挤压膨化大米做啤酒辅料的试验研究

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摘 要: 该文通过实验室试验, 研究了做啤酒辅料的大米挤压膨化系统诸参数(模孔孔径、套筒温度、物料含水率、螺杆转速), 对醪液的主要考察指标(麦汁醪液的总还原糖、过滤速度)的影响规律, 指出挤压膨化大米做啤酒辅料的可行性。

关键词: 大米; 挤压; 啤酒辅料
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挤压膨化啤酒辅料是20世纪90年代啤酒酿造技术发展趋势之一[1], 因为挤压膨化能使谷物中淀粉和蛋白质降解, 脂肪减少, 可溶性物质增加, 这有利于在酿造业应用该项技术。国内外学者的研究表明: 用膨化啤酒辅料制备的麦汁, 糖化和过滤困难[2~6]。本文在前人研究的基础上, 以膨化大米啤酒辅料制备的麦汁的总还原糖和过滤速率为主要考察指标。通过实验室试验, 研究挤压膨化大米做啤酒辅料时, 挤压膨化系统诸参数对其麦汁的糖化和过滤性能的影响规律。研究表明, 只要挤压膨化系统参数选择合适, 膨化大米啤酒辅料制备的麦汁, 难于糖化和过滤的难题是可以解决的。现已申报发明专利。

1 试验材料、设备及分析方法

1.1 设备与材料

挤压设备为自制的单螺杆挤压膨化机, 生产率为100～150 kg/h, 它由组合套筒和螺杆组成, 螺杆转速为0～1 200 r/min, 无级变速, 套筒温度为0～300℃连续可调, 配有温度数显仪表闭环自控系统, 挤压机模孔孔径可有级调节。

供试材料为大米(品种: 松938, 产地: 五常), 粉碎后, 其平均粒径 $d_{大米} = 0.55$ mm, 其含水率为 $W_{大米} = 12.5\%$。

1.2 分析方法

大米含水率测定采用GB 5497-85标准测定, 麦汁醪液的总还原糖按文献[7]的有关规定进行测定。麦汁醪液的过滤速率, 按文献[8]的有关方法进行测定。

表1 因素水平

Table 1 Factors and their levels

	X_1 (φ/mm)	X_2 (T/℃)	X_3 (W/%)	X_4 (N/r·min^{-1})
-2	8	35	10.0	100
-1	10	55	14.5	140
0	12	75	19.0	180
1	14	95	23.5	220
2	16	115	28.0	260

2 试验与结果分析

2.1 试验安排及其结果

试验因素为: 挤压机套筒温度 T、模孔孔径φ、物料含水率 W 和螺杆转速 N。考查指标为: 膨化大米对应麦汁醪液的总还原糖和过滤速率。采用二次正交旋转组合设计进行试验研究。因素水平安排见表1, 试验安排及结果见表2。

挤压膨化大米的糖化工艺为:

麦芽粉碎物(30 g)、挤压膨化大米粉碎物(20 g)和水(250 mL)混合加热至37℃, 保温并搅拌10 min。再升温至50℃, 保温并搅拌50 min。再升温至68℃, 保温并搅拌60 min。然后作碘检。再升温至76℃, 将麦汁醪液过滤。

未膨化大米的传统糖化工艺为:

大米粉碎物(15 g)和水(110 mL)混合加热至37℃, 保温并搅拌10 min。再升温至70℃, 保温并搅拌20 min。再升温至100℃, 保温并搅拌50 min。与此同时, 麦芽粉碎物(35 g)和水(140 mL)混合加热至37℃, 保温并搅拌10 min。再升温至50℃, 保温并搅拌50 min。将上述两种醪液混合, 即合醪。使合醪后的醪液温度为68℃, 保温并搅拌60 min。然后作碘检。再升温至76℃, 将麦汁醪液过滤。

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表 2　试验安排及结果

Table 2　Experimental arrangement and results

序号	` X_1	T X_2	W X_3	N X_4	过滤速率 ömL·s^{-1}	总还原糖 ög·L^{-1}
1	1	1	1	1	0.098	99.62
2	1	1	1	-1	0.093	98.30
3	1	1	-1	1	0.048	101.64
4	1	1	-1	-1	0.046	100.72
5	1	-1	1	1	0.119	100.19
6	1	-1	1	-1	0.119	100.83
7	1	-1	-1	1	0.119	99.79
8	1	-1	-1	-1	0.079	102.11
9	-1	1	1	1	0.139	100.82
10	-1	1	1	-1	0.104	103.72
11	-1	1	-1	1	0.044	102.43
12	-1	1	-1	-1	0.037	101.22
13	-1	-1	1	1	0.185	103.20
14	-1	-1	1	-1	0.128	101.59
15	-1	-1	-1	1	0.046	102.13
16	-1	-1	-1	-1	0.042	102.58
17	2	0	0	0	0.069	100.74
18	-2	0	0	0	0.042	104.83
19	0	2	0	0	0.043	103.11
20	0	-2	0	0	0.098	99.28
21	0	0	2	0	0.076	102.51
22	0	0	-2	0	0.031	107.91
23	0	0	0	2	0.139	99.57
24	0	0	0	-2	0.119	99.19
25	0	0	0	0	0.111	106.97
26	0	0	0	0	0.088	107.88
27	0	0	0	0	0.064	103.32
28	0	0	0	0	0.072	103.72
29	0	0	0	0	0.076	103.17
30	0	0	0	0	0.069	104.04
31	0	0	0	0	0.072	103.49
32	0	0	0	0	0.088	107.52
33	0	0	0	0	0.079	107.24
34	0	0	0	0	0.083	104.03
35	0	0	0	0	0.067	102.71
36	0	0	0	0	0.076	104.04
未膨化大米对应醪液					0.139	98.06

2.2　试验结果分析

用 REDA 软件处理表 2 中试验数据。设 Y_1、Y_2 分别代表各考察指标 —— 总还原糖、过滤速率, 设 X_1、X_2、X_3、X_4 分别代表挤压系统主要参数 —— 模孔孔径、套筒温度、大米的水分含量、螺杆转速。各试验因素对诸考查指标影响规律的回归方程为(1) 及(2)。

$$Y_1 = 104.84 - 0.945X_1 + 0.155X_2 - 0.631X_3 - 0.020X_4 - 0.654X_1^2 - 0.083X_1X_2 - 0.393X_1X_3 - 0.012X_1X_4 - 1.052X_2^2 - 0.172X_2X_3 + 0.147X_2X_4 - 0.048X_3^2 + 0.002X_3X_4 - 1.506X_4^2 \quad (A= 0.05) \tag{1}$$

$$Y_2 = 0.079 + 0.002X_1 - 0.014X_2 + 0.026X_3 + 0.008X_4 - 0.004X_1^2 - 0.005X_1X_2 - 0.016X_1X_3 - 0.004X_1X_4 - 0.003X_2X_4 - 0.004X_3^2 + 0.003X_3X_4 + 0.015X_4^2 \quad (A= 0.05) \tag{2}$$

大米挤压膨化系统主要参数的因子贡献率见表 3, 其计算最优值见表 4。统计频数选优[9]的较优参数范围见表 5。

表 3　大米挤压膨化系统主要参数的因子贡献率

Table 3　The factor contribution ratio of parameters of extrusion system of rice used as beer adjunct

考察指标	挤压系统主要参数的因子贡献率			
	X_1ö`	X_2öT	X_3öW	X_4öN
总还原糖(Y_1)	1.597	0.905	0.648	0.954
过滤速率(Y_3)	0.578	0.924	1.755	1.706

表 4　大米挤压膨化系统主要参数的计算最优值

Table 4　The calculated optimum values of main parameters of rice extrusion system

考察指标	挤压系统主要参数的计算最优值				
	` ömm	T ö°C	W ö%	N ör·min^{-1}	Y_{max}
总还原糖(Y_1ög·L^{-1})	12	80	10	180	105.99
过滤速率(Y_2ömL·s^{-1})	8	35	28	260	0.28

表 5　统计频数选优结果

Table 5　The results obtained by statistical frequency optimization

考察指标及其范围	大米挤压系统较优参数			
	` ömm	T ö°C	W ö%	N ör·min^{-1}
总还原糖(Y_1ög·L^{-1}) 100 < Y_1	8.8～11.5	77.5～77.6	16.9～18.5	176.02～184.0
过滤速率(Y_2ömL·s^{-1}) 0.18 < Y_2	9.8～11.2	52.0～67.6	24.1～26.2	249.0～259.0

注: 表中大米挤压系统较优参数的置信区间为 95%。

由上述回归方程(1)至(2)及表 3、表 4 可知, 对于总还原糖, 孔径对其影响是最主要的, 转速和温度的影响是次要的, 大米的水分含量的影响是最次要的。水分增加则总还原糖含量略下降。温度增加总还原糖先增加, 后下降, 套筒的温度为 80°C时, 总还原糖有极大值。转速为零水平时, 总还原糖有极大值。模孔的孔径增加时, 总还原糖先增加, 后下降, 模孔的孔径` = 12 mm 时, 总还原糖有极大值。对于过滤速率, 温度的影响是最主要的, 转速和孔径的影响是次要的, 大米的水分含量的影响是最次要的。温度增加, 过滤速率减低, 温度 T = 35°C时, 过滤速率有极大值。孔径增加过滤速率增加, 但变化范围不大。水分增加过滤速率增加。转速增加过滤速率下降, 但变化范围不大。

由于国内外学者普遍认为, 膨化啤酒辅料制备

的麦汁, 难于糖化和过滤。现以膨化大米啤酒辅料制备的麦汁的过滤速率和总还原糖为主要考察指标。

由表 2 可见, 第 9 号试验、第 13 号试验、第 23 号试验的试验结果较理想。其总还原糖和过滤速率的对应值分别为 99.57～103.20 $g \cdot L^{-1}$和 0.139～0.185 $mL \cdot s^{-1}$。对照的不膨化大米的对应值分别为 98.06 $g \cdot L^{-1}$和 0.139 $mL \cdot s^{-1}$。可见, 大米挤压膨化物对应麦汁醪液的总还原糖值和过滤速率均大于对照样——不膨化大米的麦汁醪液的对应值。由表 2、表 3、表 4、表 5 和上述回归方程(1)、(2)可见, 大米挤压膨化系统主要参数较优范围为: 8 mm < ` < 12 mm, 35℃< T < 80℃, 10% < W < 26.5%, 176 $r \cdot min^{-1}$< N < 260 $r \cdot min^{-1}$。试验表明, 只要挤压膨化系统主要参数选择合适, 挤压膨化大米做啤酒辅料制备的麦汁, 难于糖化和过滤的难题是可以解决的。在啤酒酿造中应用膨化啤酒辅料而产生的其他问题, 需进一步研究。

3 结 论

1) 只要挤压膨化啤酒辅料的参数选择合适, 挤压膨化大米可以做啤酒辅料, 其麦汁难于糖化和过滤的难题可以解决。

2) 可以用大米啤酒辅料的挤压膨化工艺过程代替其传统的蒸煮糊化工艺过程。

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Key words: maltogenase; B2enzyme; extremely high maltose syrup

Starch Paste Clarity and Its Influcence Factors ·· (129)

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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 leached2but amylose completely formed a three2dimensional 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)

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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)

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Abstract: The exploition 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 characteristerics 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)

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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 water2solution extracted from P. V. has the similar function. In order to know the effective ingredients to prevent and cure constipation extracted in the water2solution, the extraction technology of soluble polysaccharides from wild P. V. was studied, and single factor test and orthogonal experiment design methods ($L_9(3^3)$) were applied to analyze the influence of each factor in solid2liquid ratio, temperature and time on the extraction percent of the polysaccharides from the water solution of P. V.. Experimental results indicated that temperature and solid2liquid ratio significantly affect the extraction percent of the soluble polysaccharides. The optimum solid2liquid ratio is 1∶20, temperature is 100℃ and the extraction time is 6 hours. In this condition, the extraction percent of soluble polysaccharides is 2.58%.

Key words: patrinia villosa; soluble polysaccharides; extraction technology; content measurement; phenol2sulfate method; constipation

Extraction of Flavonoid From Pagodatree Flower ·· (142)