度升高到一定程度时, 糖化液中麦芽糖含量最高; 液化程度升高或降低都不利于麦芽糖的生成。  $\beta$ 淀粉酶或 Maltogenase 与脱支酶共同糖化时, 液化程度越低, 糖化液中麦芽糖含量越高; 在生产超高麦芽糖时, 要控制液化程度, 在不产生凝沉的前提下, 尽可能降低液化程度。

2) 与 Maltogenase 或  $\beta$ 淀粉酶单独与脱支酶糖化相比, Maltogenase 和  $\beta$ 淀粉酶共用与脱支酶协同作用时可得到更高纯度的超高麦芽糖浆。

### [参 考 文 献]

- [1] 张力田 淀粉糖[M] 北京: 中国轻工业出版社, 1998 83~ 287.
- [2] 尤 新 淀粉精品生产与应用手册[M] 北京: 中国轻工业出版社, 1997, 49
- [3] Tachauer E, Cobb J T, Shan Y T. Hydrolysis of starch by a mixture of enzymes in a membrane reactor[J] Biotechnology and Bioengineering, 1974, 16(3): 545~ 550
- [4] Madgarkar A M, Shan Y T, Cobb J T. Hydrolysis of starch in a membrane reactor[J] Biotechnology and Bioengineering 1977, 19(11): 1719~ 1726
- [5] [日]二国二郎 王微青等译 淀粉科学手册[M] 北京: 中国轻工业出版社, 1990, 31~ 44, 496~ 502

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**Abstract:** The K cycle of rubber-tea-chicken ecological agricultural model, a typical tropical agro-forestry system in Wenchang municipality of Hainan Province was studied with quantitative experiment and qualitative analysis, compared with rubber and rubber-tea. The results showed that the K cycling rate, K output and K surplus in soil of rubber-tea-chicken agro-forestry system were all the highest, being 59%, 134.5 kgÖhm<sup>2</sup> and 168.2 kgÖhm<sup>2</sup>, respectively. The ratio of K output to K input of chicken subsystem was 91% and the ratio of K output to K input in chicken products was only 23%. Amount of cycling K inside chicken garden is the highest, being 414.9 kgÖhm<sup>2</sup>, the K cycling structure of rubber-tea-chicken agro-forestry system is more reasonable structure, and its K cycling was the most active.

**Key words:** agro-forestry system; ecological agricultural model; K cycle; rubber-tea-chicken

## · Agro-product Treatment Technology and Processing Engineering ·

### Compound Preservative Technology and Vacuum Package for Beef ..... (118)

Jia Yingmin, Wang Ling, Ma Ai'jin, Zhang Zide, Chen Zhizhou (Institute of Food Science and Technology, Hebei Agricultural University, Baoding 071001, China)

**Abstract:** The preservative and color protective agents used for beef preservation were studied and screened out. The compound preservative formula was studied by the experiments for combining the preservative and color protective agents. It was combined with vacuum package and the vacuum compound preservative bags were prepared for beef preservation. The bags were used in beef vacuum package for preservation. The preserved period reached 35 days with good quality indexes.

**Key words:** beef; vacuum package; compound preservation

### Interaction Mechanism of Two Strains in Production of Microbiological Protein (MBP) 4320 for Feed Use ..... (122)

Guo Weilie, Guo Qinghua, Xie Xiaobao, Xu Hong (Guangdong Institute of Microbiology, Guangzhou 510070, China)

**Abstract:** This paper reports for the first time that the MBP fermentation is based on the relationship between the two selected good strains of *Candida albicans* 2361 and *Aspergillus niger* No. 303, which is commensalism. The floras, like the appearance of hybridization formed by *C. albicans* 2361 when it is co-cultivated with No. 303 in 4320 MBP fermentation, are proved to be a specific feature of commensalism through Fusant Test, Heterocaryon Test, Substrate Mycelia Observation, Diffusion Block Test and Microscopic Examination. The quantity of floras directly reflects the extent of commensalism and the quality of MBP 4320 as well, which is of great application value. Effective factors in commensalism are citric acid, protease, glucanase, and amylase produced by No. 303, and they function directly, indirectly and cooperatively. Among the factors, amino acids, especially Glu, catalyzed by protease from No. 303 and citric acid produced by No. 303 can stimulate growth of No. 2361 strikingly. They are the two newly found top commensal factors in producing MBP from starch materials, which is discovered through orthogonal test and is completely different from other reports that the main factors in producing SCP with starch materials are such enzymes as glucanase.

**Key words:** microbiological protein; interaction mechanism; commensalism

### Application of Maltogenase and B-Enzyme to the Production of Maltose Syrup ..... (126)

Zhou Jianqin<sup>1</sup>, Luo Faxing<sup>2</sup> (1. Department of Biology and Food, Hefei University of Technology, Hefei 230069, China; 2. College of Food Engineering and Biology, South China University of Technology, Guangzhou 510640, China)

**Abstract:** The effect of liquefaction degree on saccharification of Maltogenase and B-enzyme and the effect of raising dosage of saccharifying enzymes on the maltose content are studied in this paper. The combination of Maltogenase, B-enzyme is also studied. Based on the above experiments, the liquefaction degree has a profound effect on saccharification; the combination of Maltogenase, B-enzyme is found to be able to increase maltose content effectively.

**Key words:** maltogenase; Enzyme; extremely high maltose syrup

**Starch Paste Clarity and Its Influence Factors** ..... (129)

Du Xianfeng<sup>1</sup>, Xu Shiyong<sup>2</sup>, Wang Zhang<sup>2</sup> (1. *Department of Food Engineering, Anhui Agricultural University, Hefei 230036, China;* 2. *School of Food Science, Wuxi University of Light Industry, Wuxi 214036, China*)

**Abstract:** Starch paste clarity and the effects of molecular structure, retrogradation and some food ingredients such as NaCl, sucrose and citric acid were investigated. The experimental results indicate that the starch molecular structure is the principal factor to influence the starch paste clarity. NaCl was proved to be able to reduce starch paste clarity, and sucrose, citric acid are proved to be able to increase the clarity. During the initial storage period (4, 0~4 d), the clarity decreased abruptly, then it gradually decreased to its minimum as the leached but amylose completely formed a three-dimensional network with amylopectin embedded in and reinforced to the interpenetrating amylose gel matrix.

**Key words:** starch paste; clarity; molecular structure; food ingredient; retrogradation

**Experimental Study on Extruded Rice Used as Beer Adjunct** ..... (132)

Shen Dechao, Meng Yang (*Engineering Technology College, Northeast Agricultural University, Harbin 150030, China*)

**Abstract:** In this paper the influence of the parameters of the extrusion system of rice used as beer adjunct on indexes observed was studied by experiments in the laboratory. These parameters are the diameter of nozzle, barrel temperature, moisture content of rice and screw speed. The indexes include total reduced sugar concentration and filtration rate. The research results indicate that the extruded rice can be used as beer adjunct.

**Key words:** rice; extrusion; beer adjunct

**Rheological Law of the Crop Stem Fibrous Material During Compression Process** ... (135)

Yang Mingshao, Zhang Yong, Li Xuying (*Inner Mongolia Agricultural and Husbandry University, Hohhot 010018, China*)

**Abstract:** The exploitation of the loose crop material needs compression process. To determine the structural parameters and optimize the design of compression equipment, the law of compression process, the relationship among main parameters in the whole compression process and the characteristics of the material to be compressed are investigated. Based on the achievement acquired by our research group, a basic law of the stress and strain variation pattern was obtained by use of advanced measuring means, which provided a theoretical basis for the further study and optimum design of compression equipment.

**Key words:** crop material; rheology; compression

**Extraction Technology of Soluble Polysaccharides From Wild Patrinia Villosa** ..... (138)

Zhu Jiajin (*College of Agricultural Engineering and Food Science, Zhejiang University, Hangzhou 310029, China*)

**Abstract:** Patrinia villosa (P. V.) can cure diarrhea, but it can also do good to constipation. Not only the leaves and the stems can relax the constipation, but also the water-solution extracted from P. V. has the similar function. In order to know the effective ingredients to prevent and cure constipation extracted in the water-solution, the extraction technology of soluble polysaccharides from wild P. V. was studied, and single factor test and orthogonal experiment design methods (L<sub>9</sub>(3<sup>3</sup>)) were applied to analyze the influence of each factor in solid-liquid ratio, temperature and time on the extraction percent of the polysaccharides from the water solution of P. V.. Experimental results indicated that temperature and solid-liquid ratio significantly affect the extraction percent of the soluble polysaccharides. The optimum solid-liquid ratio is 1:20, temperature is 100 and the extraction time is 6 hours. In this condition, the extraction percent of soluble polysaccharides is 25.8%.

**Key words:** patrinia villosa; soluble polysaccharides; extraction technology; content measurement; phenol-sulfate method; constipation

**Extraction of Flavonoid From Pagodatree Flower** ..... (142)