



Research Association of Animal Products Processing of Inner Mongolia

内蒙古畜产品加工研究会



## 简介

内蒙古畜产品加工研究会成立于1988年，挂靠于内蒙古农业大学食品科学与工程学院。我会现有会员105人，其中教授、博士生导师有7人，副教授17人，企业董事长、总经理等高管21人，博士、硕士学位以上人员占比超过了60%。我会是畜产品加工领域的科技工作者、企业家自愿组成的全区性、学术性、非营利性社会组织，具有社会团体法人资格，是党和政府联系全区畜产品加工业科技工作者及生产企业的桥梁和纽带，是支撑我区畜产品加

工业科技发展的主要社会力量。

学会围绕内蒙古自治区“乳与乳制品、肉与肉制品和动物副产品”等畜产品科学研究与产业化开发，以学术研究与交流为主要活动形式，团结和凝聚我区畜产品行业广大科技工作者和企业家，推动产、学、研相结合，努力促进我区畜产品行业科技创新、成果转化和技术推广。

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# 学会风采

## 第六届四次学术年会暨绿色畜产品安全生产关键技术交流

### 研讨与党建工作会议



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# 一、优秀海报



## 羊骨胶原多肽螯合钙的结合特性及稳定性研究

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### Introduction

我国是羊肉生产与消费大国, 随着养殖业的迅猛发展, 羊肉产量逐年递增, 其副产物羊骨的产量也随之迅速增加。由于我国畜禽骨副产物加工水平较为落后, 导致绝大部分羊骨副产品主要用来加工骨粉、骨泥等附加值低的产品, 甚至被丢弃, 这严重造成资源的浪费。但羊骨中含有丰富的蛋白质以及人体所需的多种必需氨基酸。同时羊骨中钙的含量是等量鲜肉的几十甚至上百倍, 钙磷比近似为2:1, 是适合人体吸收的最佳比例。因此如何高效开发和利用羊骨副产物中的营养物质变得至关重要。

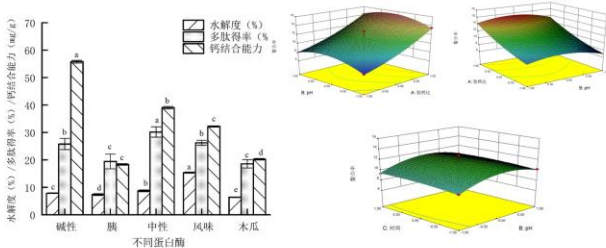
本研究以羊骨为原料, 采用双酶法水解, 得到具有钙结合能力的羊骨多肽, 并对羊骨多肽和肽钙螯合物的结构、稳定性和抗氧化性进行分析。项目的研发为羊骨副产物的加工与利用提供一种新思路与方法。



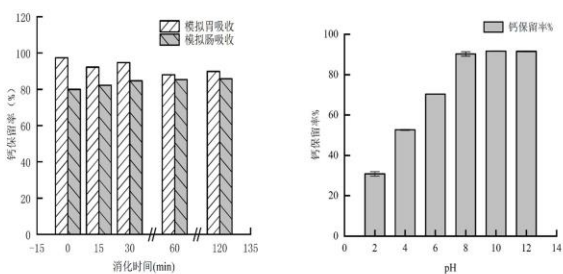
注: 上图从左往右依次是羊骨、骨粉、羊骨多肽

### Results & Discussion

使用五种不同的蛋白酶(碱性蛋白酶, 中性蛋白酶, 风味蛋白酶, 木瓜蛋白酶和胰蛋白酶)在它们的最佳温度和pH值下酶解骨粉, 以研究其水解度, 肽产量和钙结合能力。酶水解产物的钙结合能力的顺序为: 碱性>中性酶>风味>胰蛋白酶>木瓜。碱性蛋白酶具有最高的钙结合能力, 但是其水解度低于中性蛋白酶和风味蛋白酶。然后利用单因素和响应面试验得到其最优螯合工艺为螯合时间45℃、肽钙质量比3:1、螯合pH 7, 此时螯合率最高可达88.38%。



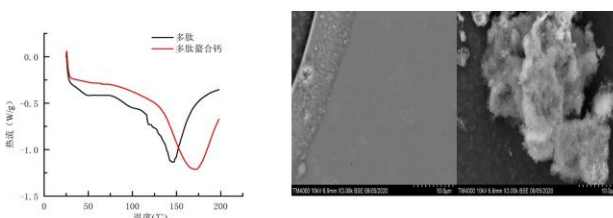
研究肽钙螯合物在不同pH值和模拟胃肠道消化条件下的稳定性, 结果发现胃蛋白酶对螯合物的稳定性影响不大, 但对pH值敏感, 酸性条件下螯合物的不稳定性导致结合钙解离成离子状态。胃消化后加入胰酶进行第二次消化, 钙保留率显著下降, 随后缓慢回升。



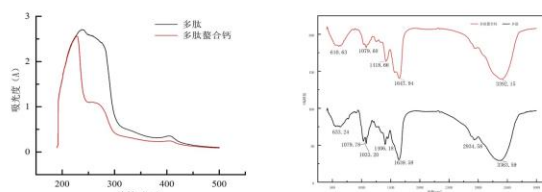
模拟后, 肽和肽钙螯合物的DPPH清除能力和还原能力均略有下降, 这可能是由于在SGID后形成了具有较低抗氧化活性的新片段。然而, 对于羟基自由基清除活性, 消化后SBPHs和SBPHs-Ca的值分别从62.74%、52.4%增加到95.1%和96.8%。这可能是由于消化后, 大量的His残留物暴露于肽和肽钙螯合物的表面, 对OH·清除具有刺激作用。

	羟自由基清除能力 (%)		DPPH 自由基清除率 (%)		总抗氧化能力	
	模拟前	模拟后	模拟前	模拟后	模拟前	模拟后
多肽	62.74±0.19	95.61±0.22	55.08±0.24	49.66±1.2	0.434±0.05	0.323±0.005
多肽螯合钙	52.4±0.21	96.83±0.16	57.92±0.15	55.36±0.45	0.327±0.12	0.269±0.24

多肽螯合钙的结构比多肽更稳定, 断裂所需的能量也较大, 因此断裂温度升高, 表明羊骨多肽具有很好的热稳定性。从扫描电镜结果可以看出多肽表面光滑细腻, 呈片状结构。螯合后变得疏松, 多孔状, 不规则, 表面有“镶嵌”着白色颗粒。



通过紫外光谱可以发现当多肽螯合钙的最大吸收峰整体移向短波波长, 这可能是Ca<sup>2+</sup>与肽中的N和O形成复合键, 从而影响肽键上的C=O和-NH<sub>2</sub>电子跃迁; 傅里叶红外光谱分析, 多肽与钙的结合主要是通过羧基氧原子和氨基氮原子的相互作用。



由表可知, 羊骨多肽和肽钙螯合物中谷氨酸(Glu)和天冬氨酸(Asp)的相对含量较高, Asp和Glu被认为是影响多肽的钙结合能力的关键氨基酸。说明羊骨多肽具有良好的钙螯合活性。

氨基酸种类	羊骨g/100g	多肽g/100g	多肽螯合钙g/100g
天冬氨酸/Asp	1.30	3.46	3.76
苏氨酸/Thr	0.60	1.62	0.90
丝氨酸/Ser	0.67	1.97	1.04
谷氨酸/Glu	2.03	6.04	6.16
脯氨酸/Pro	1.60	5.11	1.57
甘氨酸/Gly	2.54	9.86	5.96
丙氨酸/Ala	1.40	4.82	2.32
半胱氨酸/Cys	0.11	0.11	0.16
缬氨酸/Val	0.72	1.97	0.76
蛋氨酸/Met	0.17	0.55	0.28
异亮氨酸/Ile	0.39	1.06	0.51
亮氨酸/Leu	1.12	3.01	1.10
酪氨酸/Tyr	0.39	0.98	0.55
苏丙氨酸/Phe	0.69	1.75	0.73
赖氨酸/Lys	1.05	2.60	1.79
组氨酸/His	0.37	0.84	0.56
精氨酸/Arg	1.32	4.33	2.54



# 苏尼特羊肥尾脂质代谢分析

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内蒙古农业大学

内蒙古畜产品加工研究会  
第六届四次学术年会

## Introduction

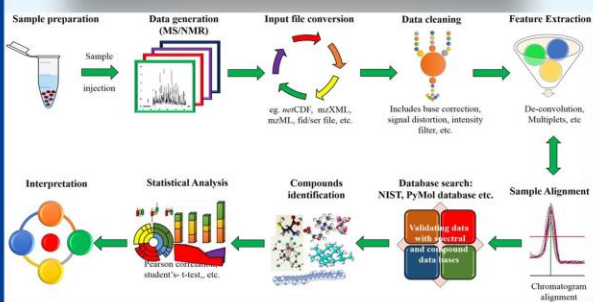
羊肉副产物中有许多潜在的功能性物质, 但某些副产物尚未得到认真的对待和使用, 例如, 绵羊的肥尾、羊皮、羊毛等造成了大量的库存积累和浪费……地方优良品种资源蒙古羊是内蒙古地区绵羊中的主体。蒙古羊的尾巴短而肥厚, 尾宽大于尾长, 又被人称为肥尾羊。随着我国肉羊养殖业的不断扩大, 屠宰量也不断加大, 必然导致羊尾的大量积压, 平均每只羊尾部脂肪、肾周围脂肪以及网油重量达4kg以上。羊油脂不能长期贮藏, 并且油脂氧化酸败会造成环境污染等问题, 我国针对羊油脂综合利用的研究很少, 所以针对羊油脂综合利用有待于开展更深入的研究。



## Methods

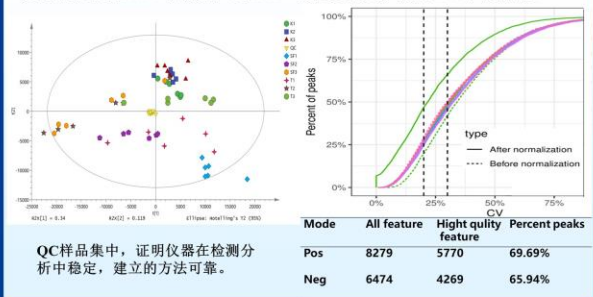
本研究采用脂质代谢组学方法, 采取了6、18、30月龄的羊尾脂(T)、肾周围脂肪(K)、以及皮下脂肪(SF)组织进行研究

- 1、称取等量的脂肪组织样品, 液氮研磨。
- 2、向样品加入120 μl 50%甲醇, 震动混匀, 常温静置10min。
- 3、提取液放-20℃过夜, 沉淀样品中的蛋白质。
- 4、4000g离心20min, 将上清液转移到96孔板中。
- 5、利用稀释液(异丙醇: 乙腈: 水=2:1:1, 体积比)稀释脂质提取液。
- 6、稀释后的脂质提取液每个样品等量提取10 μl混合成QC样品。
- 7、所有脂质代谢样品在上样前放-180℃冰箱保存。

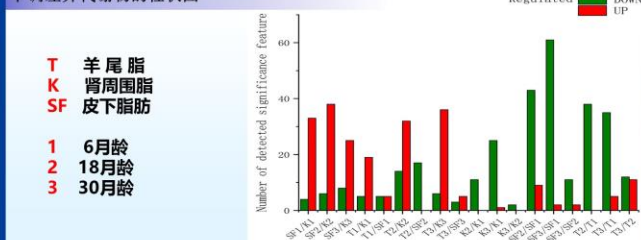


## Results

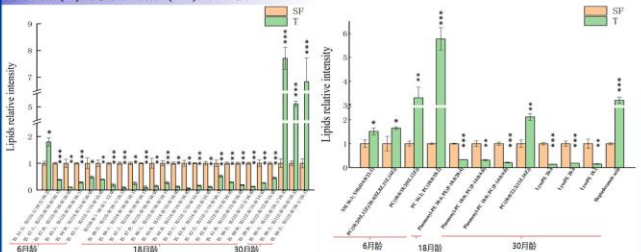
所有样品经XCMS软件提取后, 正离子模式下提取到8279个物质, 负离子模式下提取到6474个物质; 通MS2二级鉴定最终共确定205个代谢物。



经MS2二级检测后, 鉴定组与组之间具有显著性上下调差异代谢物的柱状图



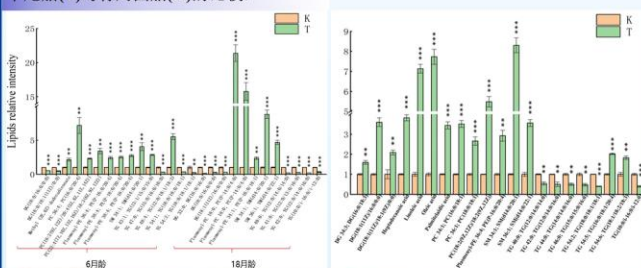
羊尾脂(T)与皮下脂肪(SF)的比较:



羊尾脂(T)与皮下脂肪(SF)的TG比较:  
6月龄时, TG S1:5 TG(15:1/18:2/18:2)在羊尾脂中呈增加趋势(P<0.05),  
18月龄: 羊尾脂中所有的甘油三酯与皮下脂肪比, 均显著减少(P<0.01).  
30月龄时: 羊尾脂中所有的甘油三酯与皮下脂肪比, 极显著增加 (P<0.001).

羊尾脂(T)与皮下脂肪(SF)比较:  
6月龄, 鞘脂和甘油磷脂显著增加(P<0.05)  
18月龄, 仅有PE 38:4极显著增加 (P<0.001)  
30月龄, 甘油磷脂类中仅有PC(18:0/22:0(13Z,16Z))显著增加(P<0.01);  
Heptadecanoic acid极显著增加(P<0.001)

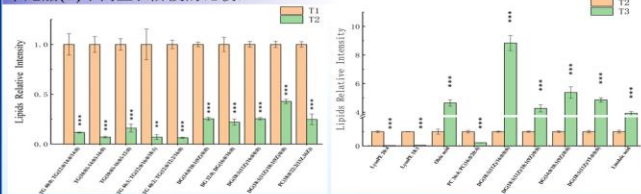
羊尾脂(T)与肾周围脂肪(K)的比较:



6、18月龄羊尾脂(T)与肾周围脂肪(K)比较:  
6月龄, 甘油二酯显著减少(P<0.001);  
甘油磷脂以及鞘脂显著增加(P<0.01)  
甘油三酯: TG 43:1 与TG 48:4显著增加(P<0.001).  
18月龄, 甘油酯类均显著减少(P<0.01)  
甘油磷脂及鞘脂均显著增加(P<0.01)

30月龄羊尾脂(T)与肾周围脂肪(K)比较:  
甘油二酯、十七烷酸、亚油酸、油酸、棕榈油酸、鞘脂等显著增加(P<0.01)  
甘油三酯类, TG(54:5)及TG(54:6)显著增加(P<0.01)

羊尾脂(T)不同生长阶段的比较:



以上两个柱状图显示了随着年龄的增长, 羊尾脂中的营养成分在变化: 甘油三酯、甘油磷脂在逐渐降低; 甘油二酯先降低后增加, 在18月龄时相对含量较高; 此外, 18-30月龄, 油酸、亚油酸显著增加(P<0.001)。



# Effects of Ultra High Pressure Treatment on Angiotensin-converting enzyme inhibitory activity and quality of *Lactobacillus delbrueckii* QS306 fermented milk

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## Abstract

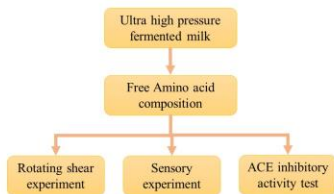
The objective was to investigate the effects of ultra high pressure (UHP) treatment on ACE inhibitory activity of *Lactobacillus delbrueckii* QS306 fermented milk. The treatment condition was treatment pressure, holding time, and detection index was ACE inhibitory activity. The physical and chemical indexes, sensory indexes and microorganisms were analyzed. The results showed that when the pressure was 400 MPa, the holding time was 10 min, and the fermentation time was 48 h, the ACE inhibition rate of the fermented milk reached 86.55 ± 0.17 % and increased 10.97 % compared with 75.58 ± 1.69 % of the untreated group. After treatment, the hydrolysis ability of protein was significantly increased, the content of free amino acids was increased 0.71 ± 0.35 mg/g, and 7 species were increased. The pH value, acidity, water retention rate and whey precipitation rate of fermented milk were not significantly changed. The viscosity increased 1.6 Pa·s, and showed a downward trend with the extension of shear time, and finally remained stable. Ultra high pressure treatment lead to an increase of the redness and yellowness (a\* value and b\* value), and decrease of brightness and whiteness (L\* value). The umami and richness of fermented milk increased significantly, while the bitterness and astringency decreased significantly. After treatment, the response values of W1C and W2W sensors in fermented milk were significantly increased, while W6S was significantly decreased. Other substances were relatively stable. Conclusion: The ultra high pressure treatment significantly improved the ACE inhibitory activity of *Lactobacillus delbrueckii* QS306 fermented milk and no significant effect on the physical and chemical indexes of fermented milk, and improved the flavor, taste and color of fermented milk, and enhanced the sensory quality of fermented milk. This study provides a theoretical basis for future research on *Lactobacillus delbrueckii* QS306 fermented milk.

Key words: Ultra high pressure treatment Fermented milk Angiotensin-converting enzyme inhibitory

## Method

Using Ultra High Pressure equipment to process *Lactobacillus delbrueckii* QS306 fermented milk, determine the ACEI activity of fermented milk in different pressure and processing time, and select the best processing method for subsequent experiments.

The best processing conditions were used to process fermented milk, determined the free amino acids of the treated group and the untreated group, and carry out storage experiments for four time periods.



## Results and discussion

Ultra High Pressure treatment has a significant effect (P < 0.05) on the ACE inhibitory activity of fermented milk (Figure 1). The pressure is 400 MPa, fermented milk has the highest ACE inhibition rate (90.23 ± 0.11 %). As the pressure increases, the ACE inhibition rate shows a trend of first rising and then falling. The Ultra High Pressure treatment time is 10 min, fermented milk has the highest ACE inhibition rate (86.80 ± 0.14 %). Therefore, 400MPa 10min is selected as the basic condition for subsequent experiments.

Eight kinds free amino acids were detected in the untreated group and fifteen kinds free amino acids were detected in the ultra high pressure treatment group (Table 1). The species and contents of essential amino acids, aromatic amino acids, and hydrophobic amino acids have increased significantly. The significant increase of amino acids such as valine, histidine and isoleucine, enhance the ACE inhibitory activity of fermented milk. The end of the ACE inhibitory peptide is proline, which can improve the ACE inhibitory activity and stability of the polypeptide. And high content of free amino acids can improve the sensory quality of fermented milk.

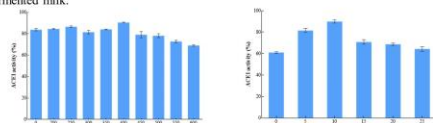


Figure 1 Effects of different pressures and ACE inhibitory activity of fermented milk

Amino acid	Fermented milk		Ultra high pressure fermented milk	
	Content (mg/g)	Proportion (% w/w)	Content (mg/g)	Proportion (% w/w)
Arg	0.13 ± 0.01	0.13 ± 0.01	0.13 ± 0.01	0.13 ± 0.01
Asp	0	0	0.39 ± 0.05	0.39 ± 0.05
Asn	0	0	0.48 ± 0.06	0.48 ± 0.06
Glu	0.15 ± 0.03	21.48 ± 1.46	0.57 ± 0.02	8.65 ± 0.78
Gly	-	-	0.29 ± 0.03	4.57 ± 0.42
Ala	-	-	0.22 ± 0.02	2.89 ± 0.43
Val	-	-	0.29 ± 0.04	4.61 ± 0.79
Met	-	-	0.36 ± 0.02	4.18 ± 0.41
Ile	-	-	0.96 ± 0.04	15.22 ± 1.14
Leu	0.15 ± 0.03	10.97 ± 2.03	0.96 ± 0.04	15.22 ± 1.14
Trp	0.13 ± 0.01	6.96 ± 1.03	0.46 ± 0.06	6.97 ± 1.13
Phe	0.23 ± 0.04	18.67 ± 3.38	0.70 ± 0.04	8.27 ± 1.15
His	-	-	0.12 ± 0.02	2.07 ± 0.22
Lys	0.15 ± 0.04	10.29 ± 2.29	0.67 ± 0.02	7.81 ± 0.93
Pro	-	-	0.75 ± 0.04	8.07 ± 0.60
Thr	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Cha	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Pro	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
His	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Met	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Val	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Ile	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Leu	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Trp	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Phe	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Ala	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Gly	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Asp	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
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Cys	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
Tyr	0.16 ± 0.02	10.96 ± 0.96	0.71 ± 0.03	8.25 ± 0.84
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Asn				



# Response surface methodology (RSM) in evaluation of the vitamin C concentrations in microwave treated milk

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## Abstract

During the microwave treatment process of the milk, response surface methodology (RSM) based on three-level three-factorial Box-Behnken design was used. The response vitamin C concentration was studied. The predicted value of model (11.84 µg/mL) was in excellent accordance with experimental value (11.83 µg/mL). Milk layer thickness was the most significant factor that affects the measured responses, and the effects of microwave time and microwave power were dependent on milk layer thickness levels. The variables microwave time, milk layer thickness and microwave power have the opposite effect on vitamin C concentration in milk treated by microwave. Synergistic interactions between milk layer thickness and microwave power was highly significant ( $p < 0.0001$ ).

Key words: Cow's milk . Milk layer thickness . Microwave time . Microwave power . Box-Behnken design

## Method

Experimental design The three-level, three-factorial Box-Behnken experimental design with categorical factor of 0 was employed to study the effect of microwave based on the concentration of the vitamin C concentrations in milk (response). The design was composed of three levels (low, medium and high, being coded as -1, 0 and +1) and a total of 17 runs were carried out in duplicate to optimize the level of chosen variables, such as microwave power, microwave time, milk layer thickness. For the purpose of statistical computations, the three independent variables were denoted as  $X_1$ ,  $X_2$  and  $X_3$ , respectively. According to the preliminary experiments, the range and levels used in the experiments are selected and listed in Table 1.

Table 1 Independence factors and corresponding levels

Variables	Real values of coded levels		
	-1	0	1
milk layer thickness, $X_1$ (cm)	3	4	5
microwave time, $X_2$ (s)	40	60	80
microwave power, $X_3$ (W)	160	320	480

## Results and discussion

The effect experiments are conducted according to the design matrix and corresponding results are listed in Table 2. The quadratic equation for predicting the optimum point was obtained according to the Box-Behnken design and input variables, and then the empirical relationship between the response and independent variables in the coded units was presented on the basis of the experimental results as follows:

Run	milk layer thickness $X_1$ (cm)	microwave time $X_2$ (s)	microwave power $X_3$ (W)	$Y_{predicted}$ (µg/mL)	$Y_{actual}$ (µg/mL)
1	3	40	160	11.57	11.57
2	3	40	320	11.69	11.76
3	3	40	480	11.76	11.76
4	3	60	160	11.76	11.82
5	3	60	320	11.82	11.82
6	3	60	480	11.82	11.89
7	3	80	160	11.82	11.84
8	3	80	320	11.76	11.76
9	3	80	480	11.69	11.68
10	4	40	160	11.71	11.76
11	4	40	320	11.69	11.76
12	4	40	480	11.64	11.65
13	4	60	160	11.54	11.53
14	4	60	320	11.54	11.54
15	4	60	480	11.53	11.51
16	4	80	160	11.52	11.56
17	4	80	320	11.48	11.48

where  $Y$  is the vitamin C concentration,  $X_1$ ,  $X_2$  and  $X_3$  is milk layer thickness, microwave time and microwave power, respectively. The results of the analysis of variance (ANOVA) for the quadratic equation are tabulated in Table 3. The ANOVA indicates the equation and actual relationship between the response and significant variables represented by the equation are accurate. The significance of the coefficient term is determined by the values of  $F$  and  $p$ , and the larger the value of  $F$  and the smaller the value of  $p$ , the more significant is. The  $p$  is lower than 0.05, suggesting the model is considered to be statistically significant. For the treated milk system, the ANOVA results indicated the  $F$ -value for the model was 45.83, suggesting that only a 0.01% chance of a "Model F-value" so large could occur due to noise and the most of the variation in the response could be explained by the regression equation and that the model was significant. In addition, the probability  $p < 0.0001$  also validated the model was significant. In the present investigation,  $X_1X_3$  and  $X_2X_2$  were highly significant parameters, while  $X_1$ ,  $X_3$ ,  $X_1X_2$ ,  $X_1X_2$  and  $X_3X_2$  were significant factors. The other model terms were not significant (Table 3). Based on the analysis of Eq. (2) depicted that the variables microwave time, milk layer thickness and microwave power have the opposite effect on vitamin C concentration in milk treated by microwave.

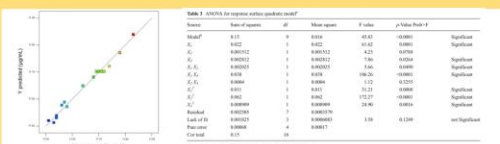


Fig. 1 The relationship between experimental and predicted values of Vitamin C concentration

Synergistic interactions between milk layer thickness and microwave power was highly significant ( $p < 0.0001$ ). On checking the  $R^2$  values, the "Predicted  $R^2$ " of 0.7984 was in reasonable agreement with the "Adjusted  $R^2$ " of 0.9619. "Adequacy Precision" measures the signal to noise ratio. It is reported that a ratio greater than 4 is desirable. The ratio of 22.486 suggested an adequate signal. As analyzed above, this model can be used to navigate the design space. The data were analyzed to examine the correlation between the experimental and predicted responses, as given in Fig. 1. As can be seen that the data points were well distributed close to a straight line ( $R^2 = 0.9833$ ), which suggested an excellent relationship between the experimental and predicted values of the response, and the underlying assumptions of the above analysis were appropriate. The results also indicated that the selected quadratic model was adequate in assuming the response variables for the experimental data.

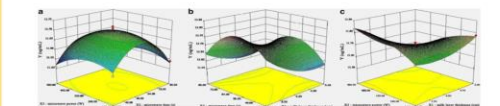


Fig. 2 Response surface plots of adsorption capacity versus the effect of variables of  $X_1, X_2, X_3$

Three-dimensional response surface plot Vitamin C concentration in milk as the response, the three dimensional response surface plots are shown in Fig. 2. It was obvious that vitamin C concentration was sensitive to milk layer thickness and microwave power, which was consistent with those analyzed about Table 3. Figure 2a depicted the three-dimensional response surface relationship between microwave power and microwave time on the vitamin C concentration in milk treated by microwave at milk layer thickness of 4 cm. The vitamin C concentration increased from 11.68 to 11.76 µg/mL and then decreased to 11.69 µg/mL at microwave time of 60s when microwave power increased from 160 to 480W. The vitamin C concentration increased from 11.59 to 11.76 µg/mL and then decreased to 11.58 µg/mL at microwave power of 320 W as microwave time increased from 40 to 80s. The effect of microwave time-milk layer thickness was such that, the vitamin C concentration increased from 9.8 to 11.76 µg/mL as milk layer thickness increased from 3 to 5 cm (Fig. 2b, at microwave time of 60s) indicating high milk layer thickness was favorable for the enhancement in the vitamin C concentration in the milk treated microwave. The effects of microwave power and milk layer thickness (Fig. 2c at milk layer thickness of 4 cm) are same to that in Fig. 2a and b. The information indicated that appropriate milk layer thickness, microwave time and microwave power would render treated milk with higher vitamin C concentration.

## Conclusion

The use of RSM has facilitated the evaluation of the vitamin C concentrations in microwave treated milk in these studies. Three-dimensional and contour response surface plots clearly demonstrate the impact of the different levels of milk layer thickness, microwave time and microwave power on the vitamin C concentration in the milk treated microwave. The response surface plots show that milk layer thickness was the most significant factor that affects the measured responses, and the effects of microwave time and microwave power were dependent on milk layer thickness levels. The variables microwave time, milk layer thickness and microwave power have the opposite effect on vitamin C concentration in milk treated by microwave. The use of this approach has permitted the identification of significant factors for the effects of microwave studied in this research and provides a framework for further investigation.

## References

Ying Bai, Gaowa Saren, Wenti Huo. Response surface methodology (RSM) in evaluation of the vitamin C concentrations in microwave treated milk[J]. Journal of Food Science and Technology, 2015, 52(7). 2015, 52(7).

## 原奶不同杀菌方式对酸马奶品质特性的影响

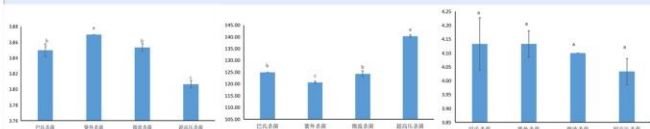
刘皓, 冯晨晨, 夏亚男\*, 双全\*  
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### Introduction

马奶具有突出的营养保健功能, 但传统酿造方法无法保证酸马奶的品质稳定, 为优化及延长酸马奶的贮藏条件, 本实验比较巴氏杀菌、紫外杀菌、微波杀菌、超高压杀菌四种原奶杀菌方式下酸马奶理化、抗氧化性、风味及菌群结构的差异, 探究适合的杀菌方式。理化结果表明, 超高压组酸马奶可溶性固形物和色差与其它杀菌组差异不明显, 但pH较低, 滴定酸度高, 更快达到发酵终点; 抗氧化性上, 超高压组酸马奶DPPH清除率为33.2%, OH自由基清除率为88%及还原力高达88.4%, 明显高于其他杀菌组; 风味上, 超高压组酸马奶在保留主体风味物质的基础上, 不良风味得到改善。经微生物群落组成PCA分析, 不同杀菌方式处理组原马奶有一定聚集, 差异不明显, 但发酵后酸马奶样品有一定差异, 微波组与超高压组酸马奶明显区别于其他组酸马奶。酸马奶优势菌属为乳杆菌属、乳球菌属、柠檬酸杆菌属和肠杆菌属。同时, KEGG、MetaCyc、COG数据库分别注释代谢通路273条、336条、23条, 主要代谢通路为ABC转运、精氨酸生物合成、氨基酸的生物合成、生物素代谢、丁酸酯代谢、碳代谢、光合作用及嘌呤代谢。

### Results

#### 1 原奶杀菌方式对酸马奶理化性质的影响



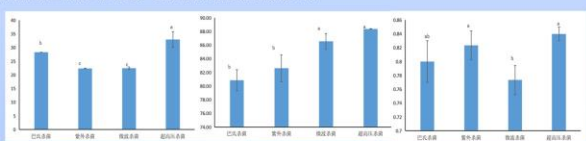
原奶不同杀菌方式对酸马奶色差的影响

	L*	a*	b*	ΔE
巴氏杀菌	44.23 <sup>d</sup>	-1.83 <sup>b</sup>	2.60 <sup>d</sup>	44.44 <sup>*</sup>
紫外杀菌	44.70 <sup>c</sup>	-1.93 <sup>c</sup>	2.40 <sup>c</sup>	44.76 <sup>*</sup>
微波杀菌	46.70 <sup>a</sup>	-1.90 <sup>bc</sup>	4.27 <sup>b</sup>	46.94 <sup>*</sup>
超高压杀菌	56.70 <sup>a</sup>	-0.60 <sup>a</sup>	6.30 <sup>a</sup>	57.05 <sup>*</sup>

pH、滴定酸度: 紫外杀菌组发酵的酸马奶pH最高, 其次是微波杀菌和巴氏杀菌, 超高压处理马奶发酵的酸马奶pH最低, 滴定酸度最高, 与其他三组差异显著 (P<0.05), 表明超高压处理能够使酸马奶更快达到发酵终点, 有利于发酵快速进行。

不同的原奶杀菌方式处理对酸马奶的可溶性固形物影响较小。超高压组后发酵的酸马奶亮度最好, 其次是微波杀菌、紫外杀菌, 巴氏杀菌组亮度稍差。

#### 2 原奶杀菌方式对酸马奶抗氧化性的影响



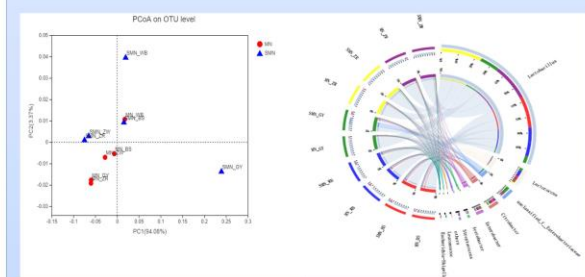
超高压组的酸马奶DPPH清除率为33.2%、OH自由基清除率为88%, 明显高于其他三组 (P<0.053) 不同杀菌方式对马奶以及酸马奶中微生物多样性的影响

#### 3 原奶杀菌方式对酸马奶风味的影响

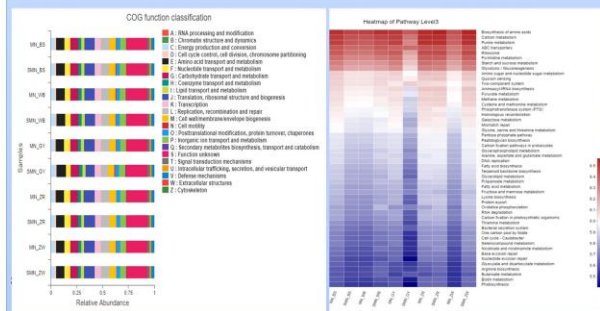
气味: 超高压组发酵酸马奶挥发性风味物质较其他组多。  
滋味: 超高压组酸马奶在保留主体风味物质的基础上, 不良风味得到改善。



#### 4 杀菌方式对酸马奶菌群结构的影响



不同杀菌方式处理组原马奶有一定聚集, 差异不明显, 但发酵后酸马奶样品较分散, 紫外组与自然发酵组较相似, 微波组与超高压组酸马奶明显区别于其他组酸马奶。酸马奶优势菌属为乳杆菌属、乳球菌属、柠檬酸杆菌属和肠杆菌属。



KEGG、MetaCyc、COG数据库分别注释代谢通路273条、336条、23条。COG功能丰度比较如图, 可见出未知功能外, 主要通路为翻译, 核糖体结构与生物发生、转录、复制、重组和修复、碳水化合物的运输和代谢、氨基酸转运与代谢和核苷酸转运与代谢, 马奶在发酵前后代谢通路丰度由细微变化。KEGG功能丰度图更清楚的显示了主要代谢通路为ABC转运、精氨酸生物合成、氨基酸的生物合成、生物素代谢、丁酸酯代谢、碳代谢、光合作用及嘌呤代谢, 且随着发酵进行, 以上通路丰度增加。

### Conclusion

本文通过比较巴氏杀菌、紫外杀菌、微波杀菌、超高压杀菌四种原奶杀菌方式下酸马奶理化、抗氧化性及风味的差异, 探究适合的杀菌方式。理化结果表明, 与其他杀菌方式相比, 原奶经过超高压杀菌的酸马奶pH低, 滴定酸度高, 可溶性固形物和色差与其它杀菌方式的样品差异不明显, 说明超高压组的酸马奶能更快达到发酵终点, 有利于发酵的进行; 抗氧化性结果表明, 原奶经过超高压杀菌处理的酸马奶DPPH清除率33%, OH自由基清除率88.4%及还原力高达0.84, 明显高于其他处理方式, 表明超高压组的酸马奶具有较好的抗氧化性; 风味结果表明, 原奶经过超高压杀菌处理的酸马奶在保留主体风味物质的基础上, 回味、涩味等不良风味得到改善。经微生物群落组成PCA分析, 不同杀菌方式处理组原马奶有一定聚集, 差异不明显, 但发酵后酸马奶样品有一定差异, 微波组与超高压组酸马奶明显区别于其他组酸马奶。酸马奶优势菌门为, 厚壁菌门和变形菌门, 优势菌属为乳杆菌属、乳球菌属、柠檬酸杆菌属和肠杆菌属。同时, KEGG、MetaCyc、COG数据库分别注释代谢通路273条、336条、23条, 主要代谢通路为ABC转运、精氨酸生物合成、氨基酸的生物合成、生物素代谢、丁酸酯代谢、碳代谢、光合作用及嘌呤代谢, 且随着发酵进行, 以上通路丰度增加。



## 两种饲养方式下苏尼特羊肉的氧化稳定性比较

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### 前言:

在肌肉组织中, 氧化稳定性是由脂质氧化与抗氧化能力共同决定的。脂质氧化主要是脂肪酸发生链式反应并产生一系列代谢产物, 包括醛、酮、醇、烃等, 在大多数情况下, 脂质过度氧化会产生令人不愉悦的气味。同时, 肉中存在的抗氧化系统能抑制氧化, 使肉质氧化达到平衡; 不合理的饲养方式会使机体过度氧化, 加快苏尼特羊的衰老, 使羊肉的质量下降。



### 目的:

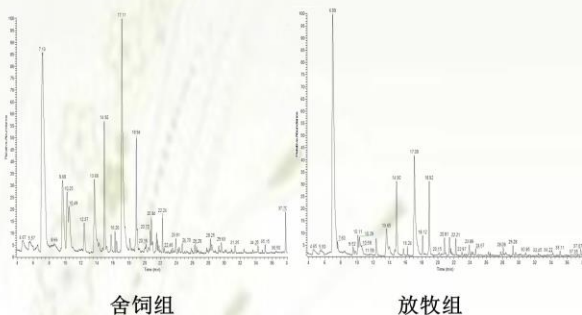
本实验通过对放牧饲养和舍饲饲养苏尼特羊肉的脂质氧化产物含量、抗氧化能力、抗氧化酶活力以及相关调控基因表达量进行测定, 对比两种饲养方式对苏尼特羊肉氧化稳定性的影响; 同时, 分析脂质氧化产物含量与抗氧化能力之间的联系, 为苏尼特羊的科学化饲养提供一定的理论依据和指导方向。

### 方法:

1. 脂质氧化产物含量的测定: GC-MS
2. 硫代巴比妥酸值、抗氧化酶活力和T-AOC的测定: 南京建成试剂盒
3. 抗氧化酶相关调控基因表达量的测定: 实时荧光定量PCR

### 结果:

#### 1. 不同饲养方式下苏尼特羊肉的脂质氧化产物 (GC-MS图)



#### 2. 不同饲养方式下苏尼特羊肉的脂质氧化产物

种类	名称	分子式	含量/(10 <sup>6</sup> AU/g)	
			放牧饲养	舍饲饲养
醛类	戊醛	C <sub>5</sub> H <sub>10</sub> O	6.90±2.31	7.03±1.58
	己醛	C <sub>6</sub> H <sub>12</sub> O	229.40±79.34*	468.87±108.96
	庚醛	C <sub>7</sub> H <sub>14</sub> O	29.21±5.31	37.84±15.70
	辛醛	C <sub>8</sub> H <sub>16</sub> O	18.86±6.60*	29.37±6.66
	壬醛	C <sub>9</sub> H <sub>18</sub> O	73.70±29.27**	119.18±33.60
	(E)-2-辛烯醛	C <sub>8</sub> H <sub>14</sub> O	3.36±0.95***	8.32±2.40
	2,4-庚二烯醛	C <sub>7</sub> H <sub>12</sub> O	0.85±0.37*	0.51±0.13
	癸醛	C <sub>10</sub> H <sub>20</sub> O	1.57±0.60	1.67±0.34
	癸甲醛	C <sub>10</sub> H <sub>18</sub> O	23.19±8.14**	12.22±6.06
	(E)-癸烯醛	C <sub>10</sub> H <sub>18</sub> O	2.48±0.93	2.95±0.49
醇类	(E)-十一烯醛	C <sub>11</sub> H <sub>20</sub> O	2.04±0.62	2.01±0.35
	(E,E)-2,4-十二碳二烯醛	C <sub>12</sub> H <sub>20</sub> O	3.24±0.96*	4.62±1.04
	十四醇	C <sub>14</sub> H <sub>30</sub> O	1.74±0.46*	2.35±0.53
	十六醇	C <sub>16</sub> H <sub>34</sub> O	6.63±2.38	4.76±1.38
	戊醇	C <sub>5</sub> H <sub>12</sub> O	15.05±3.63	12.54±3.26
	己醇	C <sub>6</sub> H <sub>14</sub> O	5.15±2.27**	3.20±0.96
	1-辛烯-3-醇	C <sub>8</sub> H <sub>16</sub> O	28.64±10.77*	42.36±11.52
	2-乙基-1-己醇	C <sub>8</sub> H <sub>18</sub> O	2.47±0.43***	1.50±0.28
	庚醇	C <sub>7</sub> H <sub>16</sub> O	3.50±1.34	2.93±0.70
	辛醇	C <sub>8</sub> H <sub>18</sub> O	7.85±1.51	8.07±1.91
酮类	反式-2-辛烯醇	C <sub>8</sub> H <sub>16</sub> O	4.23±1.44*	6.00±1.24
	癸甲酮	C <sub>10</sub> H <sub>20</sub> O	2.87±0.98*	1.80±0.52
	2,3-辛二酮	C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>	32.36±8.09***	91.89±28.7
烃类	4-十二酮	C <sub>12</sub> H <sub>22</sub> O	1.40±0.34	1.93±0.66
	十三烷	C <sub>13</sub> H <sub>28</sub>	1.73±0.60***	3.42±0.43
	十六烷	C <sub>16</sub> H <sub>34</sub>	-	2.47±0.94

#### 3. 两种饲养方式下苏尼特羊肉的抗氧化能力差异

指标	放牧饲养	舍饲饲养
T-AOC/(U/mg)	1.61±0.32***	0.88±0.34
RSA/%	27.666±1.920	26.115±1.914
CUPRAC/(mg/g)	1 973.19±290.34*	1 690.22±188.24

指标	放牧饲养	舍饲饲养
SOD活力/(U/mg)	132.45±9.06***	108.03±13.68
CAT活力/(U/mg)	7.21±3.87*	3.74±1.88
GPx活力/(U/mg)	80.19±13.42*	60.87±24.24

#### 4. 两种饲养方式下苏尼特羊肉中抗氧化酶相关调控基因表达量的差异

基因	放牧饲养表达量	舍饲饲养表达量
SOD	2.28±0.46***	1.30±0.46
CAT	1.26±0.39*	0.66±0.22
GPx	1.12±0.21*	0.88±0.17
LOX	1.37±0.32***	6.10±2.29

### 结论:

1. 舍饲饲养苏尼特羊肉TBA值高于舍饲饲养, 并且羊肉中的脂质氧化产物含量较高, 这表明舍饲饲养羊肉的脂质氧化程度比较严重。
2. 放牧饲养羊的T-AOC、CUPRAC和SOD、CAT、GPx活力均高于舍饲饲养, 这说明放牧饲养羊肉的抗氧化能力较高, 能有效抑制肉中的脂质氧化。
3. 进一步分析两种饲养方式下羊肉中的抗氧化酶相关基因表达量, 发现舍饲饲养羊肉中LOX基因表达量高于放牧饲养, 而SOD、CAT和GPx基因表达量均低于放牧饲养, 从分子水平验证了舍饲饲养羊肉脂质氧化程度更严重, 而放牧饲养羊肉的抗氧化能力较好。

# 限制性酶解结合大孔树脂吸附脱色对葵花籽蛋白功能特性及结构的影响

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## 背景

葵花籽蛋白是一种营养价值较高的植物蛋白，具有氨基酸组成平衡、生物效价高、过敏性低等特点，但颜色深和较差的功能特性限制了其在食品工业中的应用。目前，国内外通过尝试各种方法来改善葵花籽蛋白颜色的同时通过限制性酶解方法来提高葵花籽蛋白的功能特性，以期得到颜色和功能特性都较好的葵花籽蛋白。

## 目的

为探究葵花籽蛋白脱色工艺提供参考依据；为制备颜色和功能特性都较好的葵花籽蛋白提供参考数据。

## 结果

### 1、限制性酶解结合大孔树脂吸附对葵花籽蛋白脱色效果的影响

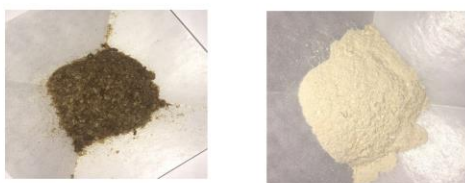


图1 限制性酶解结合大孔树脂吸附脱色对葵花籽蛋白脱色效果的影响

左为葵花籽蛋白，右为限制性酶解结合大孔树脂吸附脱色葵花籽蛋白，由图1可知，葵花籽蛋白在未脱色之前呈深灰色，颜色严重影响了蛋白质的食用性，在树脂添加量为12%、吸附温度为20℃、pH值为7.0、吸附时间为120 min 条件下葵花籽蛋白的L\*值由55.7提高至86.3，呈浅白色，脱色效果显著。

### 2、限制性酶解结合大孔树脂吸附脱色对葵花籽蛋白结构的影响

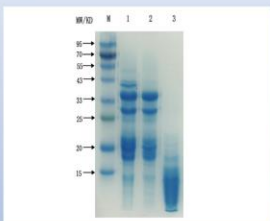


图2 葵花籽蛋白SDS-PAGE凝胶电泳图

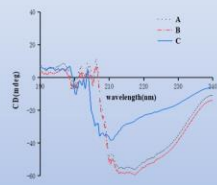


图3 葵花籽蛋白圆二色谱图

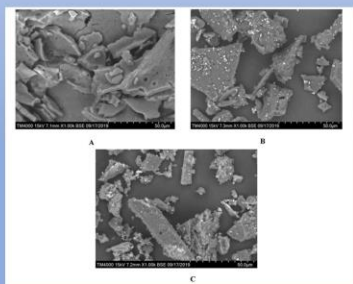


图4 葵花籽蛋白扫描电镜图

## 结论

研究了限制性酶解结合大孔树脂吸附脱色对葵花籽蛋白脱色工艺条件，得到了最佳脱色工艺参数，限制性酶解结合大孔树脂吸附脱色后葵花籽蛋白的结构发生改变，其溶解性、起泡性和乳化性都显著提高，这一创新工艺有在食品加工中广泛应用的潜力。

## 方法

以低温脱脂葵花籽粕为原料提取葵花籽蛋白，研究限制性酶解结合大孔树脂吸附脱色对葵花籽蛋白脱色效果的影响，通过SDS-PAGE凝胶电泳、圆二色谱、扫描电镜、荧光光谱和粒径来表征其结构的变化，进一步研究限制性酶解结合大孔树脂脱色对葵花籽蛋白溶解性、起泡性、乳化性及持油性的影响。

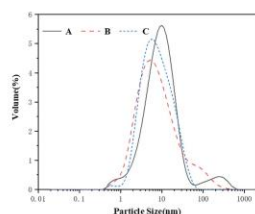


图5 葵花籽蛋白的粒径分布图

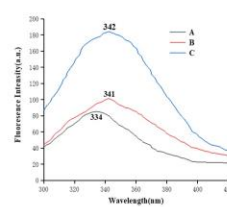


图6 葵花籽蛋白的荧光光谱图

A、葵花籽蛋白 B、大孔树脂吸附脱色葵花籽蛋白 C、限制性酶解结合大孔树脂吸附脱色葵花籽蛋白

由上图可知，经限制性酶解结合大孔树脂吸附脱色后葵花籽蛋白的结构发生了改变，分子量逐渐减小，二级结构变得更加灵活，粒径减小，内源荧光强度增加并且发生了红移现象，经限制性酶解结合大孔树脂吸附脱色后葵花籽蛋白由大的片状结构变成碎片状结构，这些结构变化对葵花籽蛋白功能特性是有利的。

### 3、限制性酶解结合大孔树脂吸附脱色对葵花籽蛋白功能特性的影响

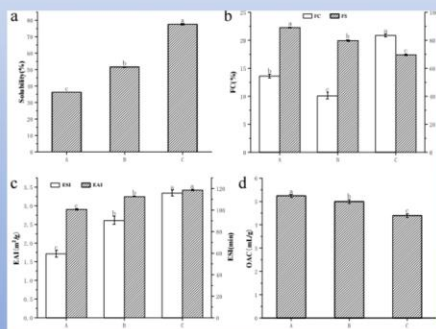


图7 限制性酶解结合大孔树脂吸附脱色对葵花籽蛋白功能特性的影响

a、溶解性 b、起泡性 c、乳化性 d、持油性

经限制性酶解结合大孔树脂吸附脱色后葵花籽蛋白溶解性、起泡性、乳化性及乳化稳定性都显著提高，泡沫稳定性和持油性降低。

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# 基于宏基因组分析酸马奶的微生物多样性及功能基因

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## Abstract

酸马奶风味独特, 保健功能突出, 与其复杂的微生物构成密切相关。本研究采用宏基因组技术分析酸马奶的微生物多样性, 挖掘其功能基因。结果表明: 酸马奶中鉴定出微生物30个门, 331个科, 913个属, 2692个种。优势菌种为克氏乳杆菌、瑞士乳杆菌、弗氏柠檬酸杆菌、鸟氨酸拉乌尔菌、柠檬酸杆菌属和乳酸乳球菌。COG、KEGG数据库注释到10849、214338个基因, 碳水化合物代谢和氨基酸代谢功能突出, 其次为辅酶因子和维生素代谢和核苷酸代谢等代谢活动。经CAZy数据库注释分析, 糖基转移酶(1238个)和糖苷水解酶(1430个)的数量最多, 占据酸马奶碳水化合物活性酶的76%。同时, 酸马奶基因中发现3种RRT12蛋白酶、2种serralyisin金属蛋白酶、第六型蛋白分泌系统(T6SS)基因、232个肽转运系统及231个蛋白酶控制基因, 具有较强的蛋白质分解转运潜力。酸马奶中编码了26个芳香转氨酶基因、40个酮酸转化酶、51个编码醇脱氢酶、68个编码醛脱氢酶基因和34个乙酰酯酶基因, 具有从氨基酸形成浓郁风味物质的基础。

## Introduction

酸马奶的独特风味及功能特性的形成均与其复杂的微生物群落密切相关。微生物利用鲜马奶中的各类营养物质(碳水化合物、蛋白质、脂肪酸等)不断分解、代谢, 生成相应的风味物质及具有特定功能的生物活性成分。

目前, 尽管酸马奶的微生物多样性已有一定研究, 但微生物种水平的不确定性及功能基因的空白仍存在遗憾, 需要深入开展。因此, 本研究应用宏基因组学方法和生物信息学分析手段, 在分类学地位“种”水平上对酸马奶中的核心微生物类群进行甄别, 更准确地分析酸马奶的微生物多样性, 并挖掘群体微生物中的功能基因, 以期为我国酸马奶产业的发展及乳酸菌资源开发提供了理论依据。

## Method

酸马奶采自于内蒙古锡林郭勒盟阿巴嘎旗。样品DNA抽提后, 经构建PE文库、桥式PCR、Illumina HiSeq测序步骤完成宏基因组测序, 进一步进行数据分析、物种注释、丰度分析及功能基因注释, 分析酸马奶的微生物多样性及功能基因。

## Results and discussion

### 物种组成

酸马奶共鉴定到72364条组装序列, 酸马奶中微生物分类门水平30个, 科水平331个, 属水平913个, 种水平2692个。其中, 相对含量大于1%的优势菌群在门水平2个, 科水平3个, 属水平6个, 种水平8个。

优势菌种: 克氏乳杆菌、瑞士乳杆菌、弗氏柠檬酸杆菌、鸟氨酸拉乌尔菌、柠檬酸杆菌属和乳酸乳球菌。

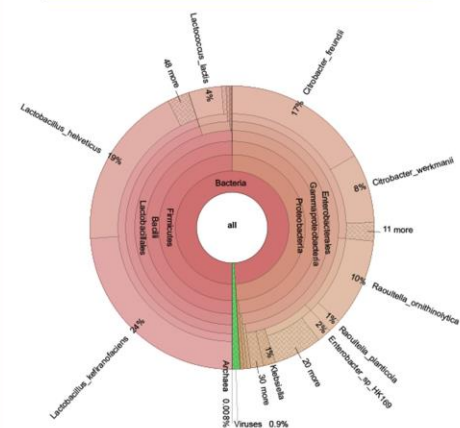


图1 酸马奶样品微生物群落Circos图  
Fig.1 Circos diagram of microbial community of koumiss

### COG注释

酸马奶的10849个基因根据其功能大致可分为23类。其中, 去除功能未知的R和S两部分, 其中功能基因数目在800个以上, 主要有氨基酸转运和代谢类基因(1208个)、复制、重组和修复类基因(1207个)、碳水化合物转运与代谢类基因(947个)、转录类基因(931个)和复制、重组和修复类基因(807个), 如图2。

### CAZy数据库注释分析

糖基转移酶(1238个)和糖苷水解酶(1430个)类最多, 占据酸马奶碳水化合物活性酶的76%, 其次是碳水化合物结合模块(235个)和碳水化合物酯酶(435个), 而辅助活动酶(109个)和多糖裂合酶(48个)类最少, 仅占据酸马奶样品检测到酶总数的4.49%。

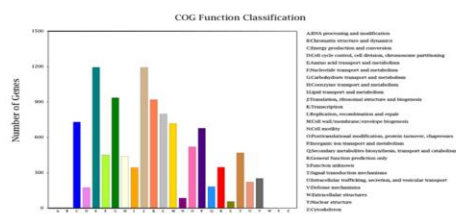


图2 酸马奶中COG、KEGG主要功能分类的基因数目  
Fig.2 The number of genes in COG primary functional classification in koumiss

### KEGG注释

酸马奶功能注释基因主要归属为6大类的代谢通路, 主要功能基因二级代谢途径42类。KEGG注释结果显示, 酸马奶功能基因主要位于细胞群体——原核生物、膜运转、信号传导、氨基酸代谢、碳水化合物代谢、辅酶因子和维生素的新陈代谢和核苷酸代谢等代谢途径(图3)。

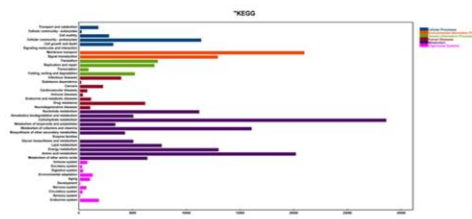


图3 KEGG主要功能分类的基因数目  
Figure 3 Number of genes classified by KEGG main function

### 蛋白质水解基因系统分析

蛋白酶: 3种RRT12蛋白酶、2种serralyisin金属蛋白酶基因

肽转运系统: 丰富寡肽Opp系统(158个)

二/三肽Dpp系统(74个)基因

肽酶: 肽链内切酶: 17个pepO、19个pepF和11个PepE, 降低苦味肽;

氨肽酶: PepB(18), pepN(28), pepM(2)和PepA(9), 与ACE抑制肽有关

二/三肽酶(67个)和脯氨酸氨酶(60个)

### 氨基酸风味形成途径分析

转氨酶: 26个(ArAT)基因, 包括AROB、tyrB、ybdI三类, 可对芳香族氨基酸、亮氨酸和蛋氨酸进行催化。

酮酸转化酶: 编码PTA(8个)和ACK(32个)基因, 酮酸经过氧化脱羧反应可被直接转化成羧酸。

醇和醛脱氢酶: 51个编码醇脱氢酶(AldDH)和68个编码醛脱氢酶(AldDH)的基因, 有效的催化醛类物质转化成相应的醇类和羧酸类

乙酰酯酶: 34个可以催化乙酸酯类合成的乙酰酯酶的基因(aes)

## Conclusion

本研究基于宏基因组技术分析酸马奶的微生物多样性, 挖掘蛋白质分解系统及氨基酸风味形成系统的功能基因。酸马奶中鉴定出微生物30个门, 331个科, 913个属, 2692个种。COG、KEGG数据库分别注释到10849、214338个基因, 代谢通路中, 碳水化合物代谢和氨基酸代谢功能突出, 其次为辅酶因子和维生素的新陈代谢和核苷酸代谢等代谢活动。酸马奶中编码了26个基因、40个酮酸转化酶、51个编码醇脱氢酶、68个编码醛脱氢酶基因和34个乙酰酯酶基因, 说明酸马奶发酵时具有从氨基酸形成浓郁风味物质的基因基础, 试验结果以期为酸马奶的品质提升及乳酸菌功能基因库的挖掘提供理论依据。



# 乳酸菌胞外多糖的分离纯化和结构分析

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## Abstract

乳酸菌胞外多糖 (Exopolysaccharides, EPS) 有两种形式, 分泌到细胞外而形成粘附于细胞表面的为荚膜多糖, 存在于细胞周边培养基中的为黏液多糖, 这些多糖是改善产品的亮度和质感必不可少的条件。凝胶性是乳清蛋白 (Whey protein, WP) 重要特性之一, 其作为增稠剂、微胶囊载体、食用膜以及脂肪替代物应用都是凝胶特性的一种体现。乳清蛋白凝胶特性受多种因素影响。本文主要以分离自嗜热链球菌 (*Streptococcus thermophilus*, *S. thermophilus*) 6063 的胞外多糖为研究对象, 对胞外多糖结构特性及 EPS/WP 混合体系流变学特性进行分析。试验结果如下: □□

1. 采用纤维素凝胶层析对粗提的 EPS 进行分离, 通过特制的多糖凝胶纯化系统进行纯化得到两种 EPS, 一种为中性多糖 ST1-EPS, 一种为酸性多糖 ST2-EPS。□□
2. 通过气相色谱-质谱联用仪的检测分析, 结果表明 ST1-EPS 主要由半乳糖, 葡萄糖和鼠李糖组成, 占 80% 以上, 还含有一些甘露糖; ST2-EPS 主要由半乳糖, 甘露糖和葡萄糖组成; 通过相对分子质量的测定, ST1-EPS 的分子量为  $2.197 \times 10^6$  kDa, ST2-EPS 的分子量为  $1.419 \times 10^6$  kDa。□□
3. 通过红外光谱仪的检测, 结果表明 ST1-EPS 和 ST2-EPS 均含有官能团 -OH、-CH<sub>2</sub>-、-COOH、酰胺基、C-O-C 及 C-C-O; 其中 ST2-EPS 中含有糖醛酸。□□
4. 通过核磁共振的检测分析, 结果表明 ST2-EPS 有 5 种糖残基, 其中 4 种为  $\alpha$  构型的吡喃糖残基, 1 种为  $\beta$  构型的吡喃糖残基, 2 种为  $\beta$  构型的吡喃糖残基。□□
5. EPS/WP 体系流变学特性测定结果表明, 两种 EPS 均能够增加 EPS/WP 体系的表现黏度, 且不同金属离子、pH 值和温度的处理条件对两种 EPS/WP 体系流变学特性均有较大影响但不相同。□□

## Method

将从上海北诺生物技术有限公司的高产 EPS 嗜热链球菌 6063 在 MRS 培养基培养三代后, 对嗜热链球菌 6063 进行 EPS 粗提; 通过纤维素凝胶层析对 EPS 进行分离, 用特制的多糖凝胶纯化系统对粗提 EPS 进行进一步纯化; 通过气相色谱-质谱联用仪对 EPS 的单糖组成进行检测分析; 通过高效液相色谱仪对 EPS 的相对分子质量进行检测; 通过红外光谱仪检测 EPS 结构组成; 通过核磁共振仪对 EPS 结构进行检测分析。□□

## Results and discussion

由图 1 可知粗多糖经 DEAE-FAST-FLOW 离子交换柱得到 2 个组分 I 和 II。其中 I 是被水洗脱下来, 因此不带电荷, 为中性多糖; II 是在含有 NaCl 洗脱下来, 即带负电荷, 为酸性多糖。分别对分离出的两个峰的成分进行收集, 通过博睿糖生物技术有限公司特制的多糖凝胶纯化系统进行纯化, 得到两个单一峰, 再分别对两个峰进行收集, 得到两种纯化后的多糖 ST1-EPS 和 ST2-EPS。□

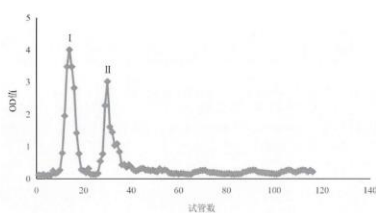


Figure 1 Elution curve of crude polysaccharide DEAE-FAST-FLOW strain

□□由表 5 可知, ST1-EPS 主要单糖组成为半乳糖、葡萄糖和鼠李糖, 含有少量甘露糖, 它们的百分比是 0.430: 0.294: 0.178: 0.098。ST2-EPS 的单糖组成为主要为半乳糖、甘露糖和葡萄糖; 它们的百分比是 0.616: 0.268: 0.117。□

表 5 EPS 单糖组成百分比

Table 5 EPS monosaccharide composition percentage

种类	保留时间	ST1-EPS	ST2-EPS
鼠李糖	20.921	0.178	0
甘露糖	21.376	0.000	0
阿拉伯糖	21.644	0.000	0
木糖	22.274	0.000	0
甘露糖	32.065	0.098	0.268
葡萄糖	32.438	0.294	0.117
半乳糖	33.088	0.430	0.616

由图 2 可知, ST1-EPS 红外光谱图出现了六个峰, 根据各个峰的强度可知 ST1-EPS 主要的官能团为 -OH、-CH<sub>2</sub>-、酰胺基、-COOH、C-O-C 及 C-C-O。□□

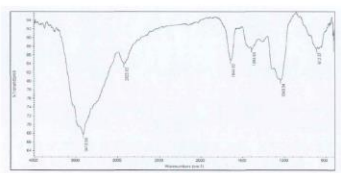


Figure 2 Fourier transform infrared spectra of the ST1-EPS

由图 3 可知, ST2-EPS 红外光谱图出现了七个峰, 根据各个峰的强度可知 ST2-EPS 主要的官能团为 -OH、-CH<sub>2</sub>-、酰胺基、-COOH、C-O-C 及 C-C-O; 且 ST2-EPS 中含有糖醛酸。□□

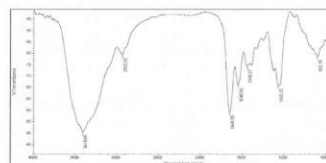


图 3 ST2-EPS 的红外光谱图

Figure 3 Fourier transform infrared spectra of the ST2-EPS

□□

ST1-EPS 的 <sup>13</sup>C-NMR 谱图如图 5 所示, 有 5 个异头碳信号分别位于 93.00 ppm、93.39 ppm、96.98 ppm、97.12 ppm 和 93.39 ppm。与 <sup>1</sup>H-NMR 谱中的 5 个异头质子信号分别相对应。这种对应关系也可以从 HSQC 谱图 (图 6) 中很明显的看出。由于  $\alpha$  型吡喃糖残基的异头碳信号一般位于 90-102 ppm 以上, 而  $\beta$  型吡喃糖一般位于 102 ppm 以下, 所以可以判断该多糖的 5 种糖残基有 4 种为  $\alpha$  构型的吡喃糖残基, 1 种为  $\beta$  型吡喃糖残基。□□

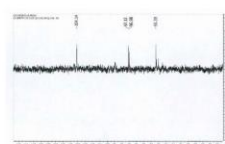


图 5 ST1-EPS 的 <sup>13</sup>C-NMR 谱图

Figure 5 <sup>13</sup>C-NMR spectra of ST1-EPS

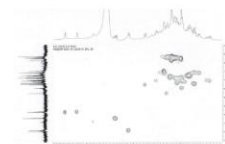


图 6 ST1-EPS 的 HSQC 谱图

Figure 6 HSQC NMR spectra of ST1-EPS

ST2-EPS 的 <sup>13</sup>C-NMR 谱图如图 9 所示, 有 5 个异头碳信号分别位于 99.53 ppm、100.93 ppm、101.25 ppm、104.33 ppm 和 106.02 ppm。与 <sup>1</sup>H-NMR 谱中的 5 个异头质子信号分别相对应。这种对应关系也可以从 HSQC 谱图 (图 10) 中很明显的看出。可以判断该多糖的 5 种糖残基有 3 种为  $\alpha$  构型的吡喃糖残基, 2 种为  $\beta$  型吡喃糖残基。□□

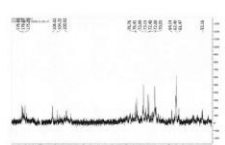


图 9 ST2-EPS 的 <sup>13</sup>C-NMR 谱图

Figure 9 <sup>13</sup>C-NMR spectra of ST2-EPS



图 10 ST2-EPS 的 HSQC 谱图

Figure 10 HSQC NMR spectra of ST2-EPS

## Conclusion

- (1) 采用纤维素凝胶层析对粗提的 EPS 进行分离, 通过特制的多糖凝胶纯化系统进行纯化得到两种 EPS, Y 一种为中性多糖 ST1-EPS, 一种为酸性多糖 ST2-EPS。
- (2) 通过气相色谱-质谱联用仪的检测分析, 结果表明 ST1-EPS 主要由半乳糖, 葡萄糖和鼠李糖组成, 占 80% 以上, 还含有一些甘露糖; ST2-EPS 主要由半乳糖, 甘露糖和葡萄糖组成; 通过相对分子质量的测定, ST1-EPS 的分子量为  $2.197 \times 10^6$  kDa, ST2-EPS 的分子量为  $1.419 \times 10^6$  kDa。
- (3) 通过红外光谱仪的检测, 结果表明 ST1-EPS 和 ST2-EPS 均含有官能团 -OH、-CH<sub>2</sub>-、-COOH、酰胺基、C-O-C 及 C-C-O。其中 ST2-EPS 中含有糖醛酸。通过核磁共振的检测分析, 结果表明 ST1-EPS 有 5 种糖残基, 其中 4 种为  $\alpha$  构型的吡喃糖残基, 1 种为  $\beta$  构型的吡喃糖残基, 2 种为  $\beta$  构型的吡喃糖残基。ST2-EPS 有 5 种糖残基, 其中 3 种为  $\alpha$  构型的吡喃糖残基, 2 种为  $\beta$  构型的吡喃糖残基。



# 降胆固醇亚麻籽蛋白酶解肽的分离纯化及结构鉴定

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## 背景

近年来国内外科研人员围绕抑制胆固醇吸收做了大量研究,发现分子量为300~600Da的植物蛋白降解产物具有抑制胆固醇吸收的作用。亚麻籽蛋白作为一种优质的植物蛋白质资源。国内外一直在对亚麻籽蛋白进行大量的研究,发现亚麻籽蛋白具有多种生物活性,但是否有降胆固醇作用、结构如何等问题尚不清楚。

## 目的

为探究亚麻籽蛋白酶解肽的降胆固醇活性提供参考依据;为制备具有降胆固醇活性的亚麻籽蛋白酶解肽提供参考数据。

## 结果

### 1、亚麻籽蛋白酶解产物的胆固醇胶束溶解度抑制率及水解度分析

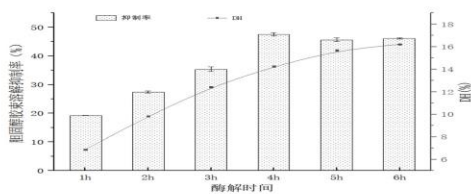


图1 亚麻籽蛋白酶解产物的水解度与胆固醇胶束溶解度抑制率曲线

由图可知,随着酶解时间的增加,水解度呈现上升趋势,而胆固醇胶束溶解度抑制率即降胆固醇活性呈现先上升后下降趋势。当酶解时间为4h时,水解度为12.25%,胆固醇胶束溶解度抑制率最高为52.87%,酶解时间继续延长至5h、6h时,水解度继续增加,但此时亚麻籽蛋白酶解产物的胆固醇胶束溶解度抑制率呈下降趋势。

### 2、超滤、DA201-C大孔树脂分离纯化降胆固醇亚麻籽蛋白酶解产物

组分	相对分子量(kDa)	得率(%)	胆固醇胶束溶解度抑制率(%)	亚麻籽肽组分	乙醇浓度(%)	得率(%)	胆固醇胶束溶解度抑制率(%)
Y	-	-	52.87±1.3 <sup>a</sup>	Y <sub>5</sub> (超滤)	-	-	70.96±1.3 <sup>a</sup>
Y <sub>1</sub>	>30	44.3±1.4 <sup>a</sup>	20.63±2.0 <sup>b</sup>	D <sub>1</sub>	25	37.09±1.1 <sup>a</sup>	35.23±0.9 <sup>b</sup>
Y <sub>2</sub>	10-30	12.2±1.3 <sup>b</sup>	34.59±0.9 <sup>c</sup>	D <sub>2</sub>	50	25.89±0.8 <sup>b</sup>	51.11±1.4 <sup>c</sup>
Y <sub>3</sub>	5-10	9.2±0.7 <sup>c</sup>	36.53±1.8 <sup>d</sup>	D <sub>3</sub>	75	16.15±2.1 <sup>c</sup>	79.84±0.6 <sup>d</sup>
Y <sub>4</sub>	3-5	5.7±0.9 <sup>d</sup>	42.28±2.2 <sup>e</sup>	D <sub>4</sub>	100	13.87±1.7 <sup>d</sup>	72.68±2.2 <sup>e</sup>
Y <sub>5</sub>	<3	28.6±1.9 <sup>e</sup>	70.96±1.3 <sup>a</sup>				

表1 超滤分离各组分得率和胆固醇胶束溶解度抑制率

表2 不同浓度乙醇洗脱组分的得率及胆固醇胶束溶解度抑制率

氨基酸种类	D <sub>1</sub> 组分	D <sub>2</sub> 组分	D <sub>3</sub> 组分	D <sub>4</sub> 组分	疏水值 (Kj/mol)
甘氨酸 (GLY)	7.74	4.56	4.99	4.73	0.90
丝氨酸 (SER)	4.60	5.02	4.29	4.49	0.17
苏氨酸 (THR)	3.23	3.02	3.09	2.90	1.85
组氨酸 (HIS)	0.89	1.07	1.00	0.88	2.10
天冬氨酸 (ASP)	8.32	8.40	7.20	4.36	2.25
谷氨酸 (GLU)	5.32	6.03	6.93	7.69	2.90
精氨酸 (ARG)	2.74	3.21	4.45	3.80	3.10
赖氨酸 (LYS)	3.67	3.81	3.92	3.85	6.25
酪氨酸 (TYR)	4.90	5.29	5.35	5.03	12.60
半胱氨酸 (CYS)	0.52	0.34	1.48	0.58	4.20
甲硫氨酸 (MET)	0.29	0.34	0.90	0.84	5.43
脯氨酸 (PRO)	2.43	3.04	3.66	3.06	7.66
丙氨酸 (ALA)	5.60	5.71	9.00	5.31	3.10
亮氨酸 (LEU)	3.48	5.34	7.73	7.10	10.10
缬氨酸 (VAL)	4.87	4.99	7.24	8.96	16.83
苯丙氨酸 (PHE)	3.47	3.56	7.10	5.64	11.10
异亮氨酸 (ILE)	2.43	4.33	3.00	3.70	12.40
平均疏水值 (Kj/mol)	3.96	4.73	5.12	5.45	

图2 氨基酸测定结果

## 结论

本研究为亚麻籽蛋白酶解肽的降胆固醇活性,得到了参考价值较高的参数,为制备具有降胆固醇活性的亚麻籽蛋白酶解肽提供参考数据,并发现四种降胆固醇亚麻籽肽降胆固醇的活性显著。

## 方法

以脱脂亚麻籽粉为原料提取亚麻籽蛋白。用Protease M酶解得到亚麻籽蛋白的酶解产物,并测定不同酶解时间时亚麻籽蛋白酶解产物的水解度、胆固醇胶束溶解度抑制率,依次利用超滤法、大孔树脂法以及RP-HPLC色谱对亚麻籽蛋白酶解产物进行分离纯化。然后通过,进行MALDI-TOF-MS/MS鉴定降胆固醇亚麻籽蛋白酶解产物结构,从中鉴定降胆固醇亚麻籽肽。

由表可知,经过超滤分级后得到相对分子量<3kDa的组分的胆固醇胶束溶解度抑制率最高为70.96%,通过乙醇洗脱后发现当乙醇浓度为75%时洗脱下来的组分胆固醇胶束溶解度抑制率为79.84%。进一步对各组分进行氨基酸检测发现,亮氨酸、脯氨酸和苯丙氨酸的含量在总氨基酸组成中所占比例呈增大趋势。

### 3、RP-HPLC分离纯化降胆固醇亚麻籽蛋白酶解产物及胆固醇胶束溶解度抑制率

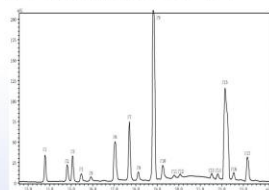


图3 RP-HPLC色谱分离纯化D3组分图谱

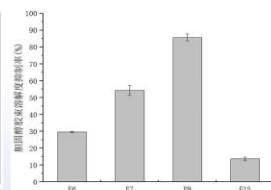


图4 RP-HPLC分离F6、F7、F9和F13组分后获得组分的胆固醇胶束溶解度抑制率

由图可知,经过RP-HPLC分离后D3组分被分离成17个组分,经冷冻干燥后测定其胆固醇胶束溶解度抑制率可知,F9组分的胆固醇胶束溶解度抑制率最高,达到85.72%。因此选用F9组分进行质谱鉴定。

### 4、MALDI-TOF-MS/MS鉴定降胆固醇亚麻籽蛋白酶解产物的结构

序号	检测/理论分子量(Da)	肽 (N端→C端)	蛋白来源
肽I	376.225/375.46	IPF	Flaxseed (Linum usitatissimum) NAD(P)H-quinone oxidoreductase subunit 5, chloroplast (Fragment) IEEAGIPFTYISA(168-170)
肽II	447.263/446.54	IPAF	Flaxseed (Linum usitatissimum) NAD(P)H-quinone oxidoreductase subunit 5, chloroplast (Fragment) SYSWIIPAFLLVP(12-15)
肽III	473.283/472.58	IPPF	Flaxseed (Linum usitatissimum) NAD(P)H-quinone oxidoreductase subunit 5, chloroplast (Fragment) LSLCGIPPFACFWS(423-426)
肽IV	588.378/587.75	FLVIP	Flaxseed (Linum usitatissimum) NAD(P)H-quinone oxidoreductase subunit 5, chloroplast (Fragment) RLLPLFLVPIYINL(289-293)

表1 降胆固醇亚麻籽肽的结构表

经MALDI-TOF-MS/MS对F9组分进行结构鉴定,从中鉴定出四种降胆固醇亚麻籽肽,其氨基酸序列分别为IPF、IPAF、IPPF和FLVIP。

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# 益生菌对苏尼特羊胃肠道菌群、脂肪酸代谢及肉品质的影响

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## Abstract

实验选取3月龄的苏尼特羊12只(体重量(16.72±1.32)kg)随机分为对照组(基础饲粮,6只)和益生菌组(基础饲粮+1.50×10<sup>9</sup> CFU/g复合益生菌,6只)进行90 d的饲养实验,屠宰后测定肉羊胃肠道菌群、代谢物、血脂指标及肉品质。结果表明:益生菌组的胃肠道菌群结构发生变化,益生菌组瘤胃菌群中拟杆菌门(Bacteroidetes)、拟杆菌属(Bacteroides)和F-Bacteroidales-BS11-gut-group的相对丰度显著高于对照组(P<0.05);益生菌组肠道菌群中毛螺菌(F-Lachnospiraceae)和Ruminococcaceae-UCG-002的相对丰度显著高于对照组(P<0.05);益生菌组瘤胃代谢物的丁酸含量均低于对照组(P<0.05),益生菌组血液中的高密度脂蛋白胆固醇(high-density lipoprotein cholesterol, HDL-C)浓度显著高于对照组(P<0.05),低密度脂蛋白胆固醇(low-density lipoprotein cholesterol, LDL-C)浓度显著低于对照组(P<0.05),益生菌组羊肉的pH24值和剪切力值显著低于对照组(P<0.05),而a\*值显著高于对照组(P<0.05)。通过相关性分析可知,瘤胃菌群中的拟杆菌门相对丰度与乙酸、丙酸含量呈显著正相关(P<0.05);肠道菌群的Ruminococcaceae-UCG-002相对丰度与异丁酸、异戊酸含量呈显著正相关(P<0.05);瘤胃菌群的普雷沃菌属-1(Prevotella-1)相对丰度与HDL-C浓度呈极显著负相关(P<0.01);瘤胃菌群的厚壁菌门(Firmicutes)相对丰度与熟肉率呈显著负相关(P<0.01);肠道菌群的厚壁菌门相对丰度与a\*值呈显著正相关(P<0.05)。整体上饲粮中添加益生菌能调整肉羊胃肠道菌群的结构,改变代谢物和血脂指标,进而改善羊肉品质。

## Introduction

苏尼特羊是内蒙古独特的优良品种,具有育肥能力强、脂肪率低、抗病性强、遗传性能稳定等优点,在我国得到了广泛的推广。苏尼特羊的优良特性不仅与遗传基因有关,还与肠道中的微生物有关。目前,羊肉生产中存在抗生素滥用的现象,因此寻找安全、高效的绿色添加剂替代抗生素是畜牧业的研究热点之一,而益生菌有着安全、高效、低成本的特点,可作为抗生素潜在的替代品,其中嗜酸乳杆菌、链球菌、干酪乳杆菌和植物乳杆菌,能在宿主的消化系统中定植,改善菌群结构,抑制病原微生物,提高畜群的产肉性能,因此添加益生菌可有效调节畜群的胃肠道菌群,并在改善肉用品质方面有巨大的潜力。胃肠道微生物群是一个信号枢纽,它可将饮食等环境输入与影响宿主新陈代谢、免疫和感染反应的遗传和免疫信号结合起来,在饲粮中添加益生菌有助于在胃肠道中建立和维持合适的微生物区系。因此,本实验通过饲粮中添加复合益生菌(植物乳杆菌和干酪乳杆菌)研究其对肉羊胃肠道菌群、代谢物及肉品质的影响,以期改善舍饲羊的肉品质,并为益生菌在肉羊产业中的应用提供理论依据。

## Method

选内蒙古巴盟中旗3月龄的苏尼特羊24只分为对照组和益生菌组(对照组饲喂基础饲粮+益生菌饲喂基础饲粮+10g复合乳酸菌),经过7天的预饲期后,进行90天的饲养试验。取其背最长肌、股二头肌、瘤胃液和粪便由液氮保存。统一带回实验室后,保存在-80℃冰箱中。

## Results and discussion

### 1. 益生菌对苏尼特羊瘤胃菌群组成的影响

表1 益生菌对苏尼特羊瘤胃微生物相对丰度的影响  
Table 1 Effect of probiotics on the relative abundance of rumen microflora in Sunit lambs

分类	菌	对照组	益生菌组
门	拟杆菌门(Bacteroidetes)	42.92±20.97 <sup>a</sup>	61.66±9.64 <sup>b</sup>
	厚壁菌门(Firmicutes)	48.03±19.12 <sup>a</sup>	31.38±8.88 <sup>b</sup>
	变形菌门(Proteobacteria)	4.58±7.33	1.32±0.92
	普雷沃菌属-1(Prevotella-1)	26.28±13.66	32.98±10.41
属	瘤胃球菌属(Ruminococcus-1)	12.11±15.96 <sup>a</sup>	1.13±0.43 <sup>b</sup>
	Erysipelotrichaceae-UCG-004	0.93±2.05 <sup>a</sup>	2.28±2.27 <sup>b</sup>
	Saccharofermentans	0.45±0.48 <sup>a</sup>	2.07±1.44 <sup>b</sup>
	月形单胞菌属-1(Selenomonas-1)	1.80±1.34 <sup>a</sup>	0.58±1.07 <sup>b</sup>
	螺菌属-2(Treponema-2)	0.46±0.32 <sup>a</sup>	1.23±0.97 <sup>b</sup>
	F-Bacteroidetes-BS11-gut-group	1.95±1.82 <sup>a</sup>	4.41±2.95 <sup>b</sup>
	拟杆菌属(Bacteroides)	0.52±0.39 <sup>a</sup>	4.41±4.94 <sup>b</sup>

注:同行前标小写字母不同表示差异显著(P<0.05),下同。

由表1可知,在门水平上共检测到25种细菌微生物,主要包括厚壁菌门(Firmicutes)、拟杆菌门(Bacteroidetes)和变形菌门(Proteobacteria),其中益生菌组中拟杆菌门的相对丰度显著高于对照组(P<0.05),厚壁菌门的相对丰度显著低于对照组(P<0.05),而变形菌门没有显著差异(P>0.05)。厚壁菌门和拟杆菌门均有助于宿主代谢,调节脂质代谢,从而提升能量效率,其中拟杆菌门是促进动物利用碳水化合物的优势菌群,而厚壁菌门是促进动物胃肠道微生物分解纤维素的菌群。在本实验的结果中,瘤胃中的菌群结构发生变化,这可能与益生菌进入动物瘤胃后,拟杆菌门的数量增加,厚壁菌门的数量降低,厚壁菌门与拟杆菌门的比例改变,能抑制有害菌的生长,维持肠道菌群结构的稳态有关。

在属水平上共检测到489种细菌微生物,苏尼特羊瘤胃中主要包括的微生物(相对丰度大于1%)有:普雷沃菌属-1(Prevotella-1)、瘤胃球菌属-1(Ruminococcus-1)、Erysipelotrichaceae-UCG-004、Saccharofermentans和拟杆菌属(Bacteroides)等。在表1中,益生菌组中F-Bacteroidales-BS11-gut-group(P<0.05)、拟杆菌属(P<0.05)、Erysipelotrichaceae-UCG-004(P<0.05)、螺菌属-2(Treponema-2)(P<0.05)和Saccharofermentans(P<0.05)的相对丰度显著高于对照组,而月形单胞菌属-1(Selenomonas-1)(P<0.05)和瘤胃球菌属(P<0.05)的相对丰度显著低于对照组。

### 2. 益生菌对苏尼特羊肠道菌群组成的影响

表2 益生菌对苏尼特羊肠道微生物相对丰度的影响  
Table 2 Effect of probiotics on the relative abundance of intestinal microflora in Sunit lambs

分类	菌	对照组	益生菌组
门	拟杆菌门(Bacteroidetes)	33.67±6.89	31.83±9.57
	厚壁菌门(Firmicutes)	50.39±4.38	46.86±8.34
	变形菌门(Proteobacteria)	5.83±5.44	4.89±1.45
属	Ruminococcaceae-UCG-002	2.14±1.20 <sup>a</sup>	3.42±1.22 <sup>b</sup>
	Ruminococcaceae-UCG-010	7.85±2.59 <sup>a</sup>	3.84±1.34 <sup>b</sup>
	Ruminococcaceae-UCG-013	5.76±2.18 <sup>a</sup>	1.29±0.75 <sup>b</sup>
	毛螺菌属(F-Lachnospiraceae)	3.35±1.23 <sup>a</sup>	7.19±2.68 <sup>b</sup>

表2中呈现了苏尼特羊肠道中门和属水平上相对丰度较高的微生物。在门水平上,苏尼特羊肠道中共检测到17种细菌微生物,优势菌门为厚壁菌门(Firmicutes)、拟杆菌门(Bacteroidetes)和变形菌门(Proteobacteria),这些微生物能够有效降解纤维、提高碳水化合物的利用率,进而促进消化,这与瘤胃中的主要微生物呈现一致性,但对对照组和益生菌组中的肠道微生物数量不显著(P>0.05)。相比于瘤胃,益生菌组肠道中的拟杆菌门数量下降,而厚壁菌门数量增加,和对照组比较接近,说明益生菌对肠道菌群的影响低于瘤胃。在属水平上共检测到249种细菌微生物。苏尼特羊肠道中主要包括的微生物(相对丰度大于1%):Ruminococcaceae-UCG-002、Ruminococcaceae-UCG-010、Ruminococcaceae-UCG-013和毛螺菌属(F-Lachnospiraceae)等,这些优势菌不仅能维持肠道的健康稳定水平,而且还能参与营养物质消化吸收,防止养分的流失。益生菌组中毛螺菌(P<0.05)和Ruminococcaceae-UCG-002(P<0.05)的相对丰度显著高于对照组,而Ruminococcaceae-UCG-010(P<0.05)和Ruminococcaceae-UCG-013(P<0.05)的相对丰度显著低于对照组。

### 3. 益生菌对苏尼特羊肉品质的影响

表6 益生菌对苏尼特羊肉品质的影响  
Table 6 Effect of probiotics on meat quality of Sunit lambs

指标	对照组	益生菌组
pH <sub>24</sub>	6.15±0.29	6.15±0.16
pH <sub>4</sub>	5.66±0.09 <sup>a</sup>	5.45±0.03 <sup>b</sup>
Z'	33.98±1.58	34.95±1.19
a*	17.47±0.23 <sup>a</sup>	18.74±0.48 <sup>b</sup>
b*	3.51±0.44 <sup>a</sup>	2.78±0.29 <sup>b</sup>
熟肉率/%	0.42±0.01	0.41±0.17
剪切力/N	79.79±10.59 <sup>a</sup>	61.70±12.39 <sup>b</sup>

如表6所示,益生菌组羊肉pH24值显著低于对照组(P<0.05),饲粮中添加益生菌后可改变宰后羊肉体内糖酵解速率,使肉中的乳酸增多,进而降低了肉的pH值。色泽能直观评价肉质的好坏,益生菌组羊肉的a\*值显著高于对照组(P<0.05),而b\*值显著低于对照组(P<0.05),说明益生菌可以提高羊肉的红色度,降低肉的品质值,从而改善肉的品质。嫩度是反映肉质的重要指标之一,益生菌组的剪切力值显著低于对照组(P<0.05),说明益生菌组的肉较嫩,乳酸菌能改善肉的品质。

## Conclusion

饲粮中添加益生菌能影响胃肠道菌群的组成,其中益生菌组羊瘤胃菌群中拟杆菌门、拟杆菌属和F-Bacteroidales-BS11-gut-group的相对丰度增加;肠道菌群中毛螺菌Ruminococcaceae-UCG-002的相对丰度增加。在胃肠道代谢物中,益生菌组瘤胃中的丙酸和丁酸含量降低;益生菌组的肠道中的丁酸、异丁酸和戊酸含量降低;血脂指标中,益生菌组的HDL-C浓度增加,LDL-C浓度降低;肉品质中,益生菌组羊肉的pH24值和剪切力值降低,而a\*值增加。苏尼特羊胃肠道菌群相对丰度与代谢物、血脂指标、肉品质的相关性分析中,瘤胃菌群中的拟杆菌门相对丰度与乙酸、丙酸含量呈显著正相关(P<0.05);肠道菌群的Ruminococcaceae-UCG-002相对丰度与异丁酸、异戊酸含量呈显著正相关(P<0.05);肠道菌群的毛螺菌相对丰度与TG、TC、LDL-C浓度呈显著正相关(P<0.05);肠道菌群的厚壁菌门相对丰度与a\*值呈显著正相关(P<0.05)。



# 超高压处理对传统奶豆腐品质的影响

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## Abstract

本文利用超高压技术, 以压力水平和保压时间为变量, 以奶豆腐的菌落总数和质构为检测指标, 筛选出超高压处理条件。以未处理奶豆腐为对照, 评价超高压处理对奶豆腐品质的影响, 并对处理前后的奶豆腐在不同温度条件下贮藏时的品质变化情况进行监测与探讨。主要研究结果如下:

- (1) 以超高压的压力水平和保压时间为变量, 以奶豆腐菌落总数和质构为检测指标, 最终筛选合适的超高压处理条件为500 MPa、10 min, 此条件处理的奶豆腐菌落总数 $<10$  CFU/mL, 硬度为 $4292.52 \pm 206.11$  g, 弹性为 $0.84 \pm 0.04$ , 粘聚性为 $0.78 \pm 0.01$ , 咀嚼性为 $2815.70 \pm 180.76$ , 奶豆腐的质构显著改善。
- (2) 奶豆腐经超高压处理后, 游离氨基酸和游离脂肪酸的含量升高, 游离氨基酸总量为 $4.82$  mg/g, 比超高压处理前升高了 $32.57\%$ , 特别是谷氨酸和甘氨酸的含量增加显著, 分别提高了 $45.50\%$ 和 $2.43$ 倍; 游离脂肪酸总含量为 $1.42$  mg/g, 比处理前升高了 $27.93\%$ 。

## Introduction

奶豆腐是我国北方地区蒙古族、哈萨克族等游牧民族的传统奶制品之一, 拥有悠久的食用历史, 是以牛乳、羊乳等为原料发酵而成的, 形状与豆腐相似, 滋味可口, 奶香浓郁。在古代, 它不仅是牧民们的生活必需品, 也是军队征战草原所带的战备粮。超高压作为“食品工业的一场革命”, 拥有得天独厚的处理优势。本试验利用超高压技术处理传统奶豆腐, 研究超高压处理对奶豆腐品质的改善作用以及处理后奶豆腐在不同贮存条件下的突出优势。本次试验旨在将传统工艺与现代科技相结合, 探究超高压处理对奶豆腐品质的影响, 对奶豆腐的工艺优化提供数据, 为将来研发出品质更优、食用感更加好的奶豆腐提供参照, 同时对超高压技术在乳制品中的应用提供一些理论依据。

## Method

奶豆腐样品采集于内蒙古锡林郭勒盟正蓝旗长虹乳制品厂, 将密封完全的新鲜奶豆腐于室温下进行不同压力梯度、不同保压时间的超高压处理, 测定处理前后奶豆腐的菌落总数和质构, 根据结果选择最佳处理条件。根据国标测定超高压处理前后奶豆腐游离氨基酸和游离脂肪酸的测定。

## Results and discussion

压力选择300、400、500、600 MPa四个水平, 保压时间选择5、10、15、20 min四个水平, 在室温条件下对奶豆腐进行处理, 以未处理奶豆腐为对照, 测定不同超高压条件对奶豆腐菌落总数的影响, 结果如表6所示。

表6 不同超高压处理条件对奶豆腐菌落总数的影响  
Table 6 Effects of different ultra-high pressure treatment conditions on the colony forming unit of huroid

处理条件 (MPa/min)	菌落总数 (CFU/mL)	致死率 (%)	处理条件 (MPa/min)	菌落总数 (CFU/mL)	致死率 (%)
未处理组	$3.23 \times 10^4$	/			
300/5	$8.72 \times 10^3$	73.00	500/5	85	99.73
300/10	$5.90 \times 10^3$	81.73	500/10	$<10$	$>99.97$
300/15	$2.50 \times 10^3$	92.08	500/15	$<10$	$>99.97$
300/20	$7.45 \times 10^2$	97.69	500/20	$<10$	$>99.97$
400/5	$1.15 \times 10^3$	96.44	600/5	21	99.93
400/10	$7.09 \times 10^2$	97.80	600/10	$<10$	$>99.97$
400/15	$3.35 \times 10^2$	98.96	600/15	0	100.00
400/20	72	99.78	600/20	0	100.00

由表6可知, 超高压处理对奶豆腐的灭菌效果显著, 在300 MPa、20 min和400 MPa、10 min条件下, 菌落总数均降低了两个数量级, 致死率均高于97.00%。当压力达到500 MPa时, 致死率均高达99.73%, 且当保压时间 $\geq 10$  min时, 菌落总数均低于 $10$  CFU/mL。

以未处理奶豆腐为对照, 测定不同超高压条件对奶豆腐质构的影响, 其中奶豆腐的硬度、弹性、粘聚性及咀嚼性在超高压处理后变化较大, 结果如图2、图3、图4、图5所示。

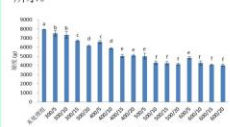


图2 不同处理条件对奶豆腐硬度的影响  
Fig.2 Effects of different treatment conditions on the hardness of huroid

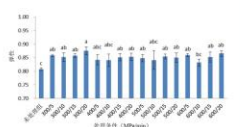


图3 不同处理条件对奶豆腐弹性的影响  
Fig.3 Effects of different treatment conditions on the elasticity of huroid

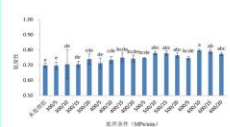


图4 不同处理条件对奶豆腐粘聚性的影响  
Fig.4 Effects of different treatment conditions on the viscosity of huroid

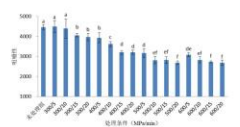


图5 不同处理条件对奶豆腐咀嚼性的影响  
Fig.5 Effects of different treatment conditions on chewability of huroid

注: 标注不同字母代表差异显著( $P < 0.05$ )

由图2、图3、图4、图5可知, 与未处理组相比, 经超高压处理的奶豆腐硬度和咀嚼性都有不同程度的降低, 且随着压力的增大, 下降越多。其中, 在500 MPa、10 min条件下, 奶豆腐的硬度为 $4292.52 \pm 206.11$  g, 下降了 $45.84\%$ , 并与增加压力和保压时间后的奶豆腐保持相同水平。咀嚼性为 $2815.70 \pm 180.76$ , 下降了 $36.97\%$ 。超高压处理后奶豆腐的弹性和粘聚性有所上升, 300 MPa、20 min条件下弹性最大, 为 $0.88 \pm 0.01$ , 升高了 $8.64\%$ ; 600 MPa、10 min条件下粘聚性最高, 为 $0.80 \pm 0.01$ , 升高了 $12.50\%$ 。

超高压处理前后奶豆腐中游离氨基酸的变化如表7所示。

表7 奶豆腐中游离氨基酸的组成及含量  
Table 7 Composition and content of free amino acids in huroid

名称	未处理组 (mg/g)	超高压处理组 (mg/g)	
天冬氨酸	Asp	0.20	0.40
苏氨酸	Thr	0.12	0.20
丝氨酸	Ser	0.17	0.27
谷氨酸	Glu	0.67	1.23
脯氨酸	Pro	0.29	0.43
甘氨酸	Gly	0.07	0.24
丙氨酸	Ala	0.03	0.08
缬氨酸	Val	0.18	0.20
蛋氨酸	Met	0.04	0.12
异亮氨酸	Ile	0.15	0.16
亮氨酸	Leu	0.31	0.42
酪氨酸	Tyr	0.21	0.24
苯丙氨酸	Phe	0.29	0.25
赖氨酸	Lys	0.26	0.32
组氨酸	His	0.08	0.13
精氨酸	Arg	0.18	0.13
总量		3.25	4.82

由表7可知, 在奶豆腐中共检测出16种游离氨基酸, 经超高压处理后, 除苯丙氨酸和精氨酸外, 其他氨基酸含量均高于未处理组。未处理组的游离氨基酸总量为 $3.25$  mg/g, 超高压处理组游离氨基酸总量为 $4.82$  mg/g, 总量增长了 $32.57\%$ 。其中, 谷氨酸在两组合含量最高, 分别为 $0.67$  mg/g和 $1.23$  mg/g, 增加了 $45.50\%$ ; 甘氨酸的增长幅度最大, 由 $0.07$  mg/g增至 $0.24$  mg/g, 增长了 $2.43$ 倍; 丙氨酸、蛋氨酸和天冬氨酸的含量均增加了一倍以上。总体来看, 超高压处理前后奶豆腐中游离氨基酸的含量变化较大。

超高压处理前后奶豆腐中游离脂肪酸的变化如表8所示。

表8 奶豆腐中游离脂肪酸的组成及含量  
Table 8 Composition and content of free fatty acids in huroid

名称	缩写	未处理组 (mg/g)	超高压处理组 (mg/g)
辛酸	C8:0	0.02	0.02
癸酸	C10:0	0.04	0.05
月桂酸	C12:0	0.04	0.05
豆蔻酸	C14:0	0.14	0.18
棕榈酸	C16:0	0.40	0.51
棕榈油酸	C16:1	0.03	0.03
硬脂酸	C18:0	0.15	0.18
油酸	C18:1	0.28	0.35
亚油酸	C18:2	0.03	0.04
总量		1.11	1.42

由表8可知, 从奶豆腐中共检测出9种游离脂肪酸, 未处理组游离脂肪酸总含量为 $1.11$  mg/g, 超高压处理组游离脂肪酸总含量为 $1.42$  mg/g, 总量上升了 $27.93\%$ 。其中, 棕榈酸在两组合含量最高, 分别为 $0.40$  mg/g和 $0.51$  mg/g, 其上升幅度最大, 处理后上升了 $27.50\%$ , 其次是油酸, 两组中含量分别为 $0.28$  mg/g和 $0.35$  mg/g, 处理后上升了 $25.00\%$ 。

## Conclusion

对奶豆腐采用不同压力水平(300、400、500、600 MPa)和不同保压时间(5、10、15、20 min)超高压处理, 以奶豆腐菌落总数和质构为检测指标进行筛选结果, 最佳超高压处理条件为500 MPa、10 min。在此条件下处理的奶豆腐菌落总数 $<10$  CFU/mL, 硬度为 $4292.52 \pm 206.11$  g, 弹性为 $0.84 \pm 0.04$ , 粘聚性为 $0.78 \pm 0.01$ , 咀嚼性为 $2815.7 \pm 180.76$ , 奶豆腐的质构显著改善。对奶豆腐进行500 MPa、10 min超高压处理后, 其游离氨基酸和游离脂肪酸的含量升高, 游离氨基酸总量为 $4.82$  mg/g, 比超高压处理前升高了 $32.57\%$ , 特别是谷氨酸和甘氨酸的含量增加显著, 分别提高了 $45.50\%$ 和 $2.43$ 倍; 游离脂肪酸总含量为 $1.42$  mg/g, 比处理前升高了 $27.93\%$ 。说明超高压处理有助于奶豆腐游离氨基酸和游离脂肪酸的释放。



# 蒙菊花茶中黄酮提取工艺优化及其抗氧化性的研究

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## Abstract

对蒙菊花茶中黄酮提取工艺进行优化, 并对其黄酮提取液的功能特性进行探讨。结果表明, 蒙菊花茶最优黄酮提取条件是料液比为1:80 g/mL, 乙醇浓度为60%, 提取时间为1 h, 提取温度为70°C。该提取条件下的黄酮含量为13.68±0.38%。蒙菊花茶中黄酮提取液具有一定的抗氧化活性与降尿酸功能, 其黄酮提取液在10 mg/mL时DPPH·清除率(88.58±1.81%)、·OH清除率(62.73±1.05%)和还原力(2.58±0.03)最强; 蒙菊花茶中黄酮提取液的XOD抑制率为64.79±1.01%, 说明蒙菊花茶具有较好的抗氧化性及降尿酸功能。

## Introduction

蒙菊因其生长于内蒙古地区而得名, 是菊科金鸡菊属一年生草本植物, 味甘、性平, 是集保健、养生为一体的天然植物, 长期以来被当作花茶饮用, 具有清热解毒、活血化痰、健脾强胃的功效, 还能治疗心慌、胃肠不适、食欲不振、痢疾等疾病。蒙菊营养价值高于其他的菊花品种, 含有人体所需要的多种氨基酸、微量元素和矿物质, 而铅、砷等有害元素含量低于大部分菊花。

蒙菊花茶保健功能很高, 但国内外对其保健成分及生物活性的研究较少。蒙菊花茶是蒙菊择优采摘后经消毒杀菌制作而成。本文对蒙菊花茶中黄酮提取工艺进行优化, 并对其黄酮提取液的抗氧化性进行探讨, 以期对蒙菊花茶的开发利用提供理论依据。

## Method



## 2 蒙菊花茶中黄酮提取正交试验结果

表1 蒙菊花茶黄酮提取条件优化正交试验结果

试验号	因素				蒙菊花茶黄酮含量 (%)
	A	B	C	D	
1	1	1	1	1	9.57
2	1	2	2	2	10.51
3	1	3	3	3	10.56
4	2	1	2	3	12.06
5	2	2	3	1	10.13
6	2	3	1	2	10.71
7	3	1	3	2	11.58
8	3	2	1	3	13.30
9	3	3	2	1	10.83
K <sub>1</sub>	10.213	11.070	11.193	3.847	
K <sub>2</sub>	10.967	11.313	11.133	4.673	
K <sub>3</sub>	11.903	10.700	10.757	6.223	
R	1.690	0.613	0.436	2.376	

主次顺序: D>A>B>C  
最优组合: A<sub>3</sub>B<sub>3</sub>C<sub>1</sub>D<sub>3</sub>

由表1可知, 各因素对蒙菊花茶中黄酮含量影响的顺序依次是: D>B>A>C, 即提取温度>乙醇浓度>料液比>提取时间。最优组合为: A<sub>3</sub>B<sub>3</sub>C<sub>1</sub>D<sub>3</sub>, 即料液比: 1:80 g/mL; 乙醇体积分数: 50%; 提取时间: 1 h; 提取温度: 70°C。使用此提取条件提取蒙菊花茶中的黄酮后, 蒙菊花茶中黄酮含量达到最高, 为11.30±0.23%。

## 3 蒙菊花茶黄酮提取液抗氧化特性

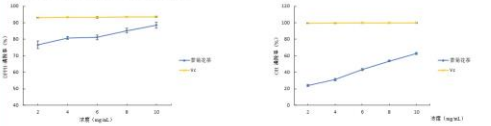


图7 蒙菊花茶黄酮提取液的DPPH·自由基清除能力

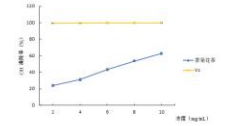


图8 蒙菊花茶黄酮提取液的·OH自由基清除能力

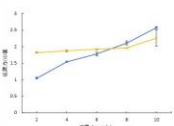


图9 蒙菊花茶黄酮提取液的还原力

由图7可知, 蒙菊花茶的DPPH·清除率均随浓度的升高而逐渐增大, 在10mg/L时, 蒙菊花茶(88.58±1.81%)的DPPH·清除率达到最高, 与Vc的DPPH·清除率(93.55±0.40%)较为接近。由图8可知, 蒙菊花茶的·OH清除率呈现较均匀的上升趋势, 在黄酮提取液浓度为10 mg/mL时, ·OH清除率为62.73±1.05%, 但与Vc的·OH清除率(99.86±0.01%)相比较还是有一定的差距。由图9可知, 蒙菊花茶的还原力一直呈上升趋势, 从8 mg/mL开始明显强于Vc, 在黄酮提取液浓度为10 mg/mL时, 蒙菊花茶还原力为2.58±0.03。

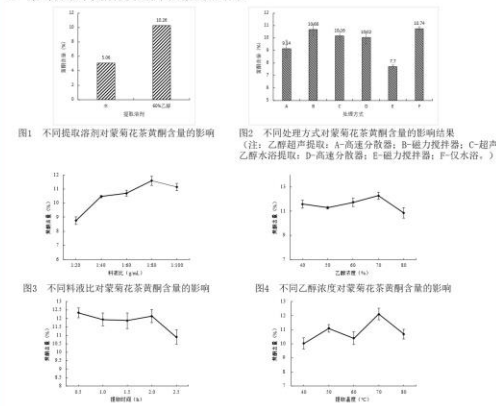
## 4 蒙菊花茶黄酮提取液降尿酸功能

高尿酸血症是痛风发展的一个关键性因素, 尿酸产生过多、肾脏尿酸排泄障碍或者两个因素的综合作用导致高尿酸血症的发生, 目前发病原因已成为仅次于糖尿病的第二大代谢病。黄嘌呤氧化酶(Xanthine Oxidase, XOD)能催化黄嘌呤和次黄嘌呤氧化生成尿酸, 并产生过氧化物自由基, 因此可通过抑制XOD的活性来减少尿酸生成, 缓解痛风。

蒙菊花茶黄酮提取液的XOD抑制率为64.79±1.01%, 也与其在提取过程中溶出的萜苷有关, 众多研究表明萜苷具有良好的XOD抑制效果, 黄酮与萜苷协同作用使得蒙菊花茶具有良好的抑制XOD的作用。

## Results and discussion

### 1 蒙菊花茶中黄酮提取的单因素试验结果



由图1可知, 用60%乙醇提取蒙菊花茶和蒙菊饼中的黄酮类化合物(10.26±0.24%)的效果均明显优于用水提取的(5.06±0.09%)。由图2, 蒙菊花茶(10.74±0.15%)使用乙醇水浴浸提的方式后黄酮含量最高。由图3-6, 蒙菊花茶在料液比为1:80 g/mL(11.58±0.32%), 乙醇浓度为70%(12.28±0.30%), 提取时间0.5h(12.33±0.30%), 提取温度为70°C(6.54±0.15%)时达到最高。

## Conclusion

通过对蒙菊花茶中黄酮提取的单一因素和正交优化试验结果分析, 4个考察因素对蒙菊花茶中黄酮含量影响的因素依次是: 提取温度>乙醇浓度>料液比>提取时间。蒙菊花茶的最优黄酮提取条件是料液比为1:80 g/mL, 乙醇浓度为50%, 提取时间为1 h, 提取温度为70°C。经提取条件下黄酮含量为11.30±0.23%。对蒙菊花茶黄酮提取液的功能特性检测分析, 结果表明, 蒙菊花茶均具有一定的抗氧化活性与降尿酸功能, 其黄酮提取液在10 mg/mL时DPPH·清除率(88.58±1.81%)、·OH清除率(62.73±1.05%)和还原力(2.58±0.03)最强; XOD抑制率为64.79±1.01%。综上所述, 蒙菊花茶具有较好的抗氧化性。



## 乳酸菌筛选及其对羊肉发酵香肠挥发性风味物质的影响

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### ABSTRACT

In this paper, 5 strains of lactobacillus were tested for their salt tolerance, acid tolerance, nitrite tolerance and bacteriostatic ability. Among them, Lactobacillus ZF22 and Lactobacillus TR1-1-3 had good salt tolerance, acid tolerance, nitrite tolerance and bacteriostatic ability, and had good fermentation performance. The selected lactic acid bacteria were used as starter cultures to produce mutton fermented sausage, and the natural fermentation was used as control group to explore the influence of lactic acid bacteria on the volatile flavor substances of mutton fermented sausage. Results show that adding lactobacillus ZF22 and TR1-1-3 could increase the kinds of volatile flavor fermented sausage, promote 1 - pentene - 3 - alcohol, 1 - octene - 3 - alcohol, 3 - methyl ethyl butyrate, ethyl trans - 4 - decyl ene, heptanoic acid ethyl ester, 2 - nonyl ketone of flavour compounds of fermented sausage flavor contribution is bigger, enrich the flavour compounds of fermented sausage.

## 前言

发酵香肠是指碎肉和丁状脂肪同盐、糖、发酵剂或香辛料等混合灌入肠衣后,经微生物发酵及干燥成熟,发生一系列复杂理化变化加工而成的一类肉制品。由于自然发酵香肠的可控性较差,现代制作工艺开始添加微生物纯培养物,即通过添加发酵剂来实现对发酵过程的控制。发酵剂是指具有代谢活性的微生物制剂,对于缩短肉品成熟期、改善色泽、增强风味和提高安全性至关重要。乳酸菌是用于制备发酵食品的最流行的微生物培养物,由于乳酸菌具有广泛的抑菌活性,因此已被证明可以改善安全性、营养和感官特性。发酵香肠中参与发酵的乳酸菌(戊糖片球菌、乳酸片球菌)、植物乳杆菌、清酒乳杆菌、干酪乳杆菌和弯曲乳杆菌。通过添加发酵剂可缩短生产时间,产品的安全性和质量稳定性也得到了有效保证。发酵肉制品由于乳酸菌产生有机酸,从而降低pH,低pH值可促使亚硝酸盐分解,减少了残留的亚硝基与二级胺作用生成亚硝胺的可能,进而可增加发酵香肠的安全性。

## 材料与amp;方法

### 1. 菌株

由内蒙古农业大学肉品科学与技术团队所提供的干酪乳杆菌ZF6、ZF8和瑞士乳杆菌ZF22、ZF13、TR1-1-3,都是从内蒙古传统风干肉制品中筛选获得。

表1 试验菌株信息

菌株名称	相似菌株	相似度	种
ZF6	<i>L. casei</i> strain 029	99.93%	干酪乳杆菌
ZF8	<i>L. helveticus</i> strain NWFU1348	99.93%	
ZF13	<i>L. plantarum</i> strain JCM 1149	100.00%	瑞士乳杆菌
ZF22	<i>L. helveticus</i> strain NM143-4	100.00%	
TR1-1-3	<i>L. helveticus</i> strain NM143-4	100.00%	

### 2. 羊肉发酵香肠原料

市售的苏尼特羊后腿肉及羊尾、人造蛋白肠衣; 辅料: 市售食盐、葡萄糖、蔗糖、胡椒粉、红曲米、亚硝酸钠、白酒。

### 3. 主要试剂

亚硝酸钠、浓盐酸(国药集团化学试剂有限公司), 2-甲基-3-庚酮(美国SIGMA公司), TPY培养基(北京奥博星生物技术有限责任公司)。

### 4. 方法

原料肉→解冻→预处理→绞碎和斩拌→添加辅料和发酵剂→低温腌制→灌肠→发酵→干燥→成熟→贮藏

操作要点: 对照组不添加发酵剂, 其它工艺与处理组相同。操作如下: 冷冻的羊肉和羊尾室温解冻, 恢复到柔软状态, 去筋、皮、膜、血管和杂质后切成小块, 放入搅拌机中搅拌的同时加入辅料。混合均匀的羊肉馅4℃腌制24小时后开始灌装、发酵、干燥、成熟。发酵条件: 温度23℃、相对湿度95%, 发酵72小时。干燥条件: 温度15℃、相对湿度75%、时间4天。成熟条件: 温度10℃、相对湿度65%, 时间3天。发酵羊肉香肠放在4摄氏度下可以贮藏15天。

## 结果

### 1. 乳酸菌对亚硝酸钠的耐受性

菌株编号	50mg/kg	100mg/kg	150mg/kg	200mg/kg	300mg/kg
	g	g	g	g	g
	OD值				
ZF6	1.3±0.0 4Ca	1.2±0.0 2Bb	1.0±0.0 4Cc	1.0±0.0 2Dc	0.9±0.0 4Dd
ZF8	1.5±0.0 2Ba	1.5±0.0 3Aa	1.5±0.0 2Ba	1.4±0.0 4Ba	1.1±0.1 2Cb
ZF13	1.3±0.0 2Ca	1.2±0.0 1Bb	1.1±0.0 6Cc	1.1±0.0 4Cc	0.8±0.0 3Dd
ZF22	1.6±0.0 2Aa	1.5±0.0 2Ac	1.5±0.0 3Abc	1.6±0.0 1Ab	1.5±0.0 3Ad
TR1-1-3	1.5±0.0 3Ba	1.5±0.0 2Aa	1.5±0.0 1ABa	1.5±0.0 1Bab	1.2±0.0 9Bc

### 1. 乳酸菌对羊肉发酵香肠挥发性物质的影响

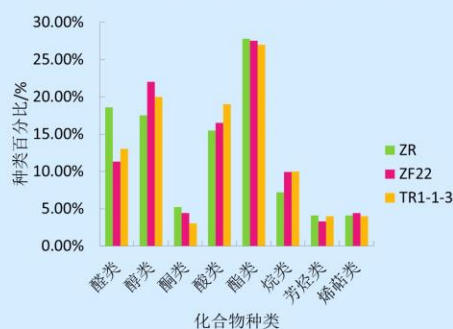


图1 挥发性风味物质的种类占比

### 2. 乳酸菌对羊肉发酵香肠挥发性物质种类的影响



图2 发酵香肠中风味物质种类及数量

## 结论

具有优良发酵特性的瑞士乳杆菌ZF22和瑞士乳杆菌TR1-1-3, 作为发酵剂制作发酵羊肉香肠, 以自然发酵为对照组, 研究乳酸菌对于羊肉发酵香肠挥发性风味物质的影响。结果表明, 瑞士乳杆菌ZF22和瑞士乳杆菌TR1-1-3确实可以使羊肉发酵香肠的风味物质种类和含量都有所增加, 可能对发酵香肠醛类, 醇类, 酸类风味成分有贡献, 促进发酵香肠挥发性风味物质的形成, 改善发酵香肠的品质。



# Bacteriostasis of High Organic Acid-producing Lactic Acid Bacteria in Fermented Meat Products

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## ABSTRACT

In this experiment, 6 strains of different lactic acid bacteria sampled from pastoral areas were taken as research objects. After 24 hours of culture in TPY medium, the kinds and contents of organic acids produced by different strains of lactic acid bacteria were determined by ion chromatography, and the bacteriostatic ability of organic acids produced by different strains of lactic acid bacteria was determined by bacteriostatic circle method after eliminating bacteriocin interference. One strain of RS1 with strong bacteriostatic ability and a strain of ZW2 with weak bacteriostatic ability were selected and added to fermented mutton sausage. The conclusion is drawn by measuring the microorganism index of sausage. The results showed that the growth of *Staphylococcus aureus* and *Escherichia coli* in RS1 group of fermented mutton sausages was the least; in the natural group, the growth of miscellaneous

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## INTRODUCTION

Glucose-based monosaccharides are needed as carbon and energy sources for the biological metabolism of lactic acid bacteria, and monosaccharides such as glucose are converted into organic acids such as small molecular lactic acid through fermentation by lactic acid bacteria, to provide energy for the metabolic activity of life. There are many substances in the metabolic products of lactic acid bacteria, one of which is organic acid. Organic acid is a kind of organic compounds, the unique carboxyl group in the molecular structure is the functional group of carboxylic acid, which constitutes the acidity of organic acid. The way of bacteriostasis of lactic acid bacteria is generally the nutrient substance that lactic acid bacteria and other microorganisms compete to grow. Under the same acid environment, lactic acid bacteria, as the dominant bacteria, can grow and reproduce well in a certain environment, however, due to the high acidity in the environment, such as *E. coli* and *Staphylococcus aureus* bacteria can not grow well, thus inhibiting the microorganisms in food, not only improving the safety of food, but also improving the shelf life of food.

## METHODS AND MATERIALS

Source of samples: 6 strains of lactic acid bacteria collected from pastoral area in laboratory. Methods: Lactic acid bacteria were cultured, TPY medium configuration, Activation of lactic acid bacteria, Preparation of lactic acid bacteria supernatant, Drawing the standard curve of organic acid with ion chromatograph and organic acid standard, Determination of kinds and contents of organic acids in lactic acid bacteria supernatant, Preparation of suspension of indicator bacteria, Treatment of lactic acid bacteria supernatant, Determination of bacteriostatic effect, Production of fermented mutton sausage, Determination of microbial index in fermented mutton sausage.

## RESULTS

After 24 hours culture, six strains of lactic acid bacteria supernatant were centrifuged and filtered, and the kinds and contents of organic acids were determined by Ion Chromatography.

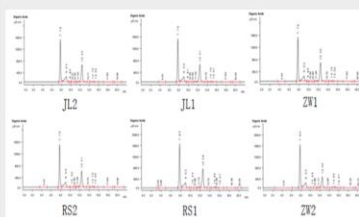


Figure .1 Chromatograms of organic acid ions in the supernatant of six lactic acid bacteria

Table .1 Types of organic acids produced by RS1

峰序号	保留时间 min	面积 (μS/cm)×min	高度 μS/cm	组分名称
1	4.224	0.1244	0.114	NA
2	7.392	302.1403	1519.504	酒石酸
3	9.001	103.9245	190.015	柠檬酸
4	10.405	0.5504	2.334	琥珀酸
5	10.873	0.1795	0.645	NA
6	11.712	8.2007	29.324	NA
7	12.420	204.7907	644.557	乳酸
8	13.691	0.5068	2.378	NA
9	14.935	11.3014	27.417	乙酸
10	16.031	0.4207	0.983	丙酸
11	18.463	0.4284	0.807	NA
12	20.104	0.1764	0.386	NA

Table .2 Types of organic acids produced by ZW2

峰序号	保留时间 min	面积 (μS/cm)×min	高度 μS/cm	组分名称
1	4.347	0.0188	0.051	NA
2	7.784	279.8375	1419.438	酒石酸
3	8.966	99.5143	185.865	柠檬酸
4	10.384	0.1643	0.665	琥珀酸
5	10.865	0.2004	0.638	NA
6	11.723	3.8878	14.083	NA
7	12.420	106.9762	352.101	乳酸
8	13.684	0.5291	2.291	NA
9	14.932	8.7721	20.562	乙酸
10	16.011	0.1101	0.338	丙酸
11	18.455	0.4502	0.817	NA
12	20.082	0.0223	0.055	NA

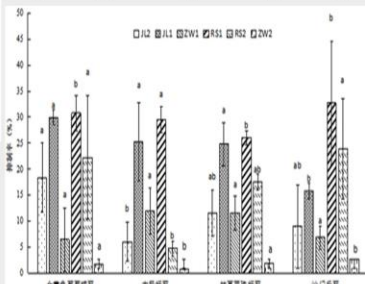


Figure. 2 Inhibition rate of organic acids produced by 6 lactic acid bacteria

## DISCUSSION

From the table, the most kinds of organic acids produced by JL1 and ZW1 were 13 kinds including lactic acid, acetic acid and propionic acid, and the other 4 strains were 12 kinds of organic acids. The peak time of lactic acid produced by ZW2 was 12.567, which was significantly different from that of other 5 lactic acid bacteria. This result may be caused by lactic acid isomer, which will be verified in later experiments. Due to the lack of standard products in the experiment, it was not possible to determine all kinds of organic acids in the Chromatogram. According to the tables and graphs, RS1 showed good bacteriostasis to all four pathogenic indicator bacteria, with an average inhibition rate of 29.07%. The average inhibition rate of JL1, RS2, JL2 and ZW1 were 23.94%, 17.09%, 11.22% and 9.19% respectively. The antibacterial activity of organic acid produced by ZW2 was weak, the average inhibitory rate was 1.70%. As can be seen from the table, the total number of bacteria in the RS-1 fermented sausage was the lowest, and the number of lactic acid bacteria, *Escherichia coli* and *Staphylococcus aureus* in rs-1 group was the lowest compared with the other two groups. The total number of bacteria in ZW2 group was in the middle, and the total number of bacteria in natural group was the most.

## CONCLUSIONS

1. After 24 hours culture, six strains of lactic acid bacteria, JL1, JL2, ZW1, ZW2, RS1 and ZW2, could produce more than 10 kinds of organic acids. Among them, JL1 and ZW1 produced more kinds of organic acids than the other five strains, 13 kinds.
2. The organic acids produced by lactic acid bacteria had certain bacteriostatic effect. The order of the bacteriostatic degree of six LACTIC ACID BACTERIA WAS: RS1 & GT; JL1 & GT; RS2 & GT; JL2 & GT; ZW1 & GT; ZW2. RS1 had good bacteriostasis to *Staphylococcus aureus*, *ESCHERICHIA coli* and lactic acid bacteria, the average inhibition rate was 29.07%, the lowest inhibition rate was ZW2, was 1.7%.

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# 马铃薯冲调营养粉喷雾干燥工艺的优化

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## Introduction

本研究以马铃薯雪花粉为主要原料, 搭配乳粉、大豆蛋白和南瓜粉, 通过喷雾干燥技术制备马铃薯冲调营养粉, 并对其工艺进行优化。首先通过响应面实验优化原料和辅料配比, 最佳结果为(以100 g马铃薯全粉的质量为基准): 乳粉、大豆蛋白、南瓜粉分别占马铃薯全粉的18.13%、9.06%和8.15% (w/w)。在此基础上, 通过正交试验优化助干剂和喷雾干燥工艺参数, 助干剂海藻酸钠、麦芽糊精、羧甲基纤维素钠的最适添加量为0.3%、9%和0.4% (w/w), 喷雾干燥的最佳工艺参数依次为进风温度200°C、泵速为15 r/min和物料浓度16% (w/v)。该条件制备的马铃薯冲调营养粉得粉率为32.77%, 水分含量为4.57%, 蛋白质含量13.50%, 氨基酸总量为206.92mg/100g。所得马铃薯冲调营养粉营养价值高、冲调性好, 可接受度强。

## Materials & Methods

主要原料: 马铃薯全粉来自赤峰凌志马铃薯科技股份有限公司; 全脂乳粉; 南瓜粉来自亳州华圣生物科技有限公司; 三氯蔗糖、羧甲基纤维素钠、麦芽糊精和谷氨酸钠均来自河南万邦实业有限公司; 海藻酸钠来自河南中泰食化有限公司。

## Results and Discussion

据单因素试验结果, 本试验以乳粉(A)、大豆蛋白(B)、南瓜粉(C)为变量, 以马铃薯冲调营养粉的溶解性为响应值(R), 设计3因素3水平响应面分析实验, 得到最优的辅料添加量, 响应面优化方案及结果见表1。回归方程:

$R(\%) = 59.90 + 0.13A + 0.055B + 0.074C - 0.068AB - 0.025AC + 0.003BC - 0.97A^2 - 0.88B^2 - 0.76C^2$  溶解性的响应面优化回归方程的方差分析如表2所示马铃薯冲调营养粉的溶解性的最佳条件为: 乳粉添加量18.13%、大豆蛋白添加量9.06%、南瓜粉添加量为8.15%, 此时马铃薯冲调营养粉的溶解性为60.05%。

表3和4为助干剂对马铃薯冲调营养粉的影响的正交试验。为了提高得粉率, 降低水分含量, 根据极差分析和方差分析, 根据极差分析和方差分析可知, 确定助干剂组合为A<sub>2</sub>B<sub>2</sub>C<sub>3</sub>, 即海藻酸钠添加量为0.3%, 麦芽糊精添加量为9%, 羧甲基纤维素钠添加量为0.4%。

表5和表6喷雾干燥工艺参数优化的正交试验。为了提高得粉率, 降低水分含量, 根据极差分析和方差分析, 确定喷雾干燥制备马铃薯冲调营养粉的适宜工艺条件为A<sub>2</sub>B<sub>2</sub>C<sub>3</sub>, 通过对组合A<sub>2</sub>B<sub>2</sub>C<sub>3</sub>进行验证试验, 所得马铃薯冲调营养粉的得粉率为32.77%±0.10%, 水分含量为4.57%±0.03%。因此, 马铃薯冲调营养粉的最佳工艺条件为: 进风温度为200°C, 蠕动泵的泵速为15 r/min, 物料浓度为16%。

由表7可知, 马铃薯冲调营养粉中共检测出16种氨基酸, 含有必需氨基酸7种, 非必需氨基酸9种。马铃薯冲调营养粉中氨基酸总量为206.92 mg/100g, 必需氨基酸与酪氨酸的含量之和为85.24 mg/100g, 占氨基酸总量的41.19%, 与马铃薯全粉相比, 马铃薯冲调粉的氨基酸含量有所提高, 且必需氨基酸与酪氨酸含量之和高于总氨基酸含量的40%, 表明马铃薯冲调营养粉具有较高的营养价值。

由图1可知, 马铃薯冲调营养粉的感官评价从组织形态、色泽、溶解性、稳定性、口感和风味均高于马铃薯全粉。通过添加助干剂, 进行喷雾干燥等工艺, 改善了马铃薯冲调营养粉溶解性, 稳定性; 与市售的马铃薯冲调营养粉相比, 马铃薯冲调营养粉在组织形态、口感、稳定性、溶解性略低于市售马铃薯冲调营养粉, 风味与市售马铃薯冲调营养粉的评分相同, 在色泽方面, 因为添加了南瓜粉, 马铃薯冲调营养粉的颜色略好于市售马铃薯冲调营养粉。

实验号	乳粉 (%)		大豆蛋白 (%)		南瓜粉 (%)	溶解性 (%)
	A	B	C	D		
1	-1	-1	0	0	0	57.79
2	1	-1	0	0	0	58.14
3	-1	1	0	0	0	58.09
4	1	1	0	0	0	58.17
5	-1	0	-1	-1	0	57.93
6	1	0	-1	-1	0	58.28
7	-1	0	1	1	0	58.12
8	1	0	1	1	0	58.37
9	0	1	-1	-1	0	58.16
10	0	1	1	1	0	58.21
11	0	-1	1	1	0	58.31
12	0	1	1	1	0	58.37
13	0	0	0	0	0	59.88
14	0	0	0	0	0	59.91
15	0	0	0	0	0	59.92
16	0	0	0	0	0	59.87
17	0	0	0	0	0	59.94

表2 Auxiliary box-behken design and result

实验号	海藻酸钠添加量 (%) A	麦芽糊精添加量 (%) B	羧甲基纤维素钠添加量 (%) C	空白	得粉率 (%)	水分含量 (%)
1	0.2	7	0.2	1	24.72	5.26
2	0.2	9	0.3	2	26.62	5.13
3	0.2	11	0.4	3	27.64	4.97
4	0.3	7	0.3	3	28.24	4.86
5	0.3	9	0.4	1	30.51	4.79
6	0.3	11	0.2	2	29.57	4.83
7	0.4	7	0.4	2	27.99	5.08
8	0.4	9	0.2	3	27.41	5.16
9	0.4	11	0.3	1	28.59	5.01
误差 R <sub>1</sub>	26.3267	26.9833	27.1667	27.94		
误差 R <sub>2</sub>	29.3733	28.18	27.8167	27.9933		
误差 R <sub>3</sub>	27.9967	28.3333	28.7133	27.7633		
误差 R <sub>4</sub>	3.0467	1.25	1.5467	0.23		
水 K <sub>21</sub>	5.12	5.0667	5.0833	5.02		
分 K <sub>22</sub>	4.8267	5.0267	5	5.0133		
总 K <sub>23</sub>	5.0833	4.9367	4.9467	4.9967		
误差 R <sub>2</sub>	0.2933	0.13	0.1367	0.0233		

表3 不同助干剂配比组合正交试验结果

实验号	进风温度 (°C) A	蠕动泵转速 (r/min) B	物料浓度 (%) C	空白	得粉率 (%)	水分含量 (%)
1	190	10	14	1	29.34	5.01
2	190	15	16	2	30.51	4.79
3	190	20	18	3	29.72	4.85
4	200	10	16	3	30.71	4.73
5	200	15	18	1	31.87	4.61
6	200	20	14	2	30.16	4.82
7	210	10	18	2	29.51	4.86
8	210	15	14	3	29.86	4.79
9	210	20	16	1	28.69	4.88
误差 R <sub>11</sub>	29.8657	29.8533	29.82	29.9667		
误差 R <sub>12</sub>	30.9133	30.78	29.97	30.06		
误差 R <sub>13</sub>	29.3867	29.3233	30.3667	30.13		
误差 R <sub>14</sub>	1.5267	1.2567	0.5467	0.1633		
水 K <sub>21</sub>	4.8833	4.8667	4.8733	4.8333		
分 K <sub>22</sub>	4.72	4.73	4.8	4.8233		
总 K <sub>23</sub>	4.8433	4.85	4.7733	4.79		
误差 R <sub>2</sub>	0.1633	0.1367	0.1	0.0433		

表5 喷雾干燥制备马铃薯冲调营养粉工艺条件正交试验结果

马铃薯全粉		马铃薯冲调粉	
氨基酸	含量 (mg/100g)	氨基酸	含量 (mg/100g)
Arg 天冬氨酸	27.57	Arg 天冬氨酸	27.58
Ser 丝氨酸	6.26	Ser 丝氨酸	10.30
Glu 谷氨酸	30.06	Glu 谷氨酸	44.97
Gly 甘氨酸	3.66	Gly 甘氨酸	8.02
Ala 丙氨酸	3.93	Ala 丙氨酸	9.12
Cys 半胱氨酸	2.05	Cys 半胱氨酸	3.09
His 组氨酸	2.99	His 组氨酸	5.16
Arg 精氨酸	9.08	Arg 精氨酸	13.44
Thr 苏氨酸	5.50	Thr 苏氨酸	7.74
The 酪氨酸	6.54	The 酪氨酸	9.26
Val 缬氨酸	8.27	Val 缬氨酸	12.70
Met 甲硫氨酸	2.60	Met 甲硫氨酸	3.12
Ile 异亮氨酸	5.76	Ile 异亮氨酸	9.27
Leu 亮氨酸	9.82	Leu 亮氨酸	16.02
Phe 苯丙氨酸	7.25	Phe 苯丙氨酸	10.84
Lys 赖氨酸	0.51	Lys 赖氨酸	14.29
氨基酸总量	144.95	氨基酸总量	206.92

表7 马铃薯全粉与马铃薯冲调营养粉氨基酸含量成分表

来源	平方和	自由度	均方	F值	P>F值	显著水平
模型	11.03	9	1.23	655.06	<0.0001	**
A	0.13	1	0.13	70.89	<0.0001	**
B	0.024	1	0.024	12.94	0.0088	*
C	0.044	1	0.044	23.26	0.0019	*
AB	0.018	1	0.018	9.74	0.0168	*
AC	0.003	1	0.003	1.34	0.2856	-
BC	0.0003	1	0.0003	0.013	0.9112	-
A2	3.98	1	3.98	2126.48	<0.0001	**
B2	3.29	1	3.29	1750.86	<0.0001	**
C2	2.41	1	2.41	1289.79	<0.0001	**
误差	0.013	7	0.002			
失拟误差	0.01	3	0.008	3.93	0.1098	-
纯误差	0.003	4				
总和	11.04	16				

表2 回归模型方差分析

变异来源	偏差平方和	自由度	方差	F值	显著水平
海藻酸钠添加量 (%)	13.971	2	6.9855	184.202	***
麦芽糊精添加量 (%)	3.9482	2	1.9741	52.056	***
羧甲基纤维素钠添加量 (%)	3.624	2	1.812	47.781	**
误差 e	0.0758	2	0.0379		
总和	21.619				
海藻酸钠添加量 (%)	0.1532	2	0.0766	183.634	***
麦芽糊精添加量 (%)	0.0296	2	0.0148	35.439	**
羧甲基纤维素钠添加量 (%)	0.0384	2	0.0142	34.049	**
误差 e	0.0008	2	0.0004		
总和	0.212				

表4 方差分析结果

变异来源	偏差平方和	自由度	方差	F值	显著水平
进风温度 (°C)	3.6738	2	1.8369	79.479	**
蠕动泵转速 (r/min)	2.5345	2	1.2673	54.831	**
物料浓度 (%)	0.4844	2	0.2422	10.479	*
误差 e	0.0462	2	0.0231		*
总和	6.739				
进风温度 (°C)	0.0415	2	0.0208	35.825	**
蠕动泵转速 (r/min)	0.0343	2	0.0172	29.596	**
物料浓度 (%)	0.0142	2	0.0071	12.211	*
误差 e	0.0012	2	0.0006		

表6 方差分析结果

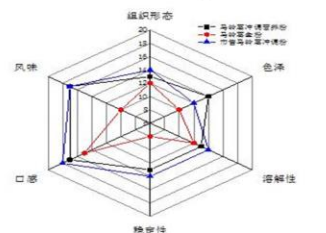


图1 马铃薯冲调营养粉感官评价图



# 运动对苏尼特羊肌纤维特性及肉品质的影响

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## 前言

肌纤维是组成肌肉组织的基本单位, 机体中肌纤维的数量在其出生时就已经稳定, 但肌纤维类型的组成易受到遗传、营养和生理等因素的影响而发生转变。肌纤维的密度、数目、直径、横截面积等都与肉品质密切相关。尤其是当肉品中氧化型肌纤维所占比例高时, 肌肉的pH值、肉品的风味、颜色、大理石纹评分和肌内脂肪含量较高, 肌肉的系水力强, 肌肉细嫩多汁, 肉质良好。研究表明通过适当运动影响肌纤维的转化是改善肉品质的重要途径。动作为刺激骨骼肌表型重塑的重要因素, 通过交叉运动神经元支配可引起神经活力的改变, 进而诱导骨骼肌纤维类型的改变。

## 目的

本实验分别运用ATP酶染色法及肌球蛋白重链(Myosin Heavy Chain, MyHC)基因表达量测定分析对肌纤维进行分型, 并测定苹果酸脱氢酶、琥珀酸脱氢酶和乳酸脱氢酶的活力和肉品质指标, 旨在研究运动对苏尼特羊肌纤维特性及肉品质的影响, 为改善肉品质提供理论依据。

## 材料与与方法

本实验在内蒙古巴彦淖尔市乌拉特中旗川井苏木进行。选择3月龄, 体况良好的纯种苏尼特羊14只, 随机分为2组: 运动组(A)、对照组(C), 两组苏尼特羊分别于大小相同的圈中集体饲养, 饲养期间自由饮水、采食。运动组每天上午下午各运动一次, 每次以0.56m/s的速度运动1 h, 对照组不做处理, 预实验期7天, 实验期90天。宰后取背最长肌为实验材料。

## 结果

### 1、苏尼特羊肌纤维ATPase染色结果

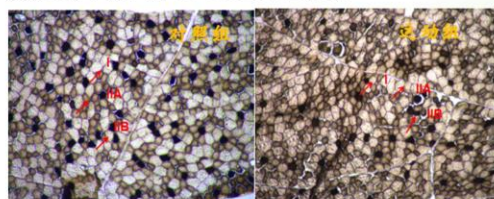


图1 对照组和运动组苏尼特羊背最长肌ATPase染色结果

### 2、运动对肌纤维数量比例、面积比例的影响

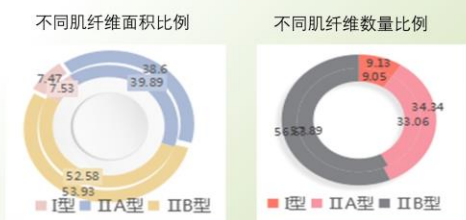


图2 运动对肌纤维数量比例、面积比例的影响

### 3、日粮中添加亚麻籽对肌纤维直径和横截面积的影响

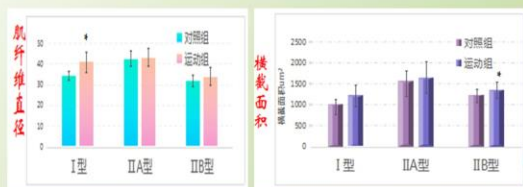


图3 运动对肌纤维直径和横截面积的影响

### 4、运动对肌球蛋白重链(MyHC)基因表达量的影响

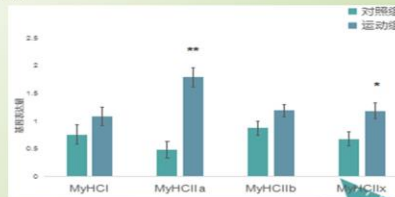


图4 运动对MyHC基因表达量的影响

### 5、运动对肌肉中乳酸脱氢酶、琥珀酸脱氢酶和苹果酸脱氢酶活力的影响

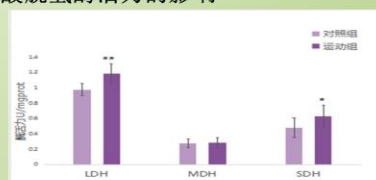


图5 运动对肌肉中琥珀酸脱氢酶和乳酸脱氢酶活力的影响

### 6、运动对苏尼特羊肉品质的影响

项目	运动组	对照组
pH <sub>0</sub>	6.14 ± 0.19 <sup>B</sup>	6.46 ± 0.25 <sup>A</sup>
pH <sub>24</sub>	5.57 ± 0.18 <sup>A</sup>	5.30 ± 0.07 <sup>B</sup>
L*	31.81 ± 1.27 <sup>B</sup>	34.58 ± 2.45 <sup>A</sup>
a*	28.41 ± 0.81 <sup>A</sup>	20.46 ± 1.13 <sup>B</sup>
b*	2.91 ± 0.44 <sup>B</sup>	4.00 ± 0.61 <sup>A</sup>
剪切力	76.56 ± 13.77 <sup>A</sup>	58.4 ± 13.53 <sup>B</sup>
蒸煮损失	0.35 ± 0.02 <sup>A</sup>	0.34 ± 0.03 <sup>A</sup>

## 结论

运动可促进肌纤维类型由酵解型向氧化型转化, 改善肌肉色泽, 提高肌肉的氧化代谢能力, 但不利于肌肉嫩度。







## 高耐受Pb<sup>2+</sup>酵母菌抗氧化及吸附Pb<sup>2+</sup>特性的研究

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### 介绍

重金属是指密度大于4.5 g/cm<sup>3</sup>的金属, 常见的有铬、铜、镉、镍等, 铅(Plumbum, Pb)是其中对环境和人体危害较大的一种。在灌溉小麦和水稻时, 如果使用含铅浓度在0.1-4.4 mg/L的水, 成熟的作物中的含铅量就会显著增加。卢楠和王颖等分别研究分析了重金属铅对野生植物种子发芽和水稻生长情况的影响, 结果表明Pb的污染对野生种子的发芽和水稻根系的生长影响显著。铅主要通过呼吸和消化两大途径进入机体, 可以蓄积于体内, 产生过多的自由基攻击生物大分子, 主要体现在DNA破损和对特定酶的氧化钝化, 甚至可能破坏细胞的结构和功能, 造成机体各大器官等一系列的系统损伤。具体表现为: 小脑和和大脑的皮层细胞损伤; 儿童智力发育损伤; 免疫系统损伤; 心血管系统损伤; 肾脏系统损伤等。故对于铅的防治与治疗引起众多学者的关注, 除西药络合类药物及食疗驱铅等治疗方法外, 对铅有吸附性及抗氧化活性高的微生物也成为研究热点。

### 材料与方法

- I. I. 异常威克汉姆酵母(*Wickerhamomyces anomalus*) Q1-1-6、Q1-1-7、QD-2-8; 内蒙古农业大学食品学院食品生物技术团队提供; 水杨酸、邻苯三酚、亚油酸等试剂均为分析纯。
- II. II. 菌悬液和无细胞提取物对羟基自由基、DPPH·自由基、超氧阴离子、脂质过氧化物的去除率。
- III. III. 研究pH值对酵母菌吸附Pb<sup>2+</sup>的影响、湿菌体浓度对酵母菌吸附Pb<sup>2+</sup>的影响、初始Pb<sup>2+</sup>浓度对酵母菌吸附Pb<sup>2+</sup>的影响、吸附温度对酵母菌吸附Pb<sup>2+</sup>的影响、吸附时间对酵母菌吸附Pb<sup>2+</sup>的影响。

### 结果与讨论

#### 3.1 *W. anomalus* 抗氧化能力测定结果

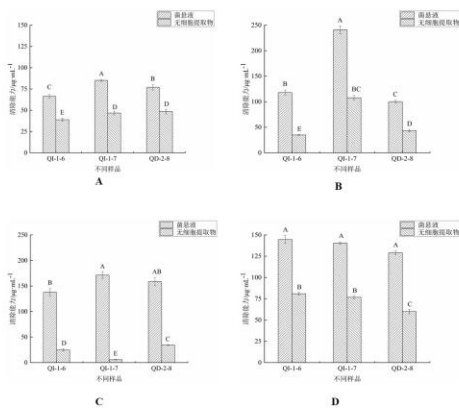


图1 酵母菌悬液和无细胞提取物的抗氧化能力

注: A、B、C、D分别代表DPPH自由基、羟基自由基、超氧阴离子和脂质过氧化物清除能力, 不同字母表示不同菌株菌悬液、无细胞提取物清除相应抗氧化能力具有显著性差异(p < 0.05)。

菌株Q1-1-6菌悬液对DPPH·清除能力较好, 达到(144.72 ± 4.53) μg·mL<sup>-1</sup>; *W. anomalus* Q1-1-7菌悬液对DPPH自由基、羟基自由基和超氧阴离子的清除能力较好, 分别达到(85.09 ± 1.11) μg·mL<sup>-1</sup>、(240.88 ± 7.69) μg·mL<sup>-1</sup>、(171.41 ± 6.92) μg·mL<sup>-1</sup>。

### 结论

- 三株异常威克汉姆酵母菌均具有一定的抗氧化应激作用, 且菌悬液和无细胞提取物的抗氧化能力不同。菌悬液清除羟基自由基、DPPH·自由基、清除超氧阴离子和抑制脂质过氧化物的能力都比无细胞提取物高。菌株Q1-1-6菌悬液对DPPH·清除能力较好, 达到(144.72 ± 4.53) μg·mL<sup>-1</sup>; *H. anomalus* Q1-1-7菌悬液对DPPH·自由基、羟基自由基和超氧阴离子的清除能力较好, 分别达到(85.09 ± 1.11) μg·mL<sup>-1</sup>、(240.88 ± 7.69) μg·mL<sup>-1</sup>、(171.41 ± 6.92) μg·mL<sup>-1</sup>。
- 当pH值为5时, *W. anomalus* Q1-1-7对Pb<sup>2+</sup>的吸附能力最强, 此时吸附率为98.31%; 菌体浓度为15g/L时, 吸附率最大为98.75%; Pb<sup>2+</sup>浓度为100g/L时, 吸附率最大为98.97%; 温度为35℃时, 吸附率最大为98.20%; 吸附时间为150min时, 菌株Q1-1-7对重金属Pb<sup>2+</sup>的吸附能力最强, 吸附率达到最大的98.86%。

#### 3.2 酵母菌对Pb<sup>2+</sup>吸附特性的研究

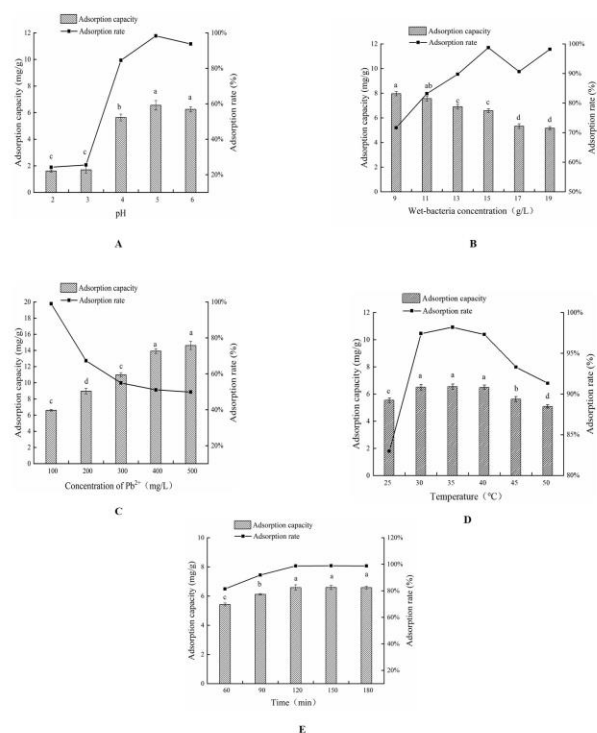


图2 酵母菌对Pb<sup>2+</sup>吸附特性的研究

注: A、B、C、D、E分别代表pH、湿菌体浓度、初始Pb<sup>2+</sup>浓度、吸附温度、吸附时间对酵母菌吸附Pb<sup>2+</sup>的影响, 不同字母表示不同条件下吸附率具有显著性差异(p < 0.05)。

由图可知, 菌株Q1-1-7对Pb<sup>2+</sup>的吸附量和吸附率随着pH的升高而升高, 且吸附量和吸附率呈正相关。具体表现为: 当pH值在2.0-3.0这个区间内, 菌株Q1-1-7吸附Pb<sup>2+</sup>的能力较弱, 当pH值达到4.0时, 菌株的吸附能力开始增大, 当pH达到5.0时, 吸附能力最强, 数值也最大, 吸附量为6.55mg/g, 吸附率为98.311%。当菌体浓度为9g/L-17g/L, 菌株吸附率呈先上升后下降的趋势。当湿菌体浓度为15g/L时, 吸附率达到了最大值, 为98.756%。当Pb<sup>2+</sup>浓度为9g/L-17g/L, 此时吸附率为最大值, 达到98.978%。当菌株的浓度增长到200mg/L时, 吸附率发生明显的下降, 当Pb<sup>2+</sup>浓度再次升高时, 吸附率表现出一个较为缓慢的下降趋势, 并且当Pb<sup>2+</sup>浓度为500mg/L时, 吸附率达到了最低值为49.849%。当温度较低的时候, 对菌株Q1-1-7的吸附量和吸附率影响较大, 之后当温度上升到30℃的时候, 变化幅度较大。菌株Q1-1-7在35℃时, 吸附率与吸附量达到最大值, 分别为98.2%和6.547mg/g。随着吸附时间的增加, 菌株Q1-1-7对Pb<sup>2+</sup>吸附的能力呈一个缓慢增长的趋势, 当吸附时间为150min时, 吸附率以及吸附量达到最大值, 分别为98.867%和6.591mg/g。当吸附时间达到120min时, 吸附率以及吸附量几乎不再发生变化。

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# 二、论文摘要

## (一)肉制品专题

## 1. 小米及肉香肠的制作

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**摘要:**目前我国研发部研制出许多具有中国特色的灌肠类, 如: 芦荟保健香肠、果蔬复合型香肠、鹅骨泥红肠等, 但以粗粮为基础的复合型香肠甚是少见, 因此本文探讨了小米鸡肉香肠的最佳生产工艺和配方。以小米、马铃薯淀粉、鸡大胸肉、鸡皮、鸡蛋为主要原料, 在传统鸡肉肠中添加粗粮中的一种即小米, 采用单因素试验和 L9(34)正交试验的方法, 研制出小米鸡肉香肠的最佳配方, 并通过产品的色泽、小米颗粒、组织状态、滋气味、口感为指标进行感官评定。试验结果表明: 以鸡大胸肉 100g 为基准, 鸡胸肉与鸡皮的比例为 7: 3, 鸡蛋的添加量为 4%, 小米的添加量为 10%, 淀粉的添加量为 11%, 制作出的小米鸡肉肠肉质嫩滑、颜色均匀, 小米颗粒可见, 组织紧密无较大孔, 口感 Q 弹。小米作为粗粮中的一种, 具有较高的营养价值, 将其添加至香肠中可以丰富产品的营养价值, 适宜各类人群。

### **Production of millet chicken sausage**

XiaoNa Zeng, YanBo Wang, Quan Shuang\*

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**Abstract:** This article discusses the best production process and recipe of millet chicken sausage. Millet, potato starch, chicken breast, chicken skin, and eggs were used as the main raw materials. One of the coarse grains, millet, was added to the traditional chicken intestine. The method of single factor test and L9 (34) orthogonal test was used to develop millet chicken sausage. The best formula of the product is sensory evaluation based on the product's color, millet granules, tissue state, odor and taste. The test results show that based on 100g of chicken breast, the ratio of chicken breast to skin is 7: 3, the amount of eggs is 4%, the amount of millet is 13%, and the amount of starch is 12%. The chicken intestines are tender, smooth and uniform in color, with millet grains visible, tight tissues without large holes, and Q-flavor. As a kind of coarse grains, millet

has high nutritional value. Adding it to sausages can enrich the nutritional value of the product, which is suitable for all types of people.

## 2. 苏尼特羊肥尾脂质代谢分析

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(内蒙古农业大学食品科学与工程学院 内蒙古 呼和浩特市 010018)

**摘要:** 本实验采用天然放牧条件下 6 月龄、18 月龄与 30 月龄苏尼特羊, 利用高效液相色谱串联高分辨率质谱技术 (UHPLC-Q-TOF/MS), 非靶向代谢组学对苏尼特羊肥尾脂肪(T)、肾周围(K)和皮下脂肪(SF)进行分析,以探究羊尾油脂的综合利用价值。结果共检测出 205 种代谢物, 主要包括脂肪酰基、甘油磷脂 (Glycerophospholipids, PC)、鞘脂(sphingolipid,SM)、甘油酯类、类固醇和类固醇衍生物。羊肥尾脂中甘油磷脂, 鞘脂, 油酸、亚油酸等不饱和脂肪酸以及十七烷酸、棕榈酸等饱和脂肪酸显著高于肾周围脂肪( $P<0.05$ ); 羊肥尾部位与皮下脂肪相比, 饱和脂肪酸十七烷酸在 30 月龄时显著增加( $P<0.05$ ), 甘油磷脂和鞘脂 SM 36:1;SM (d14:0/22:1)在 6 月龄显著增加( $P<0.05$ ), 在 18 月龄及 30 月龄仅 PC(18:0/22:2(13Z,16Z))呈增加趋势。对羊肥尾三个生长阶段脂质进一步探究发现, 18 月龄、30 月龄甘油三酯(Triglyceride,TG)除 TG 47:0; TG(15:0/16:0/16:0)外, 均较 6 月龄显著增加 ( $P<0.05$ ); 30 月龄中 PC 显著低于 6、18 月龄( $P<0.05$ ); 甘油二酯(Diglyceride,DG) 显著高于 6、18 月龄( $P<0.05$ )。综上, 与肾周围脂肪和皮下脂肪相比, 苏尼特羊肥尾脂肪具有较高的营养价值。

### Analysis of Lipid Metabolism in Tail Fat of Sunit Sheep

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**Abstract:** In this study, the 6-month-old, 18-month-old, and 30-month-old natural grazed Sunit sheep were used. To explore the comprehensive utilization value of sheep tail fat, the metabolomics data from tail fat, perirenal fat, and subcutaneous fat of Sunit sheep were analyzed by untargeted metabolomics and UHPLC-Q-TOF/MS. The results

showed that 205 metabolites were detected, mainly include fatty acyls, glycerophospholipids, sphingolipids, glycerides, steroids and steroid derivatives. Glycerophospholipids, sphingolipids and unsaturated fatty acids such as oleic acid, linoleic acid, and saturated fatty acids such as heptadecanoic acid and palmitic acid were significantly higher in the tail fat than in the perirenal fat ( $P<0.05$ ). Compared with subcutaneous fat, the saturated fatty acid heptadecanoic acid was significantly increase at 30 months of age in the tail fat ( $P<0.05$ ), glycerophospholipid and sphingolipids SM 36:1; SM (d14:0/22:1) were significantly increase at 6 months ( $P<0.05$ ), PC (18:0/22:2(13Z,16Z)) showed an increasing trend at 18 months and 30 months. Further investigation of lipids in the three growth stages of tail fat showed that except for TG 47:0; TG (15:0/16:0/16:0), triglycerides of 30 months and 18 months of age increased significantly compared with 6 months of age ( $P<0.05$ ), glycerophospholipids (PC) of tail fat at 30 months was significantly lower than that at 6 and 18 months ( $P<0.05$ ), diglyceride (DG) was significantly higher than that of 6 and 18 months ( $P<0.05$ ). Overall, the tail fat of Sunnit sheep had a higher nutrition value than perirenal fat and subcutaneous fat.

### 3. 驼肉香肠的生产工艺研究

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**摘要:** 骆驼肉具有高蛋白、低脂肪、低胆固醇的特点, 同时富含氨基酸、矿物质及不饱和脂肪酸, 是许多非洲和亚洲国家动物蛋白的重要来源。与牛肉相比, 骆驼肉的多不饱和脂肪酸含量相对较高, 这是降低与饱和脂肪酸有关的心血管疾病风险的重要因素。本试验利用传统的香肠生产工艺, 以感官评定为指标, 通过单因素试验方法研究肥瘦比、加盐量、腌制时间对驼肉香肠的感官上的影响; 随后在单因素试验基础上进行正交试验进一步优化驼肉香肠的加工条件。试验结果显示, 驼肉香肠最佳工艺参数为: 加盐量 2%, 肥瘦比 2:8, 腌制时间为 24h。

在此组合下制作的驼肉香肠口感鲜美，咸淡适中、色泽红润，肥瘦均匀、肉质鲜美且富有弹性。

## Study on production technology of camel sausage

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**Abstract:** Camel meat is high in protein, low in fat and cholesterol, rich in amino acids, minerals, and unsaturated fatty acids. It is an important source of animal protein in many African and Asian countries. Compared with beef, camel meat has a relatively high concentration of polyunsaturated fatty acids, which is an important factor in reducing the risk of cardiovascular disease associated with saturated fatty acids. In this study, the traditional sausage production process was used to determine the fat and lean ratio and the addition amount of salt and pickling time which had an effect on the sensory of camel sausage by single factor experiment, with sensory evaluation as the index. Subsequently, the best processing technology parameter of camel meat sausages were optimized by orthogonal experiment, on the basis of a single factor experiment. The results showed that the best process parameters of camel meat sausage were 2% salt addition, 2:8 fat/lean ratio, and 24h pickling time. The camel meat sausage produced under this combination parameter has characteristics of delicious taste, moderate saltiness, ruddy color, uniform fatness, and elastic texture.

## 4. 酥皮鲜肉馅饼的制作工艺及其卫生质量控制研究

程峰, 田建军\*

(内蒙古农业大学食品科学与工程学院 内蒙古 呼和浩特市 010018)

**摘要:** 馅饼是中国民间家常食品，制作方式有煎、烤、焗等，由饼包着馅料。酥皮鲜肉馅饼是通过烤制方法制作的，酥而不腻，味道鲜美，品尝后回味无穷。

文章按照国家标准及相关要求,通过对馅饼制作、细菌总数测定、白度测定、硬度和感官检验进行讨论并统计归纳数据,得出以下结论:(1)常温保存酥皮鲜肉馅饼最长保存时间为9小时左右,超过此时间馅饼内的细菌总数将会超过国家要求的卫生标准,食用后可能会对人体产生危害。(2)随着烤制时间的延长,白度值逐渐减低,但最受消费者喜爱的是烤制时间为二十二分钟左右的酥皮鲜肉馅饼。(3)硬度的增加有助于提高酥皮鲜肉馅饼的口感。(4)对比烤制时间为十八、二十、二十三分钟的酥皮鲜肉馅饼,综合考虑最受消费者喜欢的是烤制时间二十三分钟的酥皮鲜肉馅饼。

## **Research on the processing technology and hygienic quality control of pastry**

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**Abstract:** Pie is a kind of Chinese folk food. It is made by frying, baking, baking and baking. Meringue mince pies are made by baking. They are crisp but not greasy. Article in accordance with national standards and phase Clearance requirements, through to the pie, determination of the total number of bacteria and white degree, hardness and sensory test are discussed and statistical data, the following conclusions: (1) under normal temperature preservation meringue fresh meat pie save the longest time is 9 hours, more than total number of bacteria in this time of pie will exceed the requirements of the national health standards, after eating may produce bad effects on the human body. (2) with the extension of baking time, whiteness value gradually decreased, but the most popular consumer is baking time for 22 minutes or so of crisp meat pie. (3) the increase in hardness is helpful to improve the taste of crisp meat pie. (4) compared to the baking time of 18, 20, 23 minutes of fresh meat pie, the comprehensive consideration of the most popular by consumers is the baking time of 23 minutes of fresh meat pie.

## 5. 两种饲养方式下苏尼特羊肉的氧化稳定性比较

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**摘要:** 以舍饲、放牧两种饲养方式下的 12 月龄苏尼特羊股二头肌为实验材料, 分别测定脂质氧化产物含量、硫代巴比妥酸值、抗氧化能力、抗氧化酶活力以及抗氧化酶相关调控基因表达量等指标并进行比较分析, 旨在探索两种饲养方式下苏尼特羊肉的氧化稳定性。结果表明: 放牧饲养苏尼特羊肉 TBA 值高度显著低于舍饲饲养 ( $P < 0.001$ ); 羊肉中主要的脂质氧化产物为己醛、庚醛、壬醛、1-辛烯-3-醇以及 2,3-辛二酮, 其含量均在放牧饲养羊肉中显著较低 ( $P < 0.05$ ), 表明舍饲饲养羊肉的脂质氧化程度相比放牧饲养羊肉更严重。放牧饲养羊肉的总抗氧化能力 ( $P < 0.01$ )、铜离子还原能力 ( $P < 0.05$ ) 和超氧化物歧化酶 (superoxide dismutase, SOD) ( $P < 0.001$ )、过氧化氢酶 (catalase, CAT) ( $P < 0.05$ )、谷胱甘肽过氧化物酶 (glutathione peroxidases, GPx) ( $P < 0.05$ ) 活力均显著高于舍饲饲养, 说明放牧饲养羊肉中的抗氧化酶活力较高, 能有效抑制脂质氧化。通过抗氧化酶相关调控基因表达量的分析得出, 舍饲饲养羊肉中脂肪氧合酶基因表达量高度显著高于放牧饲养 ( $P < 0.001$ ), 而 SOD ( $P < 0.001$ )、CAT ( $P < 0.05$ ) 和 GPx ( $P < 0.05$ ) 基因表达量均显著低于放牧饲养, 从分子水平验证了放牧饲养羊肉的抗氧化能力较舍饲饲养好。

### Comparison of Oxidation Stability of Sunit Lamb under Two Feeding Methods

Lu Dou, Chang Liu, ZhiHao Tang, XiaoYu Chen, Lin Su, LiHua Zhao, JianJun Tian, Ye Jin\*

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**Abstract:** The objective of this study was to investigate the oxidative stability of meat from Sunit sheep fed on two different diets: pasture and forage supplemented with concentrate mixture. The amount of lipid oxidation products, thiobarbituric acid(TBA)



value, antioxidant ability, antioxidant enzymes activities and the expression of antioxidant genes in Biceps femoris muscles from sheep slaughtered at 12 months of age were determined and compared between the two feeding groups. The results showed that TBA value of meat from grazed sheep was significantly lower than that of forage plus concentrate-fed sheep ( $P < 0.001$ ). Hexanal, heptanal, nonanal, 1-octen-3-ol and 2,3-octanedione were the major lipid oxidation products in both meat samples and their values were lower in meat from grazed sheep than in forage plus concentrate-fed sheep ( $P < 0.05$ ), indicating that the latter had a higher degree of lipid oxidation. As for antioxidant properties, total antioxidant capacity (T-AOC,  $P < 0.01$ ) and cupric reducing antioxidant capacity (CUPRAC,  $P < 0.05$ ) of grazed sheep were significantly higher than those of forage plus concentrate-fed sheep. The same was true for the antioxidant enzymes, superoxide dismutase (SOD,  $P < 0.001$ ), catalase (CAT,  $P < 0.05$ ) and glutathione peroxidase (GPx,  $P < 0.05$ ). These observations suggest that meat from pasture-fed sheep has higher antioxidant enzymes activities and as a result, its lipid oxidation can be effectively inhibited. Furthermore, the gene expression of SOD ( $P < 0.001$ ), CAT ( $P < 0.05$ ) and GPx ( $P < 0.05$ ) in pasture-fed sheep was significantly higher than in forage plus concentrate-fed sheep, while the opposite was true for the gene expression of lipoxygenase ( $P < 0.001$ ). In conclusion, this study provides molecular evidence that antioxidant capacity in meat from pasture-fed sheep was better than in forage plus concentrate-fed sheep.

## 6. 抗氧化菌株的筛选及其对发酵羊肉干理化指标的影响

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**摘要:** 本试验将实验室现共有的 24 株乳酸菌分别进行抗氧化活性的筛选, 通过 DPPH 清除能力测定、羟自由基清除能力、超氧自由基清除能力、亚铁离子螯合能力的测定选出抗氧化活性最佳的乳酸菌, 并加入该菌制作发酵羊肉干。本实验分成对照组、添加发酵剂组以及香辛料和发酵剂都添加的组, 深层次地研究发

酵剂对发酵羊肉干的理化、微生物指标以及挥发性风味物质的影响，这可以为发酵羊肉干品质的控制以及工业化的生产提供理论依据。试验的结果如下：

1.初步筛选出具有较高抗氧化活性的乳酸菌是 HB5、37X-9、37X-10、37X-15，进一步进行菌株的抗氧化能力测定，研究发现：戊糖片球菌 37X-15 的 DPPH 自由基清除率达到 58.55%；羟自由基的清除能力与 VC 对照组基本保持一致；清除超氧自由基能力达到 46.96%；Fe<sup>2+</sup> 螯合率达到 91.49%。因此戊糖片球菌 37X-15 具有较强的抗氧化活性。

2.香辛料+发酵剂组的红度值为 16.02，显著高于对照组 15.72 (p<0.05)；香辛料+发酵剂组的 TBARS 值为 0.563，显著低于对照组 1.069 (p<0.05)。

## Effect of Starter and Spice on the Quality of Fermented Mutton Jerky

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**Abstract:** In this experiment, the total 24 lactic acid bacteria in the laboratory were respectively studied on their antioxidation, and the one with the best anti oxidation was selected by testing their ability to scavenge the DPPH, hydroxyl radical and superoxide radical, and to chelate ferrous ions. Afterwards, it was used to make fermented mutton jerky. The experiment contained 4 groups: the control group, the starter group and the mix group (containing both the starter and spices) and then profoundly studied the influence of the starter and spices to the physicochemical indexes. The experimental results are as follows:

1. According to the primary selection results of lactic acid bacteria, HB5, 37X-9, 37X-10 and 37X-15 were tested to have good antioxidation. After the antioxidant capacity of strains were further tested, the pediococcus pentosaceus 37X-15 was finally assured to have the best antioxidation, whose rates of scavenging DPPH free radical and superoxide radical were respectively up to 58.55% and 46.96%, ability to eliminate hydroxyl radical was around equal to the VC

control group and rate of chelating ferrous ions was up to 91.49%. Therefore, pediococcus pentosaceus has relatively high antioxidation.

2. In terms of the mix group, the figure of redness was 16.02, quite higher than that of the control group (15.72,  $p < 0.05$ ); the figures of the TBARS were 0.563, both dramatically lower than those of the control group (1.069,  $p < 0.05$ ).

## 7. 饲喂乳酸菌对苏尼特羊脂肪酸组成及肉品质的影响研究

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**摘要:** 选取对照组和乳酸菌组苏尼特羊的背最长肌为研究对象, 利用气相色谱-质谱法 (Gas chromatography-mass spectrometry) 分析苏尼特羊脂肪酸组成并测定肉品质指标 (肌内脂肪、嫩度和色泽), 研究在饲料中添加乳酸菌对羊肉脂肪酸组成及肉品质的影响。结果表明: 乳酸菌组苏尼特羊背最长肌中硬脂酸 (C18:0) 的含量显著高于对照组 ( $P < 0.05$ ); 而反式亚油酸 (C18:26T) 含量极显著低于对照组 ( $P < 0.01$ )。乳酸菌组背最长肌剪切力显著低于对照组 ( $P < 0.05$ )。总体上看, 饲料添加乳酸菌在一定程度上改变了苏尼特羊背最长肌中的脂肪酸组成和含量, 提高了肉的嫩度。

### **Effects of lactobacillus on fatty acid composition and meat quality of Sunite sheep**

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**Abstract:** The longissimus dorsi muscle of the Sunit sheep in the control group and the lactic acid bacteria group was selected as the research object. The composition of fatty acid in Sunit sheep was analyzed by gas chromatography-mass spectrometry and the meat quality was determined (intramuscular, tenderness and color) to study the

effect of adding lactic acid bacteria in feed on fatty acid composition and meat quality of lamb. The results displayed that the content of stearic acid (C18:0) in the longissimus dorsi muscle of Sunit sheep in the lactic acid bacteria group was significantly higher than the control group ( $P<0.05$ ); however the content of trans-linoleic acid (C18: 26T) was significantly lower than the control group ( $P<0.01$ ). The shear force of longissimus dorsi muscle in the lactic acid bacteria group was significantly lower than the control group ( $P<0.05$ ). In general, dietary lactic acid bacteria supplementation changed the fatty acid composition and content in the longissimus dorsi muscle of Sunit sheep, and improved the tenderness of the lamb to a certain extent.

## 8. 羊骨胶原多肽螯合钙的结合特性及稳定性研究

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**摘要:** 本研究采用碱性蛋白酶和中性蛋白酶联合制备具有高钙结合能力的胶原多肽。采用响应面法确定制备肽钙螯合物的最佳条件(50℃、pH7、肽钙质量比为3:1, 时间为40 min, 螯合率为88.38%)。紫外可见光谱和傅里叶变换红外光谱结果表明, 胶原蛋白肽中的羧基氧和氨基氮原子可以螯合钙形成肽钙螯合物。该螯合物在不同pH值和胃肠道环境中表现出良好的稳定性。此外, 肽钙螯合物在模拟消化后仍保持抗氧化活性, 且高于多肽。研究结果为开发新型钙补充剂和提高羊骨的利用价值提供了科学依据。

### Study on the binding properties and stability of sheep bone

#### polypeptide chelated calcium

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**Abstract:** In this study, alcalase and neutrase were used in combination to prepare

collagen peptides with high calcium binding ability. The optimal conditions for the preparation of peptide-calcium chelate (mass ratio of peptide/calcium of 3:1 for 40min at 45°C and pH7) were determined by response surface methodology, under which a calcium chelating rate of 88.38% was obtained. The results of Ultraviolet-Visible (UV-Vis) and Fourier transform infrared (FT-IR) spectra indicated that calcium could be chelated by carboxyl oxygen and amino nitrogen atoms of collagen peptides, thus forming peptide-calcium chelate. The chelate was stable at various pH values, and exhibited excellent stability in the gastrointestinal environment. Moreover, the peptide calcium chelate still retained antioxidant activity and was stronger than that of the peptide after simulated digestion. The findings provide a scientific basis for developing new calcium supplements and the high-value utilization of sheep bone.

## 9. 羊肝干的加工工艺优化及食用品质的研究

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**摘要:** 羊肝干是以羊肝为主要原料, 以萝卜、大蒜为去膻材料, 以食盐、白砂糖、香辛料、料酒等为调味料, 经预煮、脱膻、腌制、烘烤、包装、灭菌、水检等工艺制成的一种具有内蒙古民族特色的休闲食品。该文通过对羊肝干脱膻材料、调味料、脱膻时间和腌制时间进行单因素试验和正交优化试验设计, 确定羊肝干的<sup>最佳</sup>生产工艺。结果表明, 羊肝干的最优方案为: 选用萝卜 10 g/100 g、大蒜 5 g/100 g 为脱膻材料, 脱膻时间为 15 min, 调味料白砂糖 2%、食盐 3%、香辛料 4%、料酒 6%, 真空 (70kPa~80 kPa) 腌制 10 h, 在 55°C, 烘烤 3 h 时的羊肝干色泽鲜艳、香味浓郁, 口感适中。

### **Study on Sheep Liver Jerky's Processing Technology and Edible Quality**

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**Abstract:** Sheep liver jerky is made of sheep liver, using radish, garlic as the de-muttomy material and using salt, sugar, spicery and cooking wine as seasoner. After pre-cooking, de-odorizing, pickling, baking, packaging, sterilization, underwater inspection, etc., it is made into a leisure food with Inner Mongolia national characteristics. Single factor experiment and orthogonal optimization were carried out to determine the optimal process (de-odorizing and pickling time, de-muttomy and de-odorizing material). The results showed that radish of 10 g / 100 g, garlic of 5 g/100 g were used as de-muttomy material for 15 min, sugar 2 %, salt 3 %, spicery 4 %, cooking wine 6% were used as seasoning material, pickled in vaccum of 70 kPa-80 kPa for 10 hours at 55 °C. The sheep liver jerky was bright in color, rich in flavor and moderate in taste after baking for 3 hours in this situatio.

## 10. 羊肉发酵香肠感官品质及风味在不同成熟时间下的变化

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**摘 要:** 通过添加清酒乳杆菌及木糖葡萄球菌制作发酵羊肉香肠, 利用气质及气质联用仪测定不同成熟时间(0、3、4、5、6 d) 香肠脂肪酸及风味组成, 探究不同成熟时间对羊肉发酵香肠食用品质及风味累积的影响, 旨在确定香肠成熟最佳时间。结果表明: 随成熟时间的延长, 香肠 pH 值、水分活度( $A_w$ )显著( $P<0.05$ )下降,  $A_w$  与失重率呈显著负相关; 成熟 3-4 d 乳酸菌及葡萄球菌是香肠中的主要优势菌群, 显著抑制肠杆菌的生长繁殖, 致使香肠中肠杆菌数量显著低于 1000 CFU/g ( $P<0.05$ ); 成熟 3-4 d 香肠的红度值达到最大; 香肠中游离脂肪酸及风味含量呈先上升后下降趋势, 成熟 3-4 d 脂肪酸、风味物质的种类及含量显著高于其他时间 ( $P<0.05$ )。综上所述: 成熟 3-4 d 发酵羊肉香肠感官品质及营养组成优于其他时间。

## Change of Sensory Quality and Flavor Compounds of Fermented Mutton Sausages at Different Ripening Time

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**Abstract:** By inoculating *Lactobacillus sake* and *staphylococcus xylose* to make fermented mutton sausages. The fatty acid and flavor composition of sausage at different ripening times (0, 3, 4, 5, 6 d) were determined by gas chromatography - mass spectrometry (GC - MS), and the effects of different ripening times on edible quality and flavor accumulation of fermented mutton sausage were investigated, so as to determine the optimal ripening time of sausage. The results showed that the pH value and water activity ( $A_w$ ) of sausage decreased significantly ( $P < 0.05$ ) with the increase of ripening time. Mature 3-4 day *lactobacillus* and *staphylococcus* are the main dominant bacteria in sausage, which significantly inhibit the growth and reproduction of *enterobacter*, resulting in a significantly lower number of *enterobacter* in sausage than 1000 CFU/g. The red-degree value of mature 3-4 day sausage reached the maximum; The contents of free fatty acids and flavor substances in sausage increased first and then decreased, and the types and contents of mature 3-4-d fatty acids and flavor substances were significantly higher than those in other times ( $P < 0.05$ ). In conclusion, the sensory quality and nutritional composition of mature 3-4 day fermented mutton sausage were better than other time.

## 11. 饲料中添加甘露醇对兔肉品质的影响

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**摘要:** 试验旨在研究甘露醇对新西兰白兔屠宰性能和肉品质的影响, 选取 40 日龄新西兰兔 28 只。随机分为 4 组, 在基础饲料中甘露醇的添加水平为 1% (试验

I组)、2%(试验II组)、3%(试验III组),对照组添加1%(噻乙醇),饲喂35d后进行屠宰,取其背最长肌和后腿肌,测定兔肉屠宰性能和肉的新鲜度指标,比较甘露醇和抗生素对肉品质的影响效果,结果显示:各试验组与对照组的屠宰性能、pH值和持水力差异不显著( $P>0.05$ )。试验III组兔腿肌的剪切力值为 $22.12\pm 0.16$ ,与对照组兔腿肌的剪切力值为 $26.00\pm 3.8$ 有显著差异( $P<0.05$ ),试验II组兔背最长肌和腿肌的硬度值与对照组有显著差异( $P<0.05$ ),且高于试验I组,试验III组兔背最长肌和腿肌的 $L^*$ 值显著高于对照组( $P<0.05$ ),试验III组兔背肌的 $a^*$ 值显著高于对照组( $P<0.05$ ),各组间的 $b^*$ 值无显著差异( $P>0.05$ ),这表明甘露醇在代替抗生素方面有可行性。

### **The effect of adding mannitol in feed on the quality of rabbit meat**

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**Abstract:** The purpose of the experiment was to study the effect of mannitol on the meat quality of New Zealand white rabbits. 28 New Zealand white rabbits aged 40 days were selected. They were randomly divided into 4 groups. The levels of mannitol added to the basal diet were 1% (test group I), 2% (test group II), and 3% (test group III), while the control group was added 1% (olaquinox). After slaughtered for 35 days, the muscles of the longissimus dorsi and hind leg were measured to determine the meat slaughter performance and meat freshness index. The effects of mannitol and antibiotics on meat quality were compared. The results showed that the each test group and control slaughter performance, pH value and water holding capacity of the group were not significantly different ( $P>0.05$ ). The shear force value of rabbit leg muscle in test group III was  $22.12\pm 0.16$ , and the shear force value of rabbit leg muscle in control group was  $26.00\pm 3.8$ , which was significantly different from the control group ( $P<0.05$ ). The hardness values of muscle and leg muscles were significantly different from those of the control group ( $P<0.05$ ) and higher than that of the experimental group I. The  $L^*$  values of the longissimus dorsi and leg muscles of the experimental group III were significantly different from the control group ( $P<0.05$ ). The  $a^*$  value of the rabbit back muscle in test group III was significantly different from that in the control group



( $P < 0.05$ ), and the  $b^*$  value was not significantly different among the groups ( $P > 0.05$ ). The results showed that mannitol is feasible in substituting antibiotics.

## 12. 运动对苏尼特羊肌纤维特性及肉品质的影响

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**摘要:** 本实验旨在研究运动对苏尼特羊背最长肌肌纤维特性和肉品质的影响。选择 3 月龄、体况良好的纯种苏尼特羊 14 只, 随机分为 2 组: 运动组 (A) 和对照组 (C)。运动组每天以 0.56m/s 的速度运动 1h, 实验期 90 天。结果表明: 通过适当的运动能使 MyHCIIa 显著升高 ( $P < 0.05$ )、MyHCIIx 基因表达量显著升高 ( $P < 0.01$ ), I 型肌纤维的直径和 IIB 型肌纤维的横截面积显著升高 ( $P < 0.05$ ), 乳酸脱氢酶 (Lactate dehydrogenase, LDH) 活性、琥珀酸脱氢酶 (Succinate dhydrogenase, SDH) 活性显著升高 ( $P < 0.05$ ),  $a^*$  值显著升高 ( $P < 0.05$ ), pH24 值和剪切力值均显著升高 ( $P < 0.01$ )。pH0 值、 $L^*$  值、 $b^*$  值显著降低 ( $P < 0.05$ )。两组间数量比例、面积比例和其他肉品质指标无显著差异 ( $P > 0.05$ )。综上所述, 运动可促进肌纤维类型由酵解型向氧化型转化, 改善肌肉色泽, 提高肌肉的氧化代谢能力, 但不利于肌肉嫩度。

### The effect of exercise on muscle fiber characteristic and meat quality of Sunit sheep

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**Abstract:** The aim of this study was to investigate the effects of exercise of the longissimus dorsi (LD) muscle and meat quality of sunit sheep. A total of 14 sunit sheep (3 month old) were randomly selected and equally assigned into 2 groups: exercise group (A) and control group (C). The sunit sheep of exercise group run 1 hour at a speed of 0.56m/s every day, the experiment lasted for 90 days. The results indicated that the cross-sectional area of type I

and the diameter of type I muscle fiber in the exercise group were significantly higher than those in the control group ( $P<0.05$ ), the relative expression of MyHC II a gene in the exercise group were significantly higher than that in the control group ( $P<0.05$ ), the relative expression of MyHC I gene in the exercise group were significantly higher than that in the control group ( $P<0.01$ ), muscle from the exercise group had a statistically significant higher activity of SDH and LDH ( $P<0.05$ ), and the  $a^*$  value were significantly higher than the control group ( $P<0.05$ ),  $pH_{24}$  value and shear force value were higher than the control group ( $P<0.01$ ). The  $L^*$  value,  $b^*$  value,  $pH_0$  value were lower than the control group ( $P<0.05$ ). the number and area proportion of muscle fiber and other indexes of meat quality were not statistically significant between the two groups ( $P>0.05$ ). In summary, proper exercise can improve the muscle color and the oxidative metabolism of muscles by increasing the proportion of oxidized muscle fibers, however, it is not good for muscle tenderness.

### 13. 不同部位双峰驼肉品质特性的研究

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**摘要:** 以屠宰后 24 小时内获得的阿拉善双峰驼驼肉为原料, 利用电子舌与近红外技术对双峰驼的里脊、外脊、胸肉、腹肉、臀肉、骆驼霖、腱子肉等 7 个不同部位的肉样进行营养及食用品质特性的研究。从品种、部位、年龄等角度, 对我国主要双峰驼品种的驼肉理化品质按国标方法进行检测, 通过对不同部位的双峰驼肉的主要肉用品质、营养品质和质构特性进行具体分析, 并建立预测模型分析各不同部位肉的适宜加工方式, 为驼肉品质的检测提供理论依据。

#### **Study on meat quality characteristics of different parts of Bactrian**

#### **Camel**

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**Abstract:** The Alxa Bactrian camel meat obtained within 24 hours after slaughtering was used as raw material, the nutritional and edible quality characteristics of seven different parts of Bactrian camel were studied by electronic tongue and near infrared spectroscopy. The physical and chemical quality of camel meat of main Bactrian camel varieties in China was tested according to the national standard method from the perspective of variety, position and age. The main meat quality, nutritional quality and texture characteristics of different parts of Bactrian camel meat were analyzed in detail, and the prediction model was established to analyze the suitable processing methods of different parts of the meat, which provided theoretical basis for the detection of camel meat quality.

## 14. 益生菌对苏尼特羊胃肠道菌群、脂肪酸代谢及肉品质的影响

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**摘要:** 本试验以 24 只 3 月龄的苏尼特羊为研究对象，随机分为 2 组，对照组（基础饲料）和益生菌组（基础饲料+ $1.50 \times 10^9$  CFU/g 复合益生菌），饲喂 90 天，取肌肉组织、血液、瘤胃液及粪便作为试验材料，利用气相质谱联用技术和高通量测序技术等研究苏尼特羊胃肠道菌群结构、脂肪酸组成的差异。结果表明，益生菌组的增重和眼肌面积，羊肉的  $a^*$  值、肌内脂肪、灰分和总氨基酸含量显著高于对照组 ( $P < 0.05$ )；而 pH 值、 $b^*$  值和剪切力值显著低于对照组 ( $P < 0.05$ )。与对照组相比，益生菌组羊肉的 SFA 和 MUFA 含量显著降低 ( $P < 0.05$ )，PUFA 含量显著增高 ( $P < 0.05$ )。益生菌组血液中 HDL、ALB 含量显著高于对照组，而 LDL 和 BUN 含量显著低于对照组 ( $P < 0.05$ )。益生菌组羊的胃肠道菌群的  $\alpha$ -多样性高于对照组。在瘤胃菌群门水平上，益生菌组拟杆菌门、放线菌门和疣微菌门的相对丰度显著高于对照组 ( $P < 0.05$ )，厚壁菌门和变形菌门丰度显著低于对照组 ( $P < 0.05$ )；在属水平上，益生菌组普雷沃菌属-1、拟杆菌属、

*Saccharofermentans* 和纤维杆菌属的相对丰度显著高于对照组 ( $P<0.05$ )。在肠道菌群属水平上, 益生菌组的拟杆菌属、克里斯滕森菌科 R-7 菌、*Ruminococcaceae*\_UCG\_002 和未分类毛螺菌科的相对丰度显著高于对照组 ( $P<0.05$ )。相关性结果表明, 瘤胃菌群中瘤胃球菌属-1 与  $a^*$  呈显著负相关, 与剪切力呈显著正相关 ( $P<0.05$ ); 肠道菌群中, *Ruminococcaceae*\_UCG\_002 与剪切力呈显著负相关 ( $P<0.05$ ), 琥珀酸弧菌属与蒸煮损失呈显著负相关 ( $P<0.05$ ); 瘤胃菌群中拟杆菌属与  $\alpha$ -亚麻酸呈显著正相关 ( $P<0.05$ )。肠道菌群中, *Ruminococcaceae*\_UCG\_002、粪杆菌真核菌群与 PUFA 呈显著正相关, 考拉杆菌属、阿克曼菌属与 EPA 的沉积呈显著正相关 ( $P<0.05$ )。

## Effects of Probiotics on Gastrointestinal Microbiota, Fatty Acid Metabolism and Meat Quality of Sunit Sheep

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**Abstract:** 24 Sunit sheep of 3 months old were randomly divided into two groups in this trial, which were the control group (basic diet) and the probiotic group (basic diet +  $1.50 \times 10^9$  CFU/g compound probiotics). After 90 days of feeding, the longissimus dorsi muscle, blood, rumen fluid and intestinal feces were taken as test materials, The differences of fatty acid composition and gastrointestinal microflora structure were studied by GC-MS and high-throughput sequencing. It is known that the sheep's weight gain and eye muscle area, the  $a^*$  value, intramuscular fat, ash and the amino acid content of the lambs in the probiotics group were significantly higher than those of the control group ( $P<0.05$ ), the pH value,  $b^*$  value and shear force value were significantly lower than the control group ( $P<0.05$ ). It is known that the content of SFA and MUFA in the control group was higher than that in the probiotic group ( $P<0.05$ ), while the content of PUFA was significantly lower than that in the probiotic group ( $P<0.05$ ). The contents of HDL and ALB in the blood of the probiotic group were significantly higher than those of the control group ( $P<0.05$ ), while the contents of LDL and BUN were

significantly lower than those in the control group ( $P < 0.05$ ). The  $\alpha$ -diversity of rumen and gut microbiome in probiotic group was higher than that in control group ( $P < 0.05$ ). At rumen microbiome phylum level, The relative abundances of Bacteroides, Actinomycetes and Verrucomicrobia in probiotics group were significantly higher than those in control group ( $P < 0.05$ ), while Firmicutes and Proteobacteria were significantly lower than those in control group ( $P < 0.05$ ); At the genus level, the relative abundance of *prevotella-1*, *Bacteroides*, *Saccharofermentans* and *Fibrobacter* in probiotics group was significantly higher than that in control group ( $P < 0.05$ ). At gut microbiome genus level, the relative abundance of *Bacteroides*, *Christensenellaceae\_R7\_group*, *Ruminococcaceae\_UCG\_002*, *unclassified\_f\_Lachnospiraceae* in probiotics group was significantly higher than that in the control group ( $P < 0.05$ ). By analyzing the correlation between the gastrointestinal flora, meat quality and fatty acid content. *Rumenococcus-1* in the rumen flora was significantly negatively correlated with a and significantly positively correlated with shear force ( $P < 0.05$ ); In the intestinal flora, *Ruminococcaceae\_UCG\_002* showed a significant negative correlation with shear force, and *Succinivibrio* was significantly negatively correlated with cooking loss ( $P < 0.05$ ); An increase in *Bacteroides* in the rumen flora favors alpha-linolenic acid deposition. Among the intestinal flora, *Ruminococcaceae\_UCG\_002*, [*Eubacterium*]-*coprostanoligenes\_group* were significantly positively related to PUFA ( $P < 0.05$ ), *Phascolarctobacterium*, *Akkermansia* were significantly positively correlated with EPA deposition ( $P < 0.05$ ).

## 15. 发酵剂和香辛料对发酵羊肉干中亚硝胺含量的影响

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**摘要:** 本试验将发酵剂和香辛料添加到发酵羊肉干中, 通过对发酵羊肉干理化指标和亚硝胺含量的测定, 分析发酵剂和香辛料对发酵羊肉干理化性质和亚硝胺含量的影响。研究结果如下: 发酵羊肉干在成熟后, 发酵剂+香辛料组的红度值

a 和 e 值分别为 16.02、1.97，显著高于对照组 13.65、1.60 ( $p < 0.05$ )，说明添加发酵剂和香辛料有助于提高发酵羊肉干的色泽；发酵剂+香辛料组的 pH 为 5.65，显著低于对照组 5.88 ( $p < 0.05$ )，发酵剂+香辛料组的 Aw 值降到 0.75，显著低于对照组 0.79 ( $p < 0.05$ )，较低的 pH 和水分活度有效的减少了有害微生物的生长，保证了发酵羊肉干的安全。成熟后，发酵剂+香辛料组的亚硝酸盐 5.00mg/kg，显著低于对照组 5.42mg/kg ( $p < 0.05$ )；发酵剂+香辛料组的亚硝胺含量即 N-亚硝基二甲胺 0.37ug/kg、N-亚硝基吡咯 0.01ug/kg、N-亚硝基哌啶 0.28ug/kg、N-亚硝基二正丁胺 0.02ug/kg，分别显著低于对照组 1.76ug/kg、0.02ug/kg、0.50ug/kg、0.07ug/kg ( $p < 0.05$ )，说明加入发酵剂和香辛料对亚硝酸盐、亚硝胺有明显的抑制作用。因此，添加发酵剂和香辛料可以有效地改善发酵羊肉干的品质，提升产品的安全性。

## Effects of Starter culture and Spices on Nitros-amine Content in Fermented Mutton Jerky

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**Abstract:** In this experiment, starter culture and spices were added to fermented mutton jerky. The effects of starter culture and spices on the physico-chemical characters and nitros-amines content of fermented mutton jerky were analyzed. The results were as follows: After ripening, the redness values a and e of fermentation mutton jerky group were 16.02 and 1.97, respectively, which were significantly higher than those of control group 13.65 and 1.60 ( $p < 0.05$ ). The color of fermented mutton jerky was bright and red in adding starter and spices. The pH of starter culture + spices group was 5.65, which was significantly lower than that of control group 5.88 ( $p < 0.05$ ), and Aw of starter culture + spices group was reduced to 0.75, which was significantly lower than that of the control group (0.79) ( $p < 0.05$ ). The lower pH and water activity effectively reduce the growth of harmful microorganisms, ensuring the safety of fermented mutton jerky. After ripening, the nitrite content in the starter culture + spice group was 5.00mg/kg,

significantly lower than that in the control group (5.42mg/kg) ( $p < 0.05$ ); the N-nitrosodimethyl-amine content in the starter culture + spice group was 0.37ug/kg, N-nitrosopyrrole content was 0.01ug/kg, N-nitrosopiperidine content was 0.28ug/kg, N-nitrosodibutyl-amine content was 0.02ug/kg, significantly lower than that in the control group (1.76/kg, 0.02ug/kg, 0.50ug/kg, 0.07ug/kg, respectively). The addition of starter culture and spices on nitrite and nitros-amine has obvious inhibition effect. Therefore, adding starter and spices can effectively improve the quality of fermented mutton jerky and enhance the safety of the product.

## 16. 不同环境（山地、平原）乌拉特山羊肉品质研究

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**摘 要：**本实验以 4-6 岁的乌拉特山羊（山地和平原各 9 只）为研究对象，测定羊肉的食用品质（pH、嫩度、色泽、蒸煮损失率）和营养品质（氨基酸、脂肪酸、蛋白质、水分、脂肪、灰分含量），旨在探究不同环境对乌拉特山羊肉品质的影响。结果表明：山地组和平原组的肉用性能无明显差别（ $P > 0.05$ ）；山地组中背最长肌和股二头肌的  $pH_0$  显著高于平原组（ $P < 0.05$ ）；山地组中背最长肌的亮度值显著高于平原组（ $P < 0.05$ ），平原乌拉特山羊股二头肌的嫩度显著高于平原组（ $P < 0.05$ ）；山地组的股二头肌中脂肪和水分含量显著高于平原组（ $P < 0.05$ ），山地组背最长肌和股二头肌的饱和脂肪酸、单不饱和脂肪酸和多不饱和脂肪酸含量高于平原组，说明山地环境的乌拉特山羊肉具有更好的多汁性、嫩度和风味；平原组乌拉特山羊的背最长肌和股二头肌中必需氨基酸和非必需氨基酸含量均高于山地组，且更加符合 FAO/WHO 提出的标准。

### Study on meat quality of Urat goats in different environments

(mountains and plains)

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**Abstract:** In this experiment, four to six years old Urat goats (nine in the mountains and nine in the plains) were selected as the research objects. The eating quality (pH, tenderness, color, cooking loss rate) and nutritional quality (amino acid, fatty acid, protein, water, fat, ash content) of mutton were measured. The effect of the two environments on meat quality were analyzed. The results showed that there was no significant difference in slaughter performance between mountain group and plain group ( $P>0.05$ ). The  $pH_0$  of the longissimus dorsi and biceps femoris in the mountain group was significantly higher than that in the plain group ( $P<0.05$ ). The brightness of the longissimus dorsi in the mountain group was significantly higher than that in the plain group ( $P<0.05$ ), and the tenderness of the biceps femoris in the plain group was significantly higher than that in the mountain group ( $P<0.05$ ). The content of fat and water in biceps femoris in mountain group was significantly higher than that in plain group ( $P<0.05$ ). The content of essential amino acids and nonessential amino acids in the longissimus dorsi and biceps femoris of the plain group were higher than that of the mountain group, which were more in line with the standards proposed by FAO / WHO.

## 17. 不同地区乌拉特山羊品质的研究

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**摘要:** 本试验以典型生长地区呼勒斯太(5只)、新忽热(6只)、乌兰(5只)、温更(4只)的乌拉特山羊为研究对象,取其背最长肌、股二头肌作为试验材料,分析不同地区乌拉特山羊肉品质及营养成分差异。通过研究,在食用品质方面,呼勒斯太地区山羊背最长肌  $a^*$  显著高于其他地区 ( $P<0.05$ ); 呼勒斯太地区和新忽热地区山羊背最长肌剪切力值显著小于其他两个地区 ( $P<0.05$ ); 乌兰地区山羊股二头肌蒸煮损失率显著高于其他地区 ( $P<0.05$ )。在营养品质方面,呼勒斯太地区山羊背最长肌水分含量显著高于其他地区 ( $P<0.05$ ); 新忽热地区



山羊股二头肌灰分含量显著高于其他三个地区 ( $P < 0.05$ ), 呼勒斯太地区山羊背最长肌脂肪含量显著低于其他三个地区 ( $P < 0.05$ )。但总体上来看, 地区因素对乌拉特山羊品质影响较小。

### Study on the quality of Wulate goats in different regions

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**Abstract:** By taking the Wulate goat distributed at typically growing region of Hulstai (5 goats), Xinhure (6 goats), Ulan (5 goats) and Wen Geng (4 goats) as the study subject, the experiment takes its longissimus muscle of back and biceps femoris muscle as the materials of the experiment to analyze the difference on slaughtering property, meat quality and nutrient content of Wulate goat in different regions. According to the study, in terms of food quality, the longest dorsal muscle a \* of goats in the region of Horace was significantly higher than that in other regions ( $P < 0.05$ ). The shear force of the longissimus dorsi muscle was significantly lower than that of the other two regions ( $P < 0.05$ ). The digestibility loss rate of goat biceps in wulan was significantly higher than that in other areas ( $P < 0.05$ ). In terms of nutritional quality, the water content of the longissimus dorsi muscle was significantly higher than that of other regions ( $P < 0.05$ ). The ash content of biceps femoris was significantly higher than that of the other three regions ( $P < 0.05$ ), and the fat content of the longest dorsal muscle was significantly lower than that of the other three regions ( $P < 0.05$ ). But generally speaking, the regional factors have little influence on the quality of urat goats.

## 18. 高产有机酸乳酸菌在发酵肉制品中的抑菌作用

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**摘要:** 本试验以牧区采样所得的 6 株不同的乳酸菌为研究对象。在 TPY 培养基

中培养 24 小时后,使用离子色谱仪测定不同株乳酸菌所产有机酸的种类和含量,并且在排除细菌素干扰后,通过抑菌圈法测定的不同株乳酸菌所产有机酸的抑菌能力,选出一株产有机酸能力强且抑菌能力强的 RS1、一株产有机酸能力弱且抑菌能力弱的 ZW2,将其加入到发酵羊肉香肠中,通过测定香肠微生物指标,得出结论。结果表明,加 RS1 组发酵羊肉香肠的金黄色葡萄球菌和大肠杆菌生长量最少;自然组发酵羊肉香肠中杂菌生长最多;加 ZW2 组乳酸菌发酵羊肉香肠中杂菌生长量居中。所以加 RS1 组高产有机酸乳酸菌对发酵羊肉香肠的抑菌作用较好。

## **Bacteriostasis of High Organic Acid-producing Lactic Acid Bacteria in Fermented Meat Products**

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**Abstract:** In this experiment, 6 strains of different lactic acid bacteria sampled from pastoral areas were taken as research objects. After 24 hours of culture in TPY medium, the kinds and contents of organic acids produced by different strains of lactic acid bacteria were determined by ion chromatography, and the bacteriostatic ability of organic acids produced by different strains of lactic acid bacteria was determined by bacteriostatic circle method after eliminating bacteriocin interference. One strain of RS1 with strong bacteriostatic ability and a strain of ZW2 with weak bacteriostatic ability were selected and added to fermented mutton sausage. The conclusion is drawn by measuring the microorganism index of sausage. The results showed that the growth of *Staphylococcus aureus* and *Escherichia coli* in RS1 group of fermented mutton sausages was the least; in the natural group, the growth of miscellaneous bacteria was the highest; in the ZW2 group, the growth of miscellaneous bacteria was the middle, so RS1 group of lactic acid bacteria with high yield have better bacteriostatic effect on fermented mutton sausage.

## 19. 发酵羊肝酱配方及工艺的优化

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**摘要:** 为提高羊肉副产品利用率, 满足消费者对产品多样化的需求, 本研究以羊肝为主要原料制作发酵羊肝酱, 并对其配方及加工工艺进行优化。通过单因素试验考察食盐、玉米胚芽油、乳化剂、增稠剂对发酵羊肝酱感官评分的影响; 在单因素的基础上, 采用响应面法优化产品配方。之后通过单因素试验和正交试验对发酵温度、发酵时间、发酵剂添加量等发酵条件进行优化。结果表明: 发酵羊肝酱最佳配方为食盐添加量为 2 g/100g, 玉米胚芽油添加量为 9 ml/l, 乳化剂(单硬脂酸甘油酯: 酪蛋白酸钠=1: 1)添加量为 3 g/100g, 增稠剂(羧甲基纤维素钠:  $\beta$ -环糊精=4: 1)添加量为 6 g/100g。在最优配方条件下, 发酵羊肝酱预期感官评分为 76.75, 实际感官得分为 75.90。发酵羊肝酱的最优加工工艺为发酵温度 37 °C, 发酵时间 24 h, 发酵剂添加量 0.005 g/100g。在该配方及工艺条件下产品色泽均匀、口感细腻、具有发酵羊肝酱特有的风味。与传统羊肝制品相比, 该产品可提高羊肝附加值, 为羊肝资源的综合利用提供了新思路。

### Development of fermented lamb liver paste

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**Abstract:** In order to improve the utilization rate of mutton by-products and meet consumers' demand for product diversification, this research uses mutton liver as the main raw material to make fermented mutton liver paste, and optimizes its formula and processing technology. Single-factor experiments were conducted to investigate the effects of salt, corn germ oil, emulsifiers, and thickeners on the sensory scores of fermented lamb liver paste; on the basis of single-factor, response surface methodology was used to optimize the product formula. Afterwards, the fermentation conditions such

as fermentation temperature, fermentation time, and starter addition amount were optimized through single factor test and orthogonal test. The results showed that the best formula for fermented lamb liver sauce is 2 g/100g of salt, 9 ml/l of corn germ oil, and emulsifier (glyceryl monostearate: sodium caseinate=1:1) The dosage is 3 g/100g, and the thickener (sodium carboxymethyl cellulose:  $\beta$ -cyclodextrin = 4:1) is 6 g/100g. Under the optimal formula conditions, the expected sensory score of fermented lamb liver paste is 76.75, and the actual sensory score is 75.90. The optimal processing technology of fermented lamb liver paste is fermentation temperature of 37 °C, fermentation time of 24 h, and the addition amount of starter 0.005 g/100g. Under the formula and process conditions, the product has uniform color, fine taste, and unique flavor of fermented lamb liver paste. Compared with traditional sheep liver products, this product can increase the added value of sheep liver and provide a new idea for the comprehensive utilization of sheep liver resources.

## 20. 乳酸菌筛选及其对羊肉发酵香肠挥发性风味物质的影响

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**摘要:** 本文对 5 株乳酸菌进行了耐盐、耐酸、耐亚硝酸盐、抑菌能力试验, 其中瑞士乳杆菌 ZF22 和瑞士乳杆菌 TR1-1-3 都具有良好的耐盐、耐酸、耐亚硝酸盐和抑菌能力, 且具有较好的发酵性能。并把筛选出的乳酸菌作为发酵剂制作羊肉发酵香肠, 以自然发酵作为对照组, 探究乳酸菌对羊肉发酵香肠挥发性风味物质的影响。结果表明, 添加乳酸菌 ZF22 和 TR1-1-3 能够增加发酵香肠挥发性风味物质的种类, 促进 1-戊烯-3-醇、1-辛烯-3-醇、3-甲基丁酸乙酯、反式-4-癸烯乙酯、庚酸乙酯、2-壬酮等对发酵香肠风味贡献较大的风味物质的产生, 丰富了发酵香肠的风味物质。

## Screening of lactic acid bacteria and its effect on volatile flavor substances of mutton fermented sausage

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**Abstract:** In this paper, 5 strains of lactobacillus were tested for their salt tolerance, acid tolerance, nitrite tolerance and bacteriostatic ability. Among them, Lactobacillus ZF22 and Lactobacillus Tr1-1 -3 had good salt tolerance, acid tolerance, nitrite tolerance and bacteriostatic ability, and had good fermentation performance. The selected lactic acid bacteria were used as starter cultures to produce mutton fermented sausage, and the natural fermentation was used as control group to explore the influence of lactic acid bacteria on the volatile flavor substances of mutton fermented sausage. Results show that adding lactobacillus ZF22 and TR1-1-3 could increase the kinds of volatile flavor fermented sausage, promote 1 - pentene - 3 - alcohol, 1 - octene - 3 - alcohol, 3 - methyl ethyl butyrate, ethyl trans - 4 - decyl ene, heptanoic acid ethyl ester, 2 - nonyl ketone of flavour compounds of fermented sausage flavor contribution is bigger, enrich the flavour compounds of fermented sausage.

## 21. 日粮添加亚麻籽、乳酸菌对苏尼特羊肉风味品质的影响

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**摘要:** 将 36 只苏尼特羊分为舍饲组、亚麻籽组和乳酸菌组，每组 12 只。测定日粮添加亚麻籽、乳酸菌对苏尼特羊肉风味品质的影响。羊肉的风味包括香味和滋味。通过在饲料中添加乳酸菌、亚麻籽进行风味调控，发现羊肉的香味轮廓有差异，日粮添加亚麻籽、乳酸菌降低了羊肉的整体风味强度；进一步对挥发性物质的种类及其含量进行测定，并采用 ROAV 法筛选关键风味物质，以分析日粮中添加亚麻籽、乳酸菌对苏尼特羊肉风味物质的影响。结果表明，苏尼

特羊肉中共检测出 48 种挥发性风味物质，亚麻籽组和乳酸菌组的风味物质种类较对照组丰富。日粮添加亚麻籽显著提高了醇类、烷烃类和酮类风味物质的百分比( $P<0.05$ )；添加乳酸菌显著提高了烷烃类风味物质的比例( $P<0.05$ )。风味活性值 (ROAV) 分析结果显示，舍饲组中的关键风味物质包括己醛、庚醛、反-2-辛烯醛、正辛醛、癸醛、反-2-癸醛和苯酚。日粮添加亚麻籽使苏尼特羊肉增添了烤肉味、洋葱味和橙子味，并能够提高脂肪味、烤肉味和洋葱味；日粮添加乳酸菌使苏尼特羊肉增添了蘑菇风味、发酵香、花香、肉香味和洋葱味。总体上看，日粮添加亚麻籽、乳酸菌能够通过提高风味物质的丰富度、改变物质组成来影响羊肉气味。

## Effects of flaxseed and lactic acid bacteria to the diet on Flavor Quality of Sunite Lamb

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**Abstract:** 36 Sunit sheep were divided into concentrated group, flaxseed group and lactic acid bacteria group, 12 in each group. Determination of the effect of linseed and lactic acid bacteria in the diet on the flavor quality of Sunite lamb. Flavor includes aroma and taste. Adding lactic acid bacteria and flaxseed to the diet to regulate the flavor, it was found that the aroma fingerprint of three groups had differences. The addition of flaxseed and lactic acid bacteria to the diet reduces the overall flavor intensity of lamb. Then, the volatile flavor substance in longissimus dorsi muscle were measured and the key flavor substances were selected by ROAV method to analyze the effects of adding flaxseed and lactic acid bacteria on the flavor of Sunit lamb. The results showed that 48 volatile flavor substances were detected in Sunit lamb, and flavor substances in the flaxseed group and the lactic acid bacteria group were more abundant than those in the concentrated group. Addition of flaxseed in diet significantly increased the percentage of alcohols, alkanes and ketones ( $P<0.05$ ), and the addition of lactic acid bacteria significantly increased the proportion of alkane flavor ( $P<0.05$ ). ROAV

analysis showed that the key flavor substances in the concentrated group includes hexanal, heptanal,(E)-2-Octenal, octanal, decanal,(E)-2-Decenal, and phenol. The addition of flaxseed to the diet added the barbecue, onion and orange flavor of the Sunit lamb and enhanced the fat, roast and onion flavor; the addition of lactic acid bacteria to the diet added mushroom ,fermented, floral, meaty and onion flavor of the Sunit lamb. In general, the addition of flaxseed and lactic acid bacteria to the diet can affect the flavor of mutton by increasing the richness and changing the composition of the volatile flavor substance .

## 22. 巴尔虎羊和短尾羊不同部位肥胖基因差异性的研究

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**摘要:** 以5月龄的呼伦贝尔羊巴尔虎品系 (n=5) 和短尾品系 (n=5) 为实验材料, 利用近红外全光栅透射技术和实时荧光定量聚合酶链式反应法测定巴尔虎羊与短尾羊不同肌肉部位的脂肪含量以及肥胖基因 (Fat Mass and Obesity Associated, FTO) 和 N6-甲基腺苷转移酶基因 (Methyltransferase Like 3, METTL3) 的表达量, 研究不同品系呼伦贝尔羊肥胖相关基因表达差异及其对肌肉脂肪沉积的影响。结果表明: 短尾羊臂三头肌肌肉脂肪含量显著大于巴尔虎羊 ( $P < 0.05$ ); 巴尔虎羊臂三头肌和短尾羊股二头肌 FTO 表达量与其肌肉脂肪含量呈显著正相关 ( $P < 0.05$ ), 巴尔虎羊臂三头肌和股二头肌 METTL3 表达量与其肌肉脂肪含量呈显著负相关 ( $P < 0.05$ )。综上所述, 与巴尔虎羊相比, 短尾羊臂三头肌肌肉脂肪含量较高, 同时根据两个品种肌肉脂肪与肥胖相关基因的相关关系, 推测出 FTO 基因与 METTL3 基因在调控肌肉脂肪沉积中起到了重要作用。

### Study on the Difference of Obesity Genes in Different Parts of

### Baerhu Sheep and Short tail Sheep

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**Abstract:** Based on the experimental materials of Balhu strain(n=5) and short tail strain(n=5) of Hulunbeir sheep slaughtered in 5 month. The fat content were determined by near infrared full grating transmission technique. Fat Mass and Obesity Associated(FTO) and Methyltransferase Like 3 (METTL3) expression levels were measured by real-time fluorescence quantitative polymerase chain reaction. The results showed that the content of intramuscular in brachial triceps muscle of short-tailed sheep were significantly higher than those in Balhu sheep ( $P<0.05$ ); and the expression of FTO genes in brachial triceps muscle and biceps femoris muscle of short-tailed sheep was positively correlated with the content of intramuscular( $P<0.05$ ), there was a significant negative correlation between the expression of METTL3 genes of triceps and biceps femoris ( $P<0.05$ ). To sum up, Compared with Balhu sheep, short tail sheep have higher content of fat in arm triceps muscle. Based on the correlation between intramuscular fat and obesity-related genes in the two breeds, it can be inferred that FTO gene and METTL3 gene play an important role in the regulation of intramuscular fat deposition.



## **(二) 乳制品专题**

## 1. 基于宏基因组分析酸马奶的微生物多样性及功能基因

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**摘要:** 酸马奶风味独特, 保健功能突出, 与其复杂的微生物构成密切相关。本研究采用宏基因组技术分析酸马奶的微生物多样性, 挖掘其功能基因。结果表明: 酸马奶中鉴定出微生物 30 个门, 331 个科, 913 个属, 2692 个种。优势菌种为克氏乳杆菌、瑞士乳杆菌、弗氏柠檬酸杆菌、鸟氨酸拉乌尔菌、柠檬酸杆菌属和乳酸乳球菌。COG、KEGG 数据库注释到 10849、214338 个基因, 碳水化合物代谢和氨基酸代谢功能突出, 其次为辅酶因子和维生素代谢和核苷酸代谢等代谢活动。经 CAZy 数据库注释分析, 糖基转移酶 (1238 个) 和糖苷水解酶 (1430 个) 的数量最多, 占据酸马奶碳水化合物活性酶的 76%。同时, 酸马奶基因中发现 3 种 RRT12 蛋白酶、2 种 serralysin 金属蛋白酶、第六型蛋白分泌系统 (T6SS) 基因、232 个肽转运系统及 231 个肽酶控制基因, 具有较强的蛋白质分解转运潜力。酸马奶中编码了 26 个芳香转氨酶基因、40 个酮酸转化酶、51 个醇脱氢酶、68 个醛脱氢酶基因和 34 个乙酰酯酶基因, 具有从氨基酸形成浓郁风味物质的基础。

### **Analysis on microbiological diversity and functional genes of koumiss by metagenomic technology**

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**Abstract:** The unique flavor and health-care function of koumiss are closely related to its complex microbial structure. In this study, metagenomic technology was used to analyze the microbial diversity and functional genes of koumiss. The results showed that 30 phyla, 331 families, 913 genera and 2692 species were identified. The dominant strains were *Lactobacillus kefirifaciens*, *Lactobacillus helveticus*, *Citrobacter freundii*, *Raoultella ornithinolytica*, *Citrobacter werkmanii* and *Lactococcus lactis*. 10,849 and 214,338 genes were respectively annotated by COG and KEGG databases,

the prominent pathways were carbohydrate metabolism and amino acid metabolism, followed by metabolic activities such as co-enzyme factor and vitamin metabolism and nucleotide metabolism. After CAZy database annotation, the number of glycolytransferases (1238) and glycolytic hydrolases (1430) was the highest, accounting for 76% of the active carbohydrate enzymes of koumiss. At the same time, three RRT12 proteases, two Serralysin metalloproteinases, type 6 protein secretion system (T6SS) genes, 232 peptide transport systems and 231 peptidase control genes were found in koumiss, which showed strong protein decomposition and transport potential. Further, there were 26 ArAT genes, 40 ketoacid invertase genes, 51 AlcDH genes, 68 AldDH genes and 34 aes genes encoded in koumiss, which have the basis of forming strong flavor substances from amino acids.

## 2. 酸马奶乳清饮料的开发研究

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**摘要:** 酸马奶乳清饮料是以酸马奶、白砂糖、水等为主要原料, 经调配, 杀菌, 包装等工艺制成的具有蒙古族特色的含乳饮料。本文通过对酸马奶乳清饮料的原料配比进行单因素和正交试验, 选出最优配方, 并对酸马奶乳清饮料的理化、功能特性进行检测与分析, 同时观察酸马奶乳清饮料在贮藏期间各项指标的变化情况。主要结果如下:

(1) 通过酸马奶乳清饮料的原料选择单因素和正交试验, 获得的最佳配方为: 酸马奶乳清的添加量为 20%, 白砂糖的添加量为 6%, CMC-Na 的添加量为 0.3%, 蔗糖酯的添加量为 0.02%, 柠檬酸钠的添加量为 0.04%, 低聚异麦芽糖的 3%, 乳清蛋白粉的添加量为 2%, 其余部分为无菌水。

(2) 酸马奶乳清饮料的蛋白含量  $1.13 \pm 0.00\%$ , 脂肪含量为  $0.36 \pm 0.02\%$ , pH 值和滴定酸度分别为  $4.14 \pm 0.00$  和  $25.00 \pm 0.01^{\circ}\text{T}$ , 能量值为  $83.53 \pm 0.74\text{KJ}/100\text{g}$ 。酸马奶乳清饮料的能量较低, 较适合控制体重的人群饮用。酸马奶乳清饮料的表观黏度较稳定, 在第 12s 和第 120s 时分别为  $0.00526\text{Pa}\cdot\text{s}$  和  $0.00561\text{Pa}\cdot\text{s}$ 。从酸马

奶、酸马奶乳清饮料，市售卡尔皮斯饮料对比可得出，差异最大的是酸味，其次是甜味和咸味。

(3) 酸马奶乳清饮料中共检测出 16 种氨基酸，氨基酸的总含量为 0.28%。其中检测出 9 种必需氨基酸，总含量为 0.14%。酸马奶乳清饮料中共检测出 24 种脂肪酸，总含量为 100%，其中不饱和脂肪酸含量占总含量的 34.14%。

(4) 酸马奶乳清饮料具有一定的抗氧化性、降胆固醇能力以及降解亚硝酸盐的能力。在浓度为 10 mg/mL 时，DPPH 清除率为  $9.6\pm 0.33\%$ ，还原活性为  $0.27\pm 0.01\%$ ，羟自由基清除率为  $49.03\pm 1.00\%$ ，对超氧阴离子清除能力为  $22.36\pm 1.00\%$ 。降胆固醇能力  $0.99\pm 0.01\%$ ，亚硝酸盐降解能力为  $54.26\pm 2.5\%$ 。从此可以推断出酸马奶乳清饮料具有良好的功能特性。

(5) 酸马奶乳清饮料在贮藏期，其沉淀量和 pH 值变化均在正常范围之内。在 4℃ 贮藏条件下，酸马奶乳清饮料中的酸味、咸味和鲜味变化最大。而在 25℃ 贮藏条件下，酸味的变化较为明显。酸马奶乳清饮料在贮藏期内微生物指标也均在正常范围内，大肠菌群数、酵母及霉菌数均符合相关标准要求。

## Development and Research of Koumiss Whey Beverage

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**Abstract:** The koumiss whey beverage is a milk-containing beverage with Mongolian characteristics made by acid horse milk, white sugar, water, etc. which is prepared by blending, sterilizing and packaging. In this paper, the single-factor and orthogonal tests were carried out on the raw material ratio of the koumiss whey beverage to select the optimal formula, and the physical and chemical properties of the koumiss whey beverage were tested and analyzed, and the acid horse milk was observed. Changes in various indicators of whey beverage during storage. The main results are as follows:

(1) The best formula obtained by single factor and orthogonal test of the raw material selection of the koumiss whey beverage is: The amount of koumiss is 20%, the amount of white sugar added is 6%, the amount of CMC-Na added is 0.3%, the

amount of sucrose ester added is 0.02%, and the amount of sodium citrate added is 0.04%. 3% of isomaltose, the amount of whey protein powder added was 2%, and the rest was sterile water.

(2) The protein content of the koumiss whey beverage is  $1.13 \pm 0.00\%$ , the fat content is  $0.36 \pm 0.02\%$ , and the pH and titration acidity are  $4.14 \pm 0.00$  and  $25.00 \pm 0.01$ , respectively. The energy value is  $83.53 \pm 0.74$  KJ/100g. The koumiss whey drink has lower energy and is more suitable for people who control weight. The apparent viscosity of the koumiss whey beverage was relatively stable, and was 0.00526 Pa.s and 0.00561 Pa.s at 12s and 120s, respectively. From the comparison of koumiss, koumiss whey drink, and commercial Kalpis drink, the most common difference is the sour taste, followed by the sweet and salty taste.

(3) A total of 16 amino acids were detected in the koumiss whey beverage, and the total content of amino acids was 0.28%. Among them, 9 essential amino acids were detected, and the total content was 0.14%. A total of 24 fatty acids were detected in the koumiss whey beverage, with a total content of 100%, of which unsaturated fatty acid content accounted for 34.14% of the total content.

(4) The koumiss whey beverage has certain anti-oxidation, cholesterol-lowering ability and ability to degrade nitrite. At a concentration of 10 mg/mL, the DPPH clearance was  $9.6 \pm 0.33\%$ , the reducing activity was  $0.27 \pm 0.01\%$ , the hydroxyl radical scavenging rate was  $49.03 \pm 1.00\%$ , and the superoxide anion scavenging ability was  $22.36 \pm 1.00\%$ . The cholesterol-lowering ability was  $0.99 \pm 0.01\%$ , and the nitrite degradation ability was  $54.26 \pm 2.5\%$ . From this it can be inferred that the koumiss whey beverage has good functional properties.

(5) During the storage period, the acid milk whey beverage has a change in sedimentation amount and pH value within the normal range. Under the storage conditions of 4°C, the sour taste, salty taste and umami taste of the koumiss whey drink changed the most. Under the storage conditions of 25°C, the change of sour taste is more obvious. The microbial indicators of koumiss whey beverages were also within the normal range during storage, and the number of coliform bacteria, yeast and mold

were in compliance with relevant standards.

### 3. 驼乳乳清蛋白酶解工艺及酶解液活性研究

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**摘要：**驼乳是干旱或半干旱地区的主要乳源，近年来其凭借独特的营养价值和药用价值而备受关注。为有效利用驼乳蛋白，丰富驼乳制品种类，本研究应用胰蛋白酶水解手段提高驼乳乳清的抗氧化活性，优化酶解工艺，探讨酶解条件与其产物抗氧化活性之间的关系。在确定了乳清制备工艺的基础上，通过对 pH、酶与底物比、温度等条件的单因素及正交优化试验，得到胰蛋白酶酶解驼乳乳清的最优工艺：pH 值 7.0，底物浓度 0.2%，温度 60℃，加酶量 2%。此时酶解液的 DPPH·消除率为 79.60%，而乳清溶液的 DPPH·消除率为 42.25%。证明了蛋白酶水解可以使乳清的抗氧化能力显著上升。

#### **Study on Enzymatic Digestion of Camel Milk Whey and the Hydrolysed Activity**

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**Abstract:** Camel milk is the main source of milk in arid or semi-arid regions. In recent years, it has attracted much attention due to its unique nutritional value and medicinal value. Studies have shown that camel milk is rich in a variety of high-quality proteins, such as lactoferrin and immunoglobulins. In order to effectively use camel milk protein and to enrich the types of camel dairy products, we attempted to improve the antioxidant activity of camel milk whey by trypsin hydrolysis, and then optimize the hydrolysis conditions, and explore the relationship between the hydrolysis conditions and the antioxidant activity of the hydrolysate. On the basis of the whey preparation process, the optimal process for enzymatic hydrolysis of camel milk whey by trypsin was

obtained through single factor and orthogonal optimization tests on the conditions of enzymolysis pH, enzyme-substrate ratio, and enzymatic hydrolysis temperature. The optimal digestion condition was as follows: Enzymolysis pH7.0, substrate concentration 0.2%, enzymatic hydrolysis temperature 60°C, enzyme addition 2%. In this condition, the DPPH radical scavenging rate of the camel milk whey hydrolysate was 79.60%, while the DPPH radical scavenging rate of the camel milk whey solution was 42.25%. It was demonstrated that protease hydrolysis can significantly increase the antioxidant activity of whey.

#### 4. 原奶不同杀菌方式对酸马奶品质特性的影响

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**摘要:** 酸马奶具有突出的营养保健功能, 但传统酿造方法无法保证酸马奶的品质稳定, 为优化及延长酸马奶的贮藏条件, 本实验比较巴氏杀菌、紫外杀菌、微波杀菌、超高压杀菌四种原奶杀菌方式下酸马奶理化、抗氧化性、风味及菌群结构的差异, 探究适合的杀菌方式。理化结果表明, 超高压组酸马奶可溶性固形物和色差与其它杀菌组差异不明显, 但 pH 较低, 滴定酸度高, 更快达到发酵终点; 抗氧化性上, 超高压组酸马奶 DPPH 清除率为 33.2%, OH 自由基清除率为 88% 及还原力高达 88.4%, 明显高于其他杀菌组; 风味上, 超高压组酸马奶在保留主体风味物质的基础上, 不良风味得到改善。经微生物群落组成 PCA 分析, 不同杀菌方式处理组原马奶有一定聚集, 差异不明显, 但发酵后酸马奶样品有一定差异, 微波组与超高压组酸马奶明显区别于其他组酸马奶。酸马奶优势菌属为乳杆菌属、乳球菌属、柠檬酸杆菌属和肠杆菌属。同时, KEGG、MetaCyc、COG 数据库分别注释代谢通路 273 条、336 条、23 条, 主要代谢通路为 ABC 转运、精氨酸生物合成、氨基酸的生物合成、生物素代谢、丁酸酯代谢、碳代谢、光合作用及嘌呤代谢。

## The effect of different sterilization methods of raw milk on the quality characteristics of koumiss

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**Abstract:** Koumiss has prominent nutritional and health functions, but the traditional brewing methods can not guarantee the quality stability of koumiss. In order to optimize and prolong the storage conditions of koumiss, the differences of physicochemical, antioxidant, flavor and Flora structure of koumiss under pasteurization, ultraviolet sterilization, microwave sterilization and ultra-high pressure sterilization were compared, and the suitable sterilization methods were explored. The physicochemical results showed that the soluble solids and color difference of the ultra-high pressure group of koumiss were not significantly different from those of other sterilization groups, but the pH was lower, the titratable acidity was high, and the fermentation endpoint was reached faster; In terms of anti-oxidation, the scavenging rate of DPPH is 33.2%, OH radical scavenging rate is 88% and reducing power of ultra-high pressure group of koumiss is as high as 88.4%, which is significantly higher than other sterilization groups; In terms of flavor, the UHP koumiss retains the main flavor substances and improves the undesirable flavor. After the PCA analysis of the microbial community composition, the original koumiss in the different sterilization treatment groups has a certain accumulation, and the difference is not obvious, but there are certain differences in the koumiss samples after fermentation. The microwave group and the ultra-high pressure group koumiss are obviously different from other groups. The dominant bacteria of koumiss are Lactobacillus, Lactococcus, Citrobacter and Enterobacter. At the same time, KEGG, MetaCyc, and COG databases respectively annotate 273, 336, and 23 metabolic pathways. The main metabolic pathways are ABC transport, arginine biosynthesis, amino acid biosynthesis, biotin metabolism, butyrate metabolism, and carbon metabolism., Photosynthesis and purine metabolism.



## 5. 蒙古族传统奶豆腐工业化生产关键技术研究

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**摘要：**奶豆腐是一种高蛋白质、高钙以及富含大量微量元素的乳类食品，蒙古族奶豆腐中蛋白质的含量一般为大于 30%，在微生物和酶的作用下分解为肽、氨基酸以及无机或有机化合物等小分子物质，易于被人体消化吸收，是膳食优质蛋白质的良好来源。奶豆腐中含有较多的必需氨基酸，尤其是亮氨酸和赖氨酸等，其必需氨基酸含量占氨基酸总量的 36.10%—37.75%。奶豆腐中部分乳脂肪被分解为不饱和脂肪酸，这部分不饱和脂肪酸有助于降低人体的血清胆固醇，有利于预防心血管疾病。作为一种天然乳酸菌发酵产品，奶豆腐中含有丰富的天然益生菌资源。益生菌的作用有调节免疫功能、缓解结肠袋炎症状、缩短婴儿传染性腹泻的持续时间、增强胃肠对抗生素治疗的耐受性、缓和乳糖不耐症状、减轻便秘腹泻、减轻肠道易激综合症状和抵抗致病菌感染等。目前，人们已从奶豆腐中分离得到了一些具有益生活性的乳酸菌，如植物乳杆菌、乳酸片球菌、鼠李糖乳杆菌、肠球菌等，通常植物乳杆菌是奶豆腐的优势菌群。一些优良的乳酸菌资源在经过上千年的世代相传和自然选择中保留了下来，研究传统发酵乳制品中的乳酸菌有利于开发一些具有特殊生理功能的独特菌株，它可能是开发特色产品的重要资源，同时这些独特菌株发酵代谢产生的物质也值得深入研究。

本试验为进一步使传统奶豆腐制作工艺实现工业化生产，从辅助发酵剂菌株的分离及其发酵特性、发酵菌种配比及其添加量、发酵温度、排乳清及乳化温度四个方面对奶豆腐加工工艺及其参数进行探讨。结果显示，从传统奶豆腐用酸奶和新鲜乳清样品中进行分离与筛选，获得 8 株乳酸菌，其中 6 株乳酸杆菌和 2 株乳酸球菌，再经发酵产酸和感官特性筛选出 4 株乳酸菌 T-6、T-2、N-9 和 T-11G。对该 4 株乳酸菌以发酵时间和感官评分为指标进行复配试验获得其最佳配比为 T-6: T-2: N-9: T-11G=6: 3: 2: 1。

## Research on the Key Technology of Industrialized Production of Mongolian Traditional Milk Tofu

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**Abstract:** Milk tofu is a kind of milk food with high protein, high calcium and rich trace elements. The protein content in Mongolian milk tofu is generally more than 30%, which is decomposed into peptone, peptide, amino acid and inorganic or organic compounds under the action of microorganisms and enzymes. It is easy to be digested and absorbed by human body, and is a good source of high-quality dietary protein. Milk tofu contains more essential amino acids, especially leucine and lysine, which account for 36.10%-37.75% of the total amino acids. Some milk fat in milk tofu is decomposed into unsaturated fatty acids, which are helpful to lower serum cholesterol and prevent cardiovascular diseases. As a natural lactic acid bacteria fermented product, milk tofu is rich in natural probiotic resources. Probiotics can regulate immune function, relieve the symptoms of pouch inflammation, shorten the duration of infectious diarrhea in infants, enhance the tolerance of gastrointestinal tract to antibiotic treatment, alleviate lactose intolerance, relieve constipation diarrhea, relieve irritable bowel syndrome and resist pathogenic bacteria infection. At present, some probiotic lactic acid bacteria have been isolated from milk tofu, such as *Lactobacillus plantarum*, *Pediococcus lactis*, *Lactobacillus rhamnosus*, *Enterococcus*, etc. Usually, *Lactobacillus plantarum* is the dominant flora of milk tofu. Some excellent lactic acid bacteria resources have been preserved after thousands of years of generations and natural selection. Studying lactic acid bacteria in traditional fermented dairy products is conducive to developing some unique strains with special physiological functions, which may be an important resource for developing characteristic products. Meanwhile, the substances produced by fermentation and metabolism of these unique strains are also worthy of further study.

In this experiment, in order to further realize the industrial production of traditional

milk tofu processing technology, the processing technology and parameters of milk tofu were discussed from four aspects: the separation and fermentation characteristics of auxiliary starter strains, the ratio and addition amount of fermentation strains, fermentation temperature, whey discharge and emulsification temperature. The results showed that 8 strains of lactic acid bacteria were isolated and screened from yogurt and fresh whey samples for traditional milk tofu, including 6 strains of lactic acid bacteria and 2 strains of *Lactococcus*, and 4 strains of lactic acid bacteria T-6, T-2, N-9 and T-11G were screened by fermentation and sensory characteristics. According to the fermentation time and sensory score, the best ratio of the four strains of lactic acid bacteria was t-6: t-2: n-9: t-11g = 6: 3: 2: 1.

## 6. 锡林郭勒牧区鲜马奶和酸马奶微生物多样性研究

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**摘要:** 本研究用 Illumina Miseq 高通测序技术对鲜马奶和酸马奶样本中细菌、真菌微生物多样性进行了分析。结果表明, 从 9 个样本中共获得 391,632 条细菌和 581,204 条真菌高质量的优化序列, 每个样品的平均读数分别为 46,255 和 68,911, 平均长度为 428bp 和 195bp, 所有样本细菌序列归属于 5 个门, 6 个纲, 14 个目, 18 个科, 27 个属, 34 个种, 36 个 OTU, 而所有样本真菌序列归属于 7 个门, 19 个纲, 42 个目, 80 个科, 110 个属, 144 个种, 217 个 OTU。鲜马奶中优势细菌属分别为肠杆菌属 (*Enterobacter*), 相对丰度 63.45%, 优势真菌属为红酵母属 (*Rhodotorula*), 相对丰度为 55.51%; 马奶发酵 15h 优势细菌属为乳杆菌属 (*Lactobacillus*), 相对丰度 46.63%, 优势真菌属为德克酵母属 (*Dekkera*), 相对丰度 95.83%; 酸马奶中优势细菌属为乳球菌属 (*Lactococcus*), 相对丰度 77.43%, 优势真菌属为德克酵母属 (*Dekkera*), 相对丰度 98.54%。

### Microbial Diversity of Raw and Sour Mare Milk in Xilinguole

#### Pastoral Area

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**Abstract:** In this study, Illumina miseq high-throughput sequencing technology was used to analyze the microbial diversity of bacteria and fungi in fresh and sour mare milk samples. The results showed that a total of 391632 bacterial and 581204 fungal sequences were obtained from 9 samples. The average readings of each sample were 46255 and 68, respectively, The average length is 428 BP and 195 BP. The bacterial sequences of all samples belong to 5 phyla, 6 classes, 14 orders, 18 families, 27 genera, 34 species and 36 OTUs. The fungal sequences of all samples belong to 7 phyla, 19 classes, 42 orders, 80 families, 110 genera, 144 species and 217 OTUs. The dominant bacteria were Enterobacter with relative abundance of 63.45%, Rhodotorula with relative abundance of 55.51%, lactobacillus with relative abundance of 46.63%, Dekkera with relative abundance of 95.83%, and lactobacillus with relative abundance of 95.83% after 15 h fermentation The relative abundance of Lactococcus was 77.43%, and that of Dekkera was 98.54%.

## 7. 传统发酵奶皮子营养、品质及分离乳酸菌的抑菌特性研究

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**摘要:** 本文对内蒙古传统发酵奶皮子的营养成分(水分、蛋白质、粗脂肪、氨基酸、脂肪酸)、滋味物质和抑菌特性进行检测与分析。根据各样品中分离乳酸菌的抑菌特性筛选出优势菌株,作为发酵剂对普通奶皮子进行发酵试验,探讨其抑菌效果。结果如下:

发酵奶皮子的水分、粗蛋白和粗脂肪的平均含量分别为  $38.70\pm 4.67\%$ 、 $10.49\pm 1.28\%$ 和  $49.83\pm 5.13\%$ 。氨基酸平均含量为  $13.16\pm 2.89\%$ ,其中成人必需氨基酸含量为  $5.17\%$ ,高于鲜奶皮子中成人必需氨基酸含量( $3.20\%$ )。脂肪酸平

均含量为  $40.14\pm 5.22\%$ ，其中饱和脂肪酸含量为  $24.85\pm 3.24\%$ ，不饱和脂肪酸含量为  $15.30\pm 2.12\%$ 。在不饱和脂肪酸中，单不饱和脂肪酸含量为  $13.34\pm 1.80\%$ ，多不饱和脂肪酸含量为  $1.95\pm 0.38\%$ 。

发酵奶皮子和普通奶皮子的整体滋味品质差异显著，其中酸味值和甜味值差异极显著，滋味差异不显著。发酵奶皮子 FN-3 的酸味值最大，为 7.66，通奶皮子 PN-4 的甜味值最大，13.52。

发酵奶皮子中分离出 13 株乳酸菌的抑菌圈直径为  $15.34\pm 0.31$  mm~ $23.14\pm 0.79$  mm。采用大肠杆菌 NBRC3301 为指示菌进行抑菌试验，筛选出较好的 6 株菌，别为 M6-4、M6-5、M6-6、M6-7、M8-3 和 M8-6。测定其抑菌谱，结果显示菌株 M6-6 和 M8-3 对金黄色葡萄球菌 IID1677、蜡状芽孢杆菌 AS1.1846、枯草芽孢杆菌 HMO1、大肠杆菌 NBRC3301 和鼠伤寒沙门氏菌 NBRC12529 均有明显的抑菌效果，呈现出较广的抑菌谱。

选用菌株 M6-6 和 M8-3 对普通奶皮子进行发酵，发酵第 9 d 时其抑菌效果最好，抑菌圈直径最大可达  $18.67\pm 0.20$  mm，同时单菌发酵的抑菌圈直径平均为  $17.48\pm 0.92$  mm，混合菌发酵的抑菌圈直径平均为  $18.30\pm 0.39$  mm。

## **Study on the Nutrition and Quality of Traditional Fermented Wrum and the Antibacterial Properties of LAB Isolated From it**

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**Abstract:** In this paper, the nutritional components (water, protein, crude fat, amino acid, fatty acid), flavour substances and antibacterial properties of the traditional fermented Wrum in Inner Mongolia were detected and analyzed. The dominant strains were screened according to the antibacterial characteristics of Lactobacillus Isolated from each sample. As a starter, we studied the bacteriostatic effect of the ordinary Wrum. The results are as follows:

The average content of moisture, crude protein and crude fat of the fermented Wrum is  $38.70\pm 4.67\%$ ,  $10.49\pm 1.28\%$  and  $49.83\pm 5.13\%$ , respectively. The average

content of amino acids was  $13.16 \pm 2.89\%$ , Among them, the content of essential amino acids in adults is  $5.17\%$ , which is higher than that in raw Wrum. The content of essential amino acids in adults is  $3.20\%$ . Besides, the average content of fatty acid was  $40.14 \pm 5.22$ . The content of saturated fatty acid is  $24.85 \pm 3.24\%$ , the content of unsaturated fatty acid is  $15.30 \pm 2.12\%$ . In unsaturated fatty acids, the content of monounsaturated fatty acid is  $13.34 \pm 1.80\%$ , and the content of polyunsaturated fatty acid is  $1.95 \pm 0.38\%$ .

There were significant differences in the overall taste quality of fermented Wrum and ordinary Wrum. At the same time, there were very significant differences in the acid and sweetness value of the indexes, but the astringency difference was not significant. The sour taste value of fermented Wrum FN-3 is the largest, which is 7.66. The sweetness value of PN-4 is the largest, which is 13.52.

13 strains of lactic acid bacteria were isolated from the fermented Wrum, the diameter of the bacteriostasis was  $23.14 \pm 0.79$  mm ~ the minimum  $15.34 \pm 0.31$  mm. *Escherichia coli* NBRC3301 was used as indicator bacteria for bacteriostatic test, and 6 good strains were screened, which were M6-4, M6-5, M6-6, M6-7, M8-3 and M8-6, respectively. Determination of its antimicrobial spectrum, the results showed that strains M6-6 and M8-3 had obvious bacteriostasis effect on *Staphylococcus aureus*, *Bacillus cereus*, *Bacillus subtilis*, *Escherichia coli* and *Salmonella* in rats, and showed a wide spectrum of bacteriostasis.

The strain M6-6 and M8-3 were used to ferment ordinary Wrum. On the fermentation 9th day, the bacteriostatic effect was best, the diameter of the bacteriostasis circle was  $18.67 \pm 0.20$  mm, and the average diameter of the bacteriostasis circle of single bacteria fermentation was  $17.48 \pm 0.92$  mm, and the average diameter of the bacteriostasis circle of the mixed bacteria fermentation was  $18.30 \pm 0.39$  mm.

## 8. 乳清奶酪酥饼的品质功能特性研究

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**摘要:** 乳清奶酪酥饼是以乳清奶酪、浓缩乳清等为主要原料,经配料、加热搅拌、成型、烘烤、冷却、包装等工艺制成的具有蒙古族特色的即食含乳制品。本文通过对乳清奶酪酥饼的理化指标、品质特性和功能特性进行检测分析,同时观察产品在贮藏期间质量指标的变化。主要结果如下:

乳清奶酪酥饼的两种配方产品经理化指标检测结果表明,乳清奶酪酥饼的水分含量为 5.56-9.81%、蛋白质含量为 14.90-16.39%、脂肪含量为 17.33-22.25%,其中青稞面制作的乳清奶酪酥饼的蛋白质含量较高,而水分和脂肪含量较低,且其质地较硬、口感酥脆,而含有小麦粉的成品较为松软。

乳清奶酪酥饼共检测出 17 种氨基酸,其中含有 7 种人体必需氨基酸,青稞面和小麦粉制作的产品氨基酸总含量分别为 221.81 mg/g 和 144.79 mg/g。乳清奶酪酥饼共检测出 26 种脂肪酸,包括富含亚油酸(2.95 -8.19%)、 $\alpha$ -亚麻酸(0.76 -0.8%)和  $\gamma$ -亚麻酸(0.13 -0.15%)等必需脂肪酸。由上述结果得知,青稞面制作的乳清奶酪酥饼营养价值较好。

乳清奶酪酥饼具有一定的抗氧化活性与 ACE 抑制活性,在浓度为 10 mg/mL 时,其 DPPH 清除率为 23.43 -26.01%,羟基自由基清除率为 17.53 -39.10%,还原活性为 0.16 -0.91, ACE 抑制活性为 61.83 -66.79%,其中青稞面制作的乳清奶酪酥饼的 DPPH 清除率、还原活性和的 ACE 抑制活性较小麦粉制作的高,但其羟基自由基清除率较低。

乳清奶酪酥饼的贮藏试验结果表明,随时间的延长产品的酸价和过氧化值逐渐增高,色泽逐渐变暗,菌落总数符合产品标准要求。

## Study on Processing Technology and its Quality Function

### Characteristics of Ricotta shortcake

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**Abstract:** Ricotta shortcakes is the ricotta, condensed whey, etc as main raw materials, after mixing, molding, baking ingredients, heating, cooling, packaging technology

made with Mongolian characteristics instant containing dairy products. In this paper, the physical and chemical indexes, quality characteristics and functional characteristics of ricotta shortcake were detected and analyzed, and observing the change in the quality index of the product during storage. The main results were showed as follows:

The results of two formulations of ricotta shortcake were detected indicating, the moisture content of ricotta shortcake was 5.56-9.81%, protein content was 14.90-16.39% and the fat content was 17.33-22.25%, among then highland barley flour has high protein content and low water and fat content. The ricotta shortcake containing the highland barley flour was hard and crispy, while the finished product containing the wheat flour was relatively soft.

A total of 17 amino acids were detected in ricotta shortcake, detect the 7 kinds of essential amino acids, the total content of amino acid produced by highland barley flour and wheat flour is 221.81 mg/g and 144.79 mg/g. Ricotta shortcake were detected 26 kinds of fatty acids, including essential fatty acids were linoleic acid (2.95-8.19%), alpha-linolenic acid (0.76-0.8%) and gamma-linolenic acid (0.13-0.15%). From the above results, the nutritive value of ricotta shortcake made by highland barley flour was better.

Ricotta shortcake has certain antioxidant activity and ACE inhibitory activity. When the concentration was 10 mg/m L, DPPH radical scavenging capacity was 23.43-26.01%, Hydroxyl radical scavenging capacity was 17.53-39.10%, The reduction activity was 0.16 -0.91, The ACE inhibitory activity was 61.83-66.79%. In which that rate of DPPH clearance, reduction activity and ACE inhibitory activity of the ricotta shortcake made on the highland barley flour were high, while the hydroxyl radical scavenger rate was lower than that of wheat flour.

The storage detect results of ricotta shortcake show that, with the extension of time, the acid price and peroxide value of the products increased gradually, and the color gradually darkened, and the total number of colony the product standard requirements.



## 9. 传统奶皮子的生产现状及发展趋势

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**摘要:** 随着社会不断进步发展, 城乡居民收入水平的提高, 健康饮食的概念逐渐深入人心。因乳制品营养价值丰富, 得到大家的青睐。从而使我国传统乳制品消费逐年增加。本文首先阐述了内蒙古传统奶皮子及云南乳扇的生产现状、营养价值、加工工艺及乳酸菌在传统奶皮子中的应用。为未来进一步研发传统奶皮子提供参考依据。其次, 针对传统奶皮子、乳扇的营养价值开发利用率低, 加工制作过程一般都为牧民自家制作, 没有大规模开发利用以及从传统奶皮子、乳扇中筛选出的优势乳酸菌也相对较少等方面进行综合分析, 从而对传统奶皮子和乳扇有更加全面的了解。

### **Production status and development trend of traditional milk skin**

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**Abstract:** With the development of the society, improving the level of the income of urban and rural residents, the concept of healthy diet is gradually popular. Because rich nutritional value of dairy products, many people like to buy it. Dairy consumption has increased year by year in China. This article first elaborated research status of production status, nutritional value and processing technology of Inner Mongolia traditional urum and Yunnan fan-like cheese as well as Application of lactic acid bacteria in traditional urum. This paper can give a reference to further research and development of traditional dairy products in the future. Secondly, according to the nutritional value of traditional urum and fan-like cheese is low utilization rate, generally, the working process is made by herdsman themselves, it has not been large-scale developed and utilized and there are few dominant lactic acid bacteria screened from

traditional urum and fan-like cheese were discussed. So we can get a better understanding of traditional urum and fan-like cheese.

## 10. 蒙古族传统奶豆腐工艺优化研究

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**摘要:** 奶豆腐是蒙古族传统乳制品之一, 属于干酪的一种, 富含蛋白质、钙、铁、磷等, 受到许多消费者的喜爱。针对原料乳的预处理, 添加辅助发酵剂发酵, 调整发酵温度, 调整排乳清温度, 调整搅和(乳化)温度几个方面进行了改进, 得出最佳工业化生产工艺参数为: 原料乳脂肪为 1.4%, 添加复配发酵剂发酵, 菌种添加量 3%, 发酵温度 18 °C, 排乳清温度 58 °C, 搅和(乳化)温度 85 °C, 通过工艺改进后的工业化生产的奶豆腐的出成率为 8.31%, 感官评分为 85 分, 比传统工艺制作的奶豆腐出成率提高了 21.4%, 感官评分提高了 16.4%。

### **Research on Optimization of Mongolian Hrood's**

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**Abstract:** The Mongolian traditional cheese hurood is one of the traditional Mongolian food and belongs to cheese classification. It contains protein, calcium, iron phosphorus and so on. From the pretreatment of raw milk, adding fermentation of auxiliary starter, adjusting the fermentation temperature, adjusting the whey temperature and adjusting the mixing temperature (emulsification), the optimum industrial production parameters were as follows: raw milk fat 1.4%, adding compound fermentation, the amount of bacteria added 3%, fermentation temperature 18 C, row whey temperature 58 C, stirring (emulsification) temperature 85 C. The rate of milk tofu produced by the industrialized process was 8.31%, the sensory score was 85 points, 21.4% higher than that of the traditional process, and the sensory score increased by 16.4%.

## 11. 超高压处理对 *Lactobacillus delbrueckii* QS306 发酵乳 ACE 抑制活性及品质的影响

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**摘要:** 本文采用超高压技术, 以处理压力、保压时间和发酵时间为变量, 以 ACE 抑制活性为检测指标, 研究超高压处理对 *Lactobacillus delbrueckii* QS306 发酵乳 ACE 抑制活性的影响, 并对其理化指标、感官指标和微生物进行分析。试验结果表明, 当压力为 400 MPa, 保压时间为 10 min, 发酵时间为 48 h, 此时该发酵乳 ACE 抑制率达到  $86.55 \pm 0.17\%$  与未处理组  $75.58 \pm 1.69\%$  相比增加 10.97%; 且处理后蛋白质水解能力显著增加, 其游离氨基酸含量提高了  $0.71 \pm 0.35$  mg/g, 种类增加了 7 种。经超高压处理后发酵乳的 pH 值、酸度、持水率和乳清析出率均无显著变化; 表观黏度上升了 1.6 Pa·s, 且随剪切时间的延长呈现下降的趋势, 最终保持稳定; 处理后乳酸菌数总数为  $7.0 \times 10^4$ ; 超高压处理后样品的亮度与白度 (L\*值) 下降, 红度与黄度增加 (a\*值与 b\*值) 上升; 经处理后的发酵乳鲜味、丰度显著上升, 而苦味、涩味下降显著, 酸度及咸度相较未处理组同样有下降趋势; W1C、W2W 传感器的响应值有明显提高, 而 W6S 下降显著, 其他物质相对较稳定。结论: 超高压处理技术显著提高 *Lactobacillus delbrueckii* QS306 发酵乳的 ACE 抑制活性, 并对发酵乳的理化指标无显著影响, 且改善了发酵乳的风味、滋味和色泽, 提升了发酵乳的感官品质, 为 *Lactobacillus delbrueckii* QS306 功能性发酵乳制品的研究提供理论依据。

### Effects of Ultra High Pressure Treatment on Angiotensin-converting enzyme inhibitory activity and quality of *Lactobacillus delbrueckii* QS306 fermented milk

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**Abstract:** The objective was to investigate the effects of ultra-high pressure treatment on ACE inhibitory activity of *Lactobacillus delbrueckii* QS306 fermented milk. The

treatment condition was treatment pressure, holding time and fermentation time, and detection index was ACE inhibitory activity. The physical and chemical indexes, sensory indexes and microorganisms were analyzed. The results showed that when the pressure was 350 MPa, the holding time was 10 min, and the fermentation time was 48 h, the ACE inhibition rate of the fermented milk reached  $86.55 \pm 0.17\%$  and increased 10.97% compared with  $75.58 \pm 1.69\%$  of the untreated group. After treatment, the hydrolysis ability of protein was significantly increased, the content of free amino acids was increased  $0.71 \pm 0.35$  mg/g, and 7 types were increased. The pH value, acidity, water retention rate and whey precipitation rate of fermented milk were not significantly changed. The apparent viscosity increased 1.6 Pa·s, and showed a downward trend with the extension of shear time, and finally remained stable. The total number of lactic acid bacteria after treatment was  $7.0 \times 10^4$ . Ultra High Pressure Treatment lead to an increase of the redness and yellowness (A\* value and B\* value), and decrease of brightness and whiteness (L\* value). The fresh taste and abundance of fermented milk increased significantly, while the bitter taste and astringency decreased significantly. After treatment, the response values of W1C and W2W sensors in fermented milk were significantly increased, while W6S was significantly decreased, Other substances were relatively stable. Conclusion: The ultra-high pressure treatment technology significantly improved the ACE inhibitory activity of *Lactobacillus delbrueckii* QS306 fermented milk and no significant effect on the physical and chemical indexes of fermented milk, and improved the flavor, taste and color of fermented milk, and enhanced the sensory quality of fermented milk. This study provides a theoretical basis for future research on *Lactobacillus delbrueckii* QS306 fermented milk.

## 12. 微波处理牛奶中维生素 C 含量的响应面分析法

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**摘要:** 牛奶微波处理过程中, 采用了基于三能级三因子 Box-Behnken 设计的响应面法 (RAM)。研究了维生素 C 的反应。模型预测值(11.84 $\mu\text{g}/\text{mL}$ )与实验值(11.83 $\mu\text{g}/\text{mL}$ )吻合极好。乳层厚度是影响测量响应的最主要因素, 微波时间和微波功率的影响与乳层厚度有关。微波时间, 乳层厚度和微波功率等变量对微波处理乳中维生素 C 的含量有相反的影响。乳层厚度与微波功率之间的协同作用非常显著( $p < 0.0001$ )。

### **Response surface methodology (RSM) in evaluation of the vitamin C concentrations in microwave treated milk**

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**Abstract:** During the microwave treatment process of the milk, response surface methodology (RSM) based on three level three-factorial Box-Behnken design was used. The response vitamin C concentration was studied. The predicted value of model (11.84  $\mu\text{g}/\text{mL}$ ) was in excellent accordance with experimental value (11.83  $\mu\text{g}/\text{mL}$ ). Milk layer thickness was the most significant factor that affects the measured responses, and the effects of microwave time and microwave power were dependent on milk layer thickness levels. The variables microwave time, milk layer thickness and microwave power have the opposite effect on vitamin C concentration in milk treated by microwave. Synergistic interactions between milk layer thickness and microwave power was highly significant ( $p < 0.0001$ ).

## **13. 超高压处理对传统奶豆腐品质的影响**

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**摘要:** 本文利用超高压技术, 以压力水平和保压时间为变量, 以奶豆腐的菌落总数和质构为检测指标, 筛选出超高压处理条件。以未处理奶豆腐为对照, 评

价超高压处理对奶豆腐品质的影响，并对处理前后的奶豆腐在不同温度条件下贮藏时的品质变化情况进行监测与探讨。主要研究结果如下：

(1)以超高压的压力水平和保压时间为变量，以奶豆腐菌落总数和质构为检测指标，最终筛选合适的超高压处理条件为为 500 MPa、10 min，此条件处理的奶豆腐菌落总数 $<10$  CFU/mL，硬度为  $4292.52\pm 206.11$  g，弹性为  $0.84\pm 0.04$ ，粘聚性为  $0.78\pm 0.01$ ，咀嚼性为  $2815.70\pm 180.76$ ，奶豆腐的质构显著改善。

(2)奶豆腐经超高压处理后，游离氨基酸和游离脂肪酸的含量升高，游离氨基酸总量为 4.82 mg/g，比超高压处理前升高了 32.57%，特别是谷氨酸和甘氨酸的含量增加显著，分别提高了 45.50%和 2.43 倍；游离脂肪酸总含量为 1.42 mg/g，比处理前升高了 27.93%。

(3)奶豆腐经超高压处理后，其 DPPH $\cdot$ 和 $\cdot$ OH 自由基清除活性显著增强，由处理前的  $18.33\pm 0.96\%$ 和  $40.22\pm 0.38\%$ 提高到了  $21.53\pm 1.15\%$ 和  $41.58\pm 0.40\%$ ，其还原活性无显著变化。采用扫描电镜对超高压处理前后奶豆腐的微观结构观察发现，处理后奶豆腐的蛋白结构比较松散，形成不均匀的蛋白胶束簇，蛋白体系中出现大小不一的孔洞。

(4)将处理前后的奶豆腐在 10 $^{\circ}$ C和 4 $^{\circ}$ C环境贮藏试验结果表明，第 28 d 时超高压处理组奶豆腐的菌落总数分别为  $8.92\times 10^3$  CFU/mL 和 85 CFU/mL，相比第 1 d 的菌落总数 $<10$  CFU/mL，仅增加了 $<8.92\times 10^2$  CFU/mL 和 $<75$  CFU/mL。超高压处理后 pH 值和酸度基本无变化，较稳定；蛋白水解能力在贮存期间显著高于未处理组，28 d 时分别达到  $1148.46\pm 3.18$  ( $\mu$ g/mL Tyr)和  $674.40\pm 76.71$  ( $\mu$ g/mL Tyr)。

(5)超高压处理后，奶豆腐的白度和红度降低，透光性和黄度增强，硬度和咀嚼性显著降低，弹性和粘聚性升高，色泽和质地有所改善，并在贮存期内基本保持稳定。

(6)超高压处理后，奶豆腐的鲜味、丰度、咸味和甜味值升高，酸味、涩味、苦味和苦回味值降低，芳香成分、醇类、醛类和酮类的响应值增加，氮氧化合物、硫化物和萜类物质的响应值降低。并在贮存期内保持稳定，且贮藏温度越低越好。这说明超高压处理对奶豆腐的滋气味具有优化作用，并与低温贮藏结合有助于滋气味的形成和保护。

## Effect of Ultra High Pressure Treatment on the Quality of Traditional Huood

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**Abstract:** In this paper, the ultra-high pressure treatment conditions are selected by taking the pressure level and holding time as variables, the colony forming unit and texture of huood as detection indexes. With untreated huood as a comparison, the effect of ultra-high pressure treatment on the quality of huood has evaluated, and the quality changes in huood stored under different temperature conditions have monitored and discussed. The main findings are as follows.

(1) Taking the pressure level and holding time of ultra-high pressure as variables, and the colony forming unit and texture of huood as detection indexes, the appropriate ultra-high pressure treatment condition was finally selected as 500 MPa and 10 min. After processing with this condition, the colony forming unit of huood was less than 10 CFU/mL, the hardness was  $4292.52 \pm 206.11$  g, the elasticity was  $0.84 \pm 0.04$ , the viscosity was  $0.78 \pm 0.01$ , the chewiness was  $2815.70 \pm 180.76$ , the texture of huood was significantly improved.

(2) After the huood was treated with ultra-high pressure, the content of free amino acids and free fatty acids increased, the total amount of free amino acids was 4.82 mg/g, which was 32.57% higher than before the ultra-high pressure treatment, and the content of glutamate and glycine increased significantly, increasing by 45.50% and 2.43 times respectively. The total content of free fatty acids was 1.42 mg/g, which was 27.93% higher than before treatment.

(3) After the huood was treated with ultra-high pressure, the activity of DPPH• and •OH free radical removal was significantly enhanced, from  $18.33 \pm 0.96\%$  and  $40.22 \pm 0.38\%$  before treatment, increased to  $21.53 \pm 1.15\%$  and  $41.58 \pm 0.40\%$ , there was no significant change in the reductive activity. The microstructure of huood before and

after ultra-high pressure treatment was observed by scanning electric mirror. After treatment, the structure of huurood's protein was relatively loose, the formation of uneven protein clusters, protein system appears in different sizeholes.

(4) The storage test results of huurood at 10°C and 4°C before and after treatment shows, on the 28th day, the colony forming unit in the ultra-high pressure treatment group huurood was  $8.92 \times 10^3$  CFU/mL and 85 CFU/mL, respectively. compared with the <10 CFU/mL in first day, increased only by  $<8.92 \times 10^2$  CFU/mL and <75 CFU/mL. After ultra-high pressure treatment, pH value and acidity were basically unchanged and relatively stable; proteolysis capacity was significantly higher during storage than that of untreated group, reached  $1148.46 \pm 3.18$  ( $\mu\text{g/mL Tyr}$ ) and  $674.40 \pm 76.71$  ( $\mu\text{g/mL Tyr}$ ) on day 28, respectively.

(5) After ultra-high pressure treatment, the whiteness and redness of huurood were reduced, and the light transmittance and yellowness were enhanced. The hardness and chewability were significantly decreased, elasticity and cohesion were increased, color and texture were improved, and remained stable during storage.

(6) After ultra-high pressure treatment, the umami, abundance, saltiness and sweetness values of huurood increased, while the sour, astringent, bitter and bitter aftertaste values decreased. The response values of aromatic components, alcohols, aldehydes and ketones increased, while those of nitrogen oxides, sulfides and terpenes decreased. and remain stable during the storage period, and the lower the storage temperature, the better. This shows that ultra-high pressure treatment has an optimized effect on the smell of huurood, and combines with low temperature storage to help the formation and protection of the smell.



## 14. 锡林郭勒牧区鲜马奶挥发性风味物质与微生物多样性分析评价

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**摘要:** 本研究通过气相色谱-质谱联用(GC/MS)和 Illumina Miseq 高通量测序技术对鲜马奶中风味化合物、细菌和真菌微生物多样性进行了分析。结果表明, 鲜马奶中有 22 种风味物质, 包括 12 种酸类、4 种芳香族类、3 种酯类、2 种酮类和 1 种醇。总酸含量为  $31.15 \pm 0.59 \mu\text{g/g}$ , 其中辛酸、癸酸、苯甲酸等为主要酸类物质。醇类和芳香族类总含量分别为  $5.45 \pm 0.06 \mu\text{g/g}$ 、 $5.39 \pm 0.11 \mu\text{g/g}$ , 其余物质含量较低。高通量测序获得 116,045 条细菌和 171,178 条真菌优化序列, 细菌序列归属于 5 个门, 20 个属, 30 个 OUT, 真菌序列归属于 5 个门, 67 个属, 119 个 OUT。优势细菌属为肠球菌属(*Enterobacter*), 相对丰度是 44.83%, 主要的细菌属还有劳特菌属(*Raoultella*)、乳球菌属(*Lactococcus*)、链球菌属(*Streptococcus*)等。优势真菌属为红酵母属(*Rhodotorula*), 相对丰度是 55.51%, 主要的真菌属还有线黑粉酵母属(*Filobasidium*)、丝孢酵母菌属(*Trichosporon*)、克鲁维酵母属(*Kluyveromyces*)等。上述结果表明, 鲜马奶中风味物质较酸马奶少, 且存在一定对人体有害的污染菌。因此直接食用或使用鲜马奶缺乏安全保障, 建议进行杀菌处理操作。

### Analysis and Evaluation of Flavor Compounds and Microbial

#### Diversity of Fresh Mare Milk in Xilin Gol Pastoral Area

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**Abstract:** In this study, GC/MS and Illumina Miseq high-throughput sequencing technology were used to analyze the diversity of flavor compounds, bacteria and fungi in fresh mare milk. The results showed that there were 22 flavoring substances in fresh

mare milk, including 12 acids, 4 aromatic compounds, 3 esters, 2 ketones and 1 alcohol. The total acid content was  $31.15 \pm 0.59 \mu\text{g/g}$ , of which caprylic acid, capric acid and benzoic acid were the main acid substances. The total contents of alcohol and aromatic compounds were  $5.45 \pm 0.06 \mu\text{g/g}$  and  $5.39 \pm 0.11 \mu\text{g/g}$ , respectively, and the rest of the contents were relatively low. High-throughput sequencing was performed to obtain the optimized sequences of 116,045 bacteria and 171,178 fungi. Bacterial sequences belonged to 5 phyla, 20 genera and 30 OUT, and fungal sequences belonged to 5 phyla, 67 genera and 119 OUT. The dominant bacterial genus was *Enterobacter*, with a relative abundance of 44.83 %, and the main bacterial genus includes *Raoultella*, *Lactococcus*, and *Streptococcus*. The dominant fungal genus was *Rhodotorula*, with a relative abundance of 55.51 %. Other main fungal genus was *Filobasidium*, *Trichosporon*, *Kluyveromyces*. The above results indicated that the flavor substances of fresh mare milk were less than koumiss, and there were certain contamination bacteria harmful to human body. Therefore, direct consumption or use of fresh mare milk lacks safety guarantee, and it is recommended to carry out sterilization treatment operations.

## 15. 超高压处理对鲜驼乳品质的影响

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**摘要:** 本文以处理压力、保压时间和样品温度为变量, 以微生物、理化性质及感官特性为检测指标, 进行单因素和正交试验, 探讨超高压处理对鲜驼乳品质的影响, 并优化出超高压杀菌的最佳工艺参数。不同压力的超高压处理对鲜驼乳具有显著的杀菌作用, 且随着处理压力的增加其杀菌效果得到提升; 其中 600MPa 的超高压处理杀菌效果最佳, 菌落总数  $< 10\text{CFU/mL}$ 。经超高压处理后, 鲜驼乳的酸度降低, pH 值和表观黏度增加, 而电导率无明显变化。超高压处理可以改善鲜驼乳的感官特性, 使其  $L^*$ 值和酸味降低, 鲜味和挥发性芳香物质增加, 对咸味无显著影响。随着超高压处理时间的延长, 其对鲜驼乳的杀菌效果越显著, 当时间超过 20min 后, 微生物的致死率无明显变化。不同时间的超高压处理可以降

低鲜驼乳的酸度和电导率，同时增加其 pH 值和表观黏度。在感官特性方面，超高压处理使鲜驼乳的酸味降低，鲜味和挥发性芳香物质增加，而对咸味无显著影响。当样品温度为 40℃时致死率最低，超高压杀菌处理的结果最差。在理化特性方面，鲜驼乳的酸度和电导率降低，pH 值和表观黏度增加。不同样品温度的超高压处理使鲜驼乳的  $L^*$ 值降低，挥发性芳香物质增加，且对滋味有一定的影响。通过正交试验得出，超高压处理鲜驼乳的最优条件为处理压力 600MPa、保压时间 20min、样品温度 55℃，且处理因素对菌落总数灭菌效果的作用顺序为：处理压力>样品温度>保压时间。巴氏杀菌和超高压处理均可以使鲜驼乳中的菌落总数降低，但超高压处理的杀菌效果更显著，菌落总数<10CFU/mL，且优化后的超高压处理条件可以有效地延长鲜驼乳的保质期。

## Effect of Ultra High Pressure Treatment on the Quality of Fresh Camel Milk

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**Abstract:** This article uses processing pressure, holding time and sample temperature as variables, and uses microorganisms, physical and chemical properties and sensory characteristics as detection indicators. Single factor and orthogonal experiments are carried out to explore the effect of ultra-high pressure treatment on the quality of fresh camel milk and optimize The best process parameters for ultra-high pressure sterilization. Ultra-high pressure treatment with different pressures has a significant sterilization effect on fresh camel milk, and its sterilization effect is improved with the increase of processing pressure; among them, the ultra-high pressure treatment of 600MPa has the best sterilization effect, and the total number of colonies is <10CFU/mL. After ultra-high pressure treatment, the acidity of fresh camel milk decreased, the pH value and apparent viscosity increased, but the electrical conductivity did not change significantly. Ultra-high pressure treatment can improve the sensory characteristics of fresh camel milk, reduce its  $L^*$  value and acidity, increase umami and

volatile aromatic substances, and have no significant effect on saltiness. With the extension of the ultra-high pressure treatment time, its sterilization effect on fresh camel milk is more significant. When the time exceeds 20 minutes, the lethality of microorganisms does not change significantly. UHP treatment at different times can reduce the acidity and conductivity of fresh camel milk, while increasing its pH and apparent viscosity. In terms of organoleptic properties, the ultra-high pressure treatment reduces the sourness of fresh camel milk, increases the umami taste and volatile aromatic substances, and has no significant effect on the salty taste. When the sample temperature is 40°C, the fatality rate is the lowest, and the result of ultra-high pressure sterilization is the worst. In terms of physical and chemical properties, the acidity and conductivity of fresh camel milk decrease, while the pH and apparent viscosity increase. The ultra-high pressure treatment of different sample temperatures reduced the  $L^*$  value of fresh camel milk, increased volatile aromatic substances, and had a certain influence on the taste. Through orthogonal experiments, the optimal conditions for ultra-high pressure processing of fresh camel milk are processing pressure of 600 MPa, pressure holding time of 20 minutes, and sample temperature of 55°C. The order of effect of processing factors on the sterilization effect of the total number of colonies is: processing pressure> sample Temperature>holding pressure time. Both pasteurization and ultra-high pressure treatment can reduce the total number of colonies in fresh camel milk, but the sterilization effect of ultra-high pressure treatment is more significant, the total number of colonies is less than 10CFU/mL, and the optimized ultra-high pressure treatment conditions can effectively extend the fresh camel milk Shelf life of milk.

## 16. 酸马奶片的制作及其品质功能特性的研究

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**摘要:** 本文以酸马奶为研究对象, 以开发一款酸马奶片为目的, 对其主要原料和工艺进行单因素和正交试验, 选出最优配比和工艺, 并对酸马奶片产品的感官、

理化、微生物相关指标以及品质、功能特性进行检测和分析，观察其在贮藏期间的品质变化情况，确定保质期。研究结果如下：

(1) 酸马奶片中分别添加相同量的全脂乳粉和脱脂乳粉所制成的酸马奶片，其咀嚼度分别是  $2802.93 \pm 92.61$  和  $331.17 \pm 12.89$ ，与市售牛奶片对照样 ( $2757.47 \pm 33.84$ ) 相比，添加全脂乳粉的咀嚼度更好；感官评分分别是  $15.60 \pm 0.12$  分和  $14.20 \pm 0.12$  分。故选择全脂乳粉作为原料添加到酸马奶片中。

(2) 通过不同添加量的酸马奶粉 (70%、80%、90%、100%)、全脂乳粉 (5%、10%、15%、20%)、葡萄糖粉 (1%、3%、5%、7%) 对酸马奶片感官评分的影响单因素和正交试验结果得知，酸马奶片的最佳组合为酸马奶粉、全脂乳粉、葡萄糖粉的添加量分别为 80%、15% 和 5%。

(3) 通过搅拌时间、压片速度、压片压力对酸马奶片咀嚼度的影响单因素和正交试验结果得知，各因素主次顺序为：压片压力 > 搅拌时间 > 压片速度，最佳组合为搅拌时间 20min、压片速度 100r/min、压片压力 3.50MPa。

(4) 对酸马奶片的营养成分检测分析结果得出，蛋白质、脂肪、水分、灰分、酸度值分别为  $47.55 \pm 0.24\%$ 、 $19.20 \pm 0.70\%$ 、 $4.32 \pm 0.05\%$ 、 $4.60 \pm 0.01\%$ 、 $102.06 \pm 1.03^{\circ}\text{T}$ ；乳酸菌和酵母菌数分别为  $8.8 \times 10^4 \text{CFU/g}$ 、 $1.5 \times 10^5 \text{CFU/g}$ ；酸马奶片含有的氨基酸种类丰富，总和为  $27.05 \text{g}/100\text{g}$ ，含有 7 种人体必需氨基酸和 2 种婴幼儿必需氨基酸；酸马奶片的脂肪酸种类丰富，其中亚油酸和亚麻酸含量较其他乳制品高，含量分别为 6.92% 和 4.10%。

(5) 当酸马奶片复水浓度为  $10 \text{mg/mL}$  时，其 DPPH 清除率、羟基自由基清除率、还原活性、超氧阴离子清除率分别为  $30.11 \pm 0.16\%$ 、 $50.10 \pm 0.18\%$ 、 $0.32 \pm 0.01$ 、 $9.61 \pm 0.03\%$ 。酸马奶片胆固醇脱除率、ACE 抑制率、亚硝酸盐降解率分别为  $41.10 \pm 1.64\%$ 、 $59.26 \pm 2.02\%$ 、 $55.66 \pm 0.80\%$ 。结果证明，酸马奶片具有一定的营养及益生功能特性。

(6) 采用电子舌和电子鼻对酸马奶片的滋味和挥发性风味物质进行分析和评价，结果表明，酸马奶片的滋味物质主要是酸味和涩味，挥发性风味物质主要包括芳香化合物、芳香成分 (氨气)、氢气、烷烃和芳香化合物。

(7) 综合酸马奶片贮藏期间感官和微生物的指标变化情况，可以得出，在冷藏和冷冻条件下贮藏，酸马奶片可贮藏 10 个月以上的时间；在常温条件下贮

藏的酸马奶片，1 个月后，颜色由乳黄色变为黄褐色，并且随着时间的延长，颜色逐渐变深，故酸马奶片不宜在常温下贮藏。

## **Study on Processing Technology and Quality Function**

### **Characteristics of Fermented Koumiss Tablets**

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**Abstract:** In this experiment, fermented Koumiss was used as the research object to develop a fermented Koumiss tablet. The main raw materials and processes were tested by single factor and orthogonal test to select the optimal ratio and process. The sensory, physical and chemical, microbiological indicators, quality and functional characteristics were tested and analyzed, and the quality changes during storage were observed to determine their shelf life. The research results are as follows:

(1) The same amount of whole milk powder and skim milk powder were respectively added to the fermented Koumiss tablets, and the chewiness was  $2802.93 \pm 92.61$  and  $331.17 \pm 12.89$ , respectively, compared with the commercial milk tablets control sample ( $2757.47 \pm 33.84$ ). The whole milk powder was better. The sensory scores were  $15.60 \pm 0.12$  and  $14.20 \pm 0.12$ , respectively. Therefore, the whole milk powder was selected as a raw material and added to the fermented Koumiss tablets.

(2) Through different amounts of fermented Koumiss powder (70%, 80%, 90%, 100%), whole milk powder (5%, 10%, 15%, 20%), glucose powder (1%, 3%, 5%, 7%) added to the fermented Koumiss tablets. The single factor and orthogonal test results showed that the best combination of fermented Koumiss tablets was fermented Koumiss powder powder, whole milk powder and glucose powder was 80%, 15% and 5%, respectively.

(3) The effects of stirring time, tableting speed and tableting pressure on the chewiness of fermented Koumiss tablets were analyzed by single factor and orthogonal

test results. The order of the factors was: tableting pressure > stirring time > tableting speed. The optimum combination, stirring time was 20 min, tableting speed was 100 r/min and tableting pressure was 3.50 MPa.

(4) The analysis results of nutrient composition of fermented Koumiss tablets showed that the protein content, the fat content, the moisture content, the ash content and acidity was  $47.55\pm 0.24\%$ ,  $19.20\pm 0.70\%$ ,  $4.32\pm 0.05\%$ ,  $4.60\pm 0.01\%$  and  $102.06\pm 1.03^{\circ}\text{T}$ , respectively; the number of *lactic acid bacteria* and *yeast bacteria* was  $8.8\times 10^4\text{CFU/g}$  and  $1.5\times 10^5\text{CFU/g}$ , respectively. The fermented Koumiss tablets contained abundant amino acids, the sum was 27.05 g/100 g, containing 7 kinds of essential amino acids and 2 kinds of essential amino acids for infants. The fermented Koumiss tablets were rich in fatty acids, and the content of essential fatty acids such as Linoleic acid and Linolenic acid were more prominent than other dairy products, which were 6.92% and 4.10%, respectively.

(5) When the reconstituted water of the fermented Koumiss tablet was 10 mg/mL, the DPPH clearance rate, the hydroxyl radical scavenged rate, the reducing activity and the superoxide anion removed rate was  $30.11\pm 0.16\%$ ,  $50.10\pm 0.18\%$ ,  $0.32\pm 0.01$  and  $9.61\pm 0.03\%$ , respectively. The cholesterol removal rate, the ACE inhibition rate and the nitrite degradation rate was  $41.10\pm 1.64\%$ ,  $59.26\pm 2.02\%$  and  $55.66\pm 0.80\%$ , respectively. The results showed that the fermented Koumiss tablets had certain nutritional and probiotic properties.

(6) The electronic tongue and electronic nose were used to analyze and evaluate the taste and volatile flavor of the fermented Koumiss tablets, the results showed that the taste substances of the fermented Koumiss tablets were mainly sourness and astringency. The volatile flavors mainly included aromatic compounds, aromatics, ingredients (ammonia), hydrogen, alkanes and aromatic compounds.

The changes of sensory and microbial indicators during storage of the fermented Koumiss tablets could be concluded that the fermented Koumiss tablets could be stored for 10 months or more under refrigeration and freezing conditions. The fermented Koumiss tablets stored under normal temperature conditions, after 1 month, the color

changed from milky yellow to yellowish brown, and as time went on, the color gradually became darker, so the fermented Koumiss tablets should not be stored at normal temperature.



## **(三) 微生物专题**

## 1. 高吸附铅乳酸菌发酵剂的开发研究

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**摘要:** 重金属污染问题已经严重威胁到人们的健康, 研究表明乳酸菌对重金属有一定的吸附能力。人们对食品安全性、保健性要求的逐步提高, 具有重金属吸附能力的乳酸菌显现巨大的应用前景。本试验以前期发现的 4 株对重金属铅有吸附能力的戊糖片球菌为基础, 并从西藏牦牛乳制品分离出的乳酸菌中筛选出具有良好发酵特性的乳酸菌进行组合发酵, 根据组合后菌株的吸附能力和发酵能力筛选出最优组合, 最终得到具有吸附重金属铅的优势菌株组合的最优发酵条件。

测定 4 株具有吸附  $Pb^{2+}$  能力戊糖片球菌 Fe3、Ff3、9b1、10a1 对  $Pb^{2+}$  的吸附量在 8.92mg/g-8.96mg/g 之间, 吸附率在 94.55%~98.70% 之间。对西藏牦牛乳制品中分离出的 40 株乳酸菌的生长能力、产酸性能进行初筛试验。经过初筛和复筛选出 8 株具有良好发酵特性及风味的菌株, 其中 4 株球菌, 分别为 TG7-1-6、TG7-1-1、TG8-1-5、RM1-1-20; 4 株杆菌, 分别为 RQ1-1-1、RQ1-1-16、TG8-1-9 和 TG5-1-6。将已筛选出的 4 株球菌和 4 株杆菌两两组合, 再与 4 株具有吸附  $Pb^{2+}$  能力的戊糖片球菌组合, 共产生 64 个菌株组合, 测定 64 个菌株组合对铅的吸附量和吸附率及发酵牛乳的凝乳时间和滴定酸度, 最终筛选出组合 RM1-1-20、TG8-1-9、10a1, 其凝乳时间为 9.5h, 滴定酸度为 83.83°T, 对铅的吸附量和吸附率分别为 8.77mg/g、79.73%。

### **The Study on the Development of fermentation agent for lactic acid bacteria with High Adsorption of Lead**

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**Abstract:** The problem of heavy metal pollution has seriously threatened people's health, and it was found that lactic acid bacteria have certain absorption capacity for

heavy metals. With the improvement of food safety and health care requirements, lactic acid bacteria with heavy metal adsorption capacity show great application prospects. Based on four strains of lactic acid bacteria with adsorption capacity for heavy metal lead in the previous period of this experiment, they were combined with lactic acid bacteria isolated from Tibetan yak dairy products, which had good fermentation characteristics. According to the adsorption capacity and fermentation ability of the combined strains, the optimal combination was selected for single factor fermentation condition test and response surface optimization test. Finally, the optimal fermentation conditions of the dominant strains with heavy metal lead adsorption were obtained.

The adsorption capacity of 4 strains of *Pediococcus pentosaceus* Fe3, Ff3, 9b1, 10a1  $Pb^{2+}$  was 8.92 mg/L~8.96 mg/L and the adsorption rate was 94.55%~98.70%. The fermentation performance and aroma production ability of 8 strains of lactic acid bacteria were isolated by screening and screening. Finally, 4 strains of cocci were selected, TG7-1-6, TG7-1-1, TG8-1-5, RM1-1-20, and 4 strains of bacilli, RQ1-1-1, RQ1-1-16, TG8-1-9 and TG5-1-6, respectively. Two combinations of 4 strains of cocci and 4 strains of bacilli were selected, and then combined with 4 strains of *Pediococcus pentosaceus* Fe3, Ff3, 9b1, 10a1 with adsorption  $Pb^{2+}$  ability to produce a total 64 strains. The adsorption capacity and adsorption rate of 64 strains on curd time and titration acidity of fermented milk of 64 strains were determined, and finally the RM1-1-20, TG8-1-9, 10a1, the gelation time was 9.5h, the titration acidity was 83.83°T, and the  $Pb^{2+}$  adsorption capacity and adsorption rate were respectively 8.77mg/L, 79.73%.

## 2. 降解核苷益生菌的筛选及其干预机制的研究

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**摘要:** 本文以 30 株供试菌株为研究对象, 采用高效液相色谱法筛选出具有较高核苷分解速率的菌株。对耐酸、耐胆盐、胃肠道转运、粘附、抑菌能力和药物敏感性进行检测, 评价其益生潜力。研究结果如下:

(1) 采用高效液相色谱法从 30 株供试菌株中筛选出 4 株具有较高核苷（鸟苷、肌苷）降解率的乳酸菌，即菌株 WX-94、AM60-10PH4、SS-9 和 SD-H9。菌株 WX-94 和 AM60-10PH4 对鸟苷和肌苷的降解率均可达到 100%，菌株 SS-9 和 SD-H9 对鸟苷的降解率可达到 90% 以上，但对肌苷的降解率较低，分别为 68.18% 和 49.45%。

(2) 对 4 株乳酸菌的益生潜力进行评价结果表明，菌株 WX-94、SS-9 和 SD-H9 具有较好的潜在降尿酸作用。其中 SS-9 经胃肠道运转后存活率最高，可达到 58.40%；菌株 SD-H9 的粘附能力最强，可达到  $9.5 \pm 0.8$  CFU/cells，并对 13 种抗生素有敏感性。并且以上 3 株菌对大肠杆菌、金黄色葡萄球菌、铜绿假单胞菌和阴沟肠杆菌均有不同程度的抑制作用。

## **The screening of biodegradable nucleoside probiotics and the study of its intervention mechanism**

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**Abstract:** In this paper, 30 tested strains were used as the research object, and HPLC was used to screen for strain with higher decomposition nucleoside rate. To evaluate its prebiotic potential, acid resistance, bile salt resistance, gastrointestinal transport, adhesion, bacteriostatic ability and antibiotic sensitivity were tested. The results of the study are as follows:

(1) Four lactic acid bacteria with higher nucleoside (guanosine, inosine) degradation rate were selected from 30 candidate strains with the method of HPLC, i.e., strains WX-94, AM60-10PH4, SS-9, and SD-H9. The degradation rates of WX-94 and AM60-10PH4 to guanosine and inosine reached 100%, and the degradation rate of SS-9 and SD-H9 to guanosine reached more than 90%, but the degradation rate of inosine was relatively low, 68.18% and 49.45%, respectively.

(2) The probiotic potential for four lactic acid bacteria was evaluated, and the results showed that the strains WX-94, SS-9, and SD-H9 had a good potential to reduce

uric acid. Among them, SS-9 had the highest survival rate after gastrointestinal transit which reached 58.40%. SD-H9 had the strongest adhesion capacity, reaching  $9.5 \pm 0.8$  CFU/cells, and was sensitive to 13 antibiotics. And the above three strains of bacteria of *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Enterobacter cloacae* had different degrees of inhibition, respectively.

### 3. 具有良好风味发酵乳发酵剂的筛选及制备最佳工艺条件的确定

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**摘要:** 德氏乳杆菌保加利亚亚种 (*Lactobacillus delbrueckii* subsp. *bulgaricus*, *L. delbrueckii* subsp. *bulgaricus*) 和嗜热链球菌 (*Streptococcus thermophilus*, ST) 作为常用的酸奶发酵剂菌株被广泛的应用于乳制品生产中。本实验以购自科汉森公司的商业发酵剂为对照组, 以德氏乳杆菌保加利亚亚种和嗜热链球菌组成六组复配组发酵乳为实验组, 采用固相微萃取与气相色谱-质谱联用技术分析发酵乳中的风味物质, 发现德氏乳杆菌保加利亚亚种菌株 Tb1-1 与嗜热链球菌 MGA21-4 复配组发酵乳的风味优于其他组。在此基础上, 结合发酵温度、复配比例和蔗糖添加量等条件进行单因素正交实验, 确定发酵乳制备的最佳工艺条件。正交实验的结果表明: 德氏乳杆菌保加利亚亚种菌株 Tb1-1 与嗜热链球菌 MGA21-4 以 1:1000 的比例复配, 培养温度 45 °C、蔗糖添加量为 6.5% 的条件下发酵制得的发酵乳风味最佳。

### Screening of Starter Cultures for Fermented Milk with Good Flavor and Determination of the Optimum Preparation Conditions

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**Abstract:** *Lactobacillus delbrueckii* subsp. *bulgaricus* and *streptococcus thermophilus* are widely used in dairy production as common yoghurt starter strains. In this experiment, commercial starter purchased from Kehansen Company was used as control group, and six groups of fermented milk composed of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* were used as experimental group. Solid phase microextraction and gas chromatography-mass spectrometry were used to analyze flavor substances in fermented milk. It was found that the flavor of fermented milk composed of *Lactobacillus delbrueckii* subsp. *bulgaricus* strain Tb1-1 and *Streptococcus thermophilus* MGA21-4 was better than other groups. On this basis, single factor orthogonal experiments were carried out in combination with fermentation temperature, compound ratio and sucrose addition to determine the best technological conditions for the preparation of fermented milk. The results of orthogonal experiments showed that the fermented milk produced by *Lactobacillus delbrueckii* subsp. *bulgaricus* strain Tb1-1 and *Streptococcus thermophilus* MGA21-4 were mixed in a ratio of 1: 1000, and the fermentation temperature was 45°C, and the sucrose content was 6.5%.

#### 4. 乳酸菌胞外多糖的分离纯化和结构分析

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**摘要:** 乳酸菌胞外多糖 (Exopolysaccharides, EPS) 有两种形式, 分泌到细胞外从而形成粘附于细胞表面的为荚膜多糖, 存在于细胞周边培养基中的为黏液多糖, 这些多糖是改善产品的亮度和质感必不可少的条件。凝胶性是乳清蛋白 (Whey protein, WP) 重要特性之一, 其作为增稠剂、微胶囊壁材、食用膜以及脂肪替代物应用都是凝胶特性的一种体现。乳清蛋白凝胶特性受多种因素影响。本论文主要以分离自嗜热链球菌 (*Streptococcus thermophilus*, *S. thermophilus*) 6063 的胞外多糖为研究对象, 对胞外多糖结构特性及 EPS/WP 混合体系流变学特性进行分析。试验结果如下:

1.采用纤维素凝胶层析对粗提的 EPS 进行分离,通过特制的多糖凝胶纯化系统进行纯化得到两种 EPS,一种为中性多糖 ST1-EPS,一种为酸性多糖 ST2-EPS。

2.通过气相色谱-质谱联用仪的检测分析,结果表明 ST1-EPS 主要由半乳糖,葡萄糖和鼠李糖组成,占 80%以上,还含有一些甘露糖;ST2-EPS 主要由半乳糖,甘露糖和葡萄糖组成;通过相对分子质量的测定,ST1-EPS 的分子量为  $2.197 \times 10^3$  kDa,ST2-EPS 的分子量为  $1.419 \times 10^2$  kDa。

3.通过红外光谱仪的检测,结果表明 ST1-EPS 和 ST2-EPS 均含有官能团-OH、-CH<sub>2</sub>、-COOH、酰胺基、C-O-C 及 C-C-O;其中 ST2-EPS 中含有糖醛酸。

4.通过核磁共振的检测分析,结果表明 ST2-EPS 有 5 种糖残基,其中 4 种为  $\alpha$  构型的吡喃糖残基,1 种为  $\beta$  构型的吡喃糖残基。ST1-EPS 有 5 种糖残基,其中 3 种为  $\alpha$  构型的吡喃糖残基,2 种为  $\beta$  构型的吡喃糖残基。

5.EPS/WP 体系流变学特性测定结果表明,两种 EPS 均能够增加 EPS/WP 体系的表观黏度,且不同金属离子、pH 值和温度的处理条件对两种 EPS/WP 体系流变学特性均有较大影响但不相同。

## Isolation, Purification and Structure Analysis of Extracellular Polysaccharides from Lactic Acid Bacteria

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**Abstract:** Exopolysaccharides (EPS) can exist in two types: attached to form a capsule, and secreted into the medium to form mucus. These polysaccharides are indispensable conditions for improving the improving the brightness and texture of products. Gelation is one of the important properties of whey protein (WP). It is used as thickener, microcapsule wall material, edible film and fat substitute. The gelation property of whey protein is affected by many factors. In this paper, the structure and rheological properties of exopolysaccharides isolated from *Streptococcus thermophilus* 6063 were analyzed. The results are as follows:

1.The crude EPS was separated by cellulose gel chromatography and obtained two kinds of EPS. Two kinds of EPS were purified by the special polysaccharide gel purification system. One was neutral polysaccharide, named as ST2-EPS.

2.Through the detection detection and analysis of gas chromatography-mass spectrometry, ST1-EPS was mainly composed of galactose, glucose and rhamnose, accounting for more than 80%, and also contained a little amount of mannose. ST2-EPS was mainly composed of galactose, mannose and glucose. The molecular weight of ST1-EPS was  $2.197 \times 10^3$  kDa, and that of ST2-EPS was  $1.419 \times 10^2$  kDa.

3.Through the detection of infrared spectroscopy, the ST1-EPS and ST2-EPS all contained functional groups -OH, -CH<sub>2</sub>, -COOH, amide group, C-O-C and C-C-O. In addition, ST2-EPS contains glucuronic acid.

4.Through the detection and analysis of nuclear magnetic resonance(NMR), ST1-EPS has five sugar residues, four of which are pyranose residues in the alpha configuration and one is a pyranose residue in the beta configuration. ST2-EPS has five sugar residues, three of which are pyranose residues in the alpha configuration and two are pyranose residues in the beta configuration.

5.The results of rheological properties of EPS/WP system show that both EPSs can increase the apparent viscosity of EPS/WP system, and the rheological properties of two EPS/WP systems can be treated by different metal ions, pH and temperature. Both have a big impact but not the same.

## 5. 乳酸菌对苏尼特羊肠道菌群及肉品质的影响

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**摘要:** 反刍动物肠道菌群多样性对动物肉品质有重要的影响。本实验采用高通量测序技术分析在饲料中添加乳酸菌 (*Lactobacillus casei* HM-09、*Lactobacillus plantarum* HM-10) 对苏尼特羊肠道菌群组成及肉品质的影响。选取 3 月龄健康苏尼特羊 12 只分成 2 组, 一组饲喂基础饲料, 另一组在基础饲料中添加 0.5% 的



乳酸菌，饲养 90 天后屠宰。结果表明：在乳酸菌组肠道中厚壁菌门 (*Firmicutes*) 极显著高于对照组 ( $P<0.01$ )，疣微菌门 (*Verrucomicrobia*) 显著高于对照组 ( $P<0.05$ )，产粪甾醇真细菌 (*Eubacterium\_coprostanoligenes\_group*) 显著低于对照组 ( $P<0.05$ )；在乳酸菌组背最长肌中红度  $a^*$  值、亮度  $L^*$  值显著高于对照组 ( $P<0.05$ )，风味物质如烃类、酮类、酯类等显著高于对照组 ( $P<0.05$ )，氨基酸以及不饱和脂肪酸含量均显著高于对照组 ( $P<0.05$ )，剪切力值则显著低于对照组 ( $P<0.05$ )。整体上饲粮添加乳酸菌可以优化苏尼特羊的肠道菌群结构组成促进机体营养代谢进而改善肉品质。

## Effects of lactobacillus on intestinal flora and meat quality of Sunite Sheep

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**Abstract:** The diversity of intestinal flora in ruminants plays an important role in the quality of animal meat. In this study, high-throughput sequencing was used to analyze the effects of lactobacillus on intestinal flora composition and meat quality of Sunet lambs. Twelve 3-month-old healthy Sunite lambs were divided into two groups, one group was fed with basic diet, the other group was fed with 0.5% lactic acid bacteria (*Lactobacillus casei* HM-09, *Lactobacillus plantarum* HM-10) and slaughtered for 90 days. The results showed that in the lactobacillus group, *Firmicutes* were significantly higher than the control group ( $P<0.01$ ), *Verrucomicrobia* was significantly higher than the control group ( $P<0.05$ ), and *Eubacterium\_coprostanoligenes\_group* was significantly lower than the control group ( $P<0.05$ ). In the lactobacillus group, the reddish- $A^*$  and luminance  $L^*$  values were significantly higher than those of the control group ( $P<0.05$ ), the flavor substances such as hydrocarbons, ketones and esters were significantly higher than those of the control group ( $P<0.05$ ), the contents of amino acids and unsaturated fatty acids were significantly higher than those of the control

group ( $P<0.05$ ), and the shear force was significantly lower than that of the control group ( $P<0.05$ ). Lactobacillus added to feed could optimize intestinal flora composition of Sunit lambs, promote nutrient metabolism of the body and improve meat quality.

## 6. 乳清蛋白水解物对产胞外多糖 *L. paracasei* LX5 的促生长作用

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**摘要:** 采用三因素三水平响应面法实验优化碱性蛋白酶的水解参数。通过使用 Tricine-SDS-PAGE 电泳分析对乳清蛋白水解物(whey protein hydrolysate, WPH)进行分析。经超滤得到分子量范围分别为  $\geq 10$  kDa 和  $< 10$  kDa 的乳清蛋白水解物。将收集到的水解物分别添加到 MRS 培养基中, 对 *Lactobacillus paracasei* (*L. paracasei*) LX5 进行培养。分别进行检测活菌数及多糖产量。实验结果表明: 两个分子量范围的水解物均可促进 *L. paracasei* LX5 活菌数的增长和胞外多糖(exopolysaccharides, EPS)的产量。与添加分子量高于 10 kDa 的水解物相比, 添加分子量低于 10 kDa 的水解物, 菌株活菌数为 280.33CFU/mL, EPS 产量为 241.241mg/L, 其促生长作用及胞外多糖的产量明显高于前者。

### **Growth promotion of *Lactobacillus paracasei* LX5-producing exopolysaccharide by protein hydrolysates**

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**Abstract:** Whey protein was hydrolyzed by alkaline protease. Optimizing the technological conditions of alkaline protease by response surface method contained three factors and three levels, which was based on the single factor experiment. Whey protein hydrolysate was analysed by Tricine-SDS-PAGE electrophoresis analysis and

collected by ultrafiltration. The hydrolysates with molecular weight higher than 10 kDa and lower than 10 kDa were obtained. Two parts of hydrolysates collected were added to MRS medium respectively. The results showed that the number of living bacteria and the production of polysaccharides from *L. paracasei* LX5 were promoted by both of the hydrolysates. And the hydrolysates below 10 kDa were more effective than those above 10 kDa. The number of viable bacteria was 280.33 CFU/mL and the yield of exopolysaccharide was 241.241 mg/L in the medium supplemented with the hydrolysates below 10 kDa.

## 7. 内蒙古传统酸粥中菌株的分离及发酵过程理化指标的研究

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**摘要:** 酸粥流行于晋北地区、陕北地区以及内蒙古西部部分地区，它是一种以糜米为原料经微生物自然发酵而成的传统谷物发酵食品。本研究对内蒙古地区传统发酵酸粥中的菌株进行了分离纯化，经过镜检后，初步判断分离到乳酸菌 3 株，醋酸菌 2 株，酵母菌 3 株。同时对传统酸粥发酵过程中的理化指标进行监测，发现随着发酵的进行总酸含量不断地上升，pH 值下降，总糖含量先上升后下降，总脂肪在发酵 0-6h 含量下降，6-12h 明显上升，12-24h 明显下降，发酵 24-36h 总脂肪含量明显上升。

### Isolation of strains from traditional sour porridge in Inner Mongolia and Study on physicochemical indexes of fermentation process

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**Abstract:** Sour porridge is popular in northern Shanxi, northern Shaanxi, and parts

of western Inner Mongolia. It is a traditional grain fermented food that is naturally fermented by microorganisms using rice millet as a raw material. In this study, the strains in traditional fermented porridge in Inner Mongolia were isolated and purified. After microscopic examination, it was preliminarily determined that 3 strains of lactic acid bacteria, 2 strains of acetic acid bacteria and 3 strains of yeast were isolated. At the same time, the physical and chemical indicators of the traditional porridge fermentation process were monitored, and it was found that as the fermentation progressed, the total acid content continued to rise, the pH value decreased, the total sugar content increased first and then decreased, and the total fat content decreased at 0-6h, 6-12h obviously increased, 12-24h obviously decreased, and the total fat content of fermentation 24-36h obviously increased.

## 8. 高耐受 $Pb^{2+}$ 酵母菌抗氧化及吸附 $Pb^{2+}$ 特性的研究

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**摘要:** 随着环境污染逐渐加剧, 环境问题不断地被人们重视, 重金属对人们健康的威胁也日益突出。本试验通过对  $Pb^{2+}$  耐受浓度在 6000 mg/L 以上的异常威克汉姆酵母(*Wickerhamomyces anomalus*) QI-1-6、QI-1-7、QD-2-8 进行体外试验。结果表明, 3 株酵母菌均具有一定的抗氧化能力, 且菌悬液与无细胞提取物的抗氧化能力具有显著性差异。*W. anomalus* QI-1-7 随着 pH、吸附时间和菌体浓度增加, 吸附  $Pb^{2+}$  能力上升;  $Pb^{2+}$  初始浓度增加, 吸附  $Pb^{2+}$  能力下降; 温度增加, 吸附  $Pb^{2+}$  能力呈先上升后下降趋势。

三株异常威克汉姆酵母菌均具有一定的抗氧化应激作用, 且菌悬液和无细胞提取物的抗氧化能力不同。菌悬液清除羟基自由基、DPPH· 自由基、清除超氧阴离子和抑制脂质过氧化的能力都比无细胞提取物高。菌株 QI-1-6 菌悬液对 DPPH· 清除能力较好, 达到  $(144.72 \pm 4.53) \mu\text{g} \cdot \text{mL}^{-1}$ ; *W. anomalus* QI-1-7 菌悬液对 DPPH 自由基、羟基自由基和超氧阴离子的清除能力较好, 分别达到  $(85.09 \pm 1.11) \mu\text{g} \cdot \text{mL}^{-1}$ 、 $(240.88 \pm 7.69) \mu\text{g} \cdot \text{mL}^{-1}$ 、 $(171.41 \pm 6.92) \mu\text{g} \cdot \text{mL}^{-1}$ 。当 pH 值为 5 时, *W. anomalus* QI-1-7 对  $Pb^{2+}$  的吸附能力最强, 此时吸附率为 98.31%; 菌

体浓度为 15g/L 时, 吸附率最大为 98.75%;  $Pb^{2+}$ 浓度为 100g/L 时, 吸附率最大为 98.97%; 温度为 35℃时, 吸附率最大为 98.20%; 吸附时间为 150min 时, 菌株 QI-1-7 对重金属  $Pb^{2+}$ 的吸附能力最强, 吸附率达到最大的 98.86%。

## **Antioxidant and $Pb^{2+}$ Adsorption Characteristics of High Tolerance $Pb^{2+}$ Yeast**

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**Abstract:**With the increasing of environmental pollution, people pay more and more attention to environmental problems, and the threat of heavy metals to people's health becomes more and more prominent. An in vitro test was conducted on *Wickerhamomyces anomalus* (QI-1-6, QI-1-7, QD-2-8) at above 6000 mg/L  $Pb^{2+}$  tolerance. The results showed that all the 3 strains of yeast had certain antioxidant capacity, and the antioxidant capacity of bacterial suspension was significantly different from that of non-cell extracts. The adsorptive capacity of  $Pb^{2+}$  increased with pH, adsorption time and anomalous concentration. As the initial concentration of  $Pb^{2+}$  increases, the adsorption capacity of  $Pb^{2+}$  decreases. With the increase of temperature, the adsorption capacity of  $Pb^{2+}$  showed a trend of first increasing and then decreasing.

The three strains of *Wickerhamomyces anomalus* all had certain antioxidant stress effect, and the antioxidant ability of the bacterial suspension and the non-cell extract were different. The scavenging ability of hydroxyl radical, DPPH· radical, superoxide anion and lipid peroxidation in bacterial suspension was higher than that of the cell-free extract. The DPPH· scavenging ability of bacterial strain QI-1-6 suspension was good, reaching  $(144.72 \pm 4.53) \text{ g} \cdot \text{mL}^{-1}$ . The scavenging capacity of DPPH free radical, hydroxyl radical and superoxide anion in *W. anomalus* QI-1-7 suspension was better, which had reached  $85.09 \pm 1.11 \text{ g} \cdot \text{mL}^{-1}$ ,  $240.88 \pm 7.69 \text{ g} \cdot \text{mL}^{-1}$ ,  $171.41 \pm 6.92 \text{ g} \cdot \text{mL}^{-1}$ , respectively. At pH5, *W. anomalus* QI-1-7 had the largest adsorption capacity on  $Pb^{2+}$ , which at this time was 98.31%. When the concentration was 15g/L, the adsorption rate

was 98.75% at most. When the concentration of  $Pb^{2+}$  was 100g/L, the adsorption rate was 98.97% at most. When the temperature was 35°C, the maximum adsorption rate was 98.20%. When the adsorption time was 150min, strain QI-1-7 had the strongest adsorption capacity for heavy metal  $Pb^{2+}$ , and the adsorption rate reached 98.86%.

## 9. 戊糖乳杆菌 S1-4 所产抑菌物质的生物学特性研究

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**摘要:** 以内蒙古东部地区酸菜中分离得到的具有产抑菌活性的戊糖乳杆菌 S1-4 为供试菌, 以大肠杆菌(*Escherichiacoli*)3301 为指示菌, 采用双层琼脂扩散法对其所产抑菌物质的生物学特性进行研究。结果表明, 戊糖乳杆菌 S1-4 所产的抑菌物经木瓜蛋白酶处理后, 其抑菌活性明显降低, 但对胃蛋白酶和胰蛋白酶不敏感。该抑菌物质经热处理后, 对大肠杆菌仍保持较强的抑菌活性, 在 pH3.5~5.5 条件下, 其抑菌活性较稳定。该菌株的发酵上清液分别经部分化学试剂和紫外线照射处理后, 仍保持较好的抑菌活性。

### Characterization of antibacterial substance produced by

### *Lactobacillus pentosus* S1-4

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**Abstract:** The characteristics of antibacterial substances of *Lactobacillus pentosus* S1-4, isolated from the sourcabbage juice in the east area Inner Mongolia, were tested for *Escherichia coli* 3301 as the indicator by the double agar diffusion method. The results showed that the antibacterial activity of strain S1-4 was not destroyed after treatment with papain, but destroyed after treatment with pepsin and trypsin. This antibacterial substances of *Lactobacillus pentosus* S1-4 showed good thermal stability and stable antibacterial activity under acidic conditions in pH3.5~5.5. The inhibitory activity of

this strain fermentation supernatant was not affected by some chemical agents and ultraviolet irradiation treatment.

## 10. 蒙古马肠道微生物的分离及其功能特性的研究

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**摘要:** 本研究以采自内蒙古呼和浩特市马匹屠宰场一匹 1 岁半的公蒙古马胃肠道六个部位内容物为研究样品, 对其菌株进行分离, 并对菌株进行产胞外多糖、降解胆固醇、产 DPP-IV 抑制剂、耐酸耐胆盐、抗氧化、还原性以及疏水性试验。筛出功能特性良好的菌株, 为进一步研究蒙古马肠道中微生物的功能特性提供目的菌株和科研基础。

研究通过平板划线的方法分离纯化出 91 株菌, 包括乳酸菌 20 株, 酵母菌 31 株, 芽孢杆菌 40 株。对筛出的菌株采用苯酚硫酸法等方法进行产胞外多糖、胆固醇降解、和产 DPP-IV 抑制剂的试验, 试验筛出: MW1a、MM1、MB3、YF1a、YW4a、YF3a、YB4、LF2、LH2a、LW1 共 10 株菌具有不同程度产胞外多糖、胆固醇降解、和产 DPP-IV 抑制剂的能力。将具有以上功能特性的菌株进行耐酸耐胆盐试验、抗氧化能力试验、还原性试验以及疏水性试验。菌株 MW1a、MM1、MB3、YW4a、YB4、LH2a、LW1 具有以上功能特性, 其中菌株 YW4a 的综合能力最好, 可进行后期更深层次的研究。

### Isolation and Functional Characteristics of Intestinal Microbes in Mongolian Horse

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**Abstract:** In this study, the contents of intestinal six parts of a male Mongolian horse aged one-and-a-half-year-old collected from the horse slaughterhouse in Hohhot, Inner Mongolia were taken as the research object. Its strains were isolated, and the strains were tested for exopolysaccharides production, cholesterol degradation, DPP-IV

inhibitor production, acid and bile salt resistance, oxidation resistance, reduction and hydrophobicity tests. Strains with good functional characteristics were screened out, which provided the target strains and scientific basis for further research on functional characteristics of intestinal microbes in Mongolian horse.

In the study, 91 strains were isolated and purified, including 20 strains of lactic acid bacteria, 31 strains of yeast, and 40 strains of bacillus. The screened strains were tested for exopoly saccharides production, cholesterol degradation, and DPP-IV inhibitor production by using methods such as phenol sulfuric acid. The test screened out a total of 10 strains of MW1a, MM1, MB3, YF1a, YW4a, YF3a, YB4, LF2, LH2a, and LW1, they had the ability with different degrees of exopoly saccharides production, cholesterol degradation, and DPP-IV inhibitor production. The strains with the above functional characteristics were subjected to acid resistance bile salt resistance test, oxidation resistance test, reduction test and hydrophobicity test. Strains MW1a, MM1, MB3, YW4a, YB4, LH2a, LW1 had the above functional characteristics. Among them, the comprehensive ability of strain YW4a was the best, and deeper research in the later period can be carried out.



## **(四) 其他专题**

## 1. 食源性钙螯合肽的功能性研究

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**摘要:** 食源性螯合肽是本身具有螯合矿物质元素活性, 并可提高机体对矿物质元素生物利用度的一类肽。具有钙结合活性的肽可以提升人体对钙的吸收率。由于其具有抗氧化、控制血压、调节免疫等多种生理功能, 在功能性食品、医药品等领域展现出高度的应用潜力, 因此受到广泛关注。本文对国内外文献报道的食源性钙螯合肽的制备、分离纯化、构效关系、生物活性进行梳理总结, 以期开发新型补钙产品及为我国资源的高效利用提供新思路。

### Functional study of foodborne calcium chelating peptide

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**Abstract:** Foodborne chelating peptide is a kind of peptide which has the activity of chelating mineral elements and can improve the bioavailability of mineral elements. Peptides with calcium-binding activity can improve the absorption rate of calcium by the human body. Due to their various physiological functions, such as anti-oxidation, control of blood pressure, regulation of immunity, etc., they have shown high application potential in the fields of functional foods and pharmaceuticals, and thus have attracted wide attention. In this paper, the preparation, separation, purification and structure-activity related biological activities of food-derived calcium chelating peptides reported in domestic and foreign literatures were reviewed and summarized in order to develop new calcium supplement products and provide new ideas for the efficient utilization of resources in China.

## 2. 双峰驼血液中部分理化指标含量的测定

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**摘要:** 本试验采用液相色谱及质谱连用分析法对阿拉善双峰驼血液中氨基酸、脂肪酸和矿物质含量进行了测定。结果表明: 驼血水解后共得到 34 种氨基酸,

其中赖氨酸含量最高 ( $27.82\pm 1.86$  g/L)，其次为精氨酸 ( $23.60\pm 4.17$  g/L)，天门冬氨酸 ( $22.41\pm 1.26$  g/L)；驼血中必需氨基酸占氨基酸总含量的 41.01%，必需氨基酸与非必需氨基酸的比值为 0.69。驼血中共检出 19 种脂肪酸，其中包括生物活性成分较高的油酸、亚油酸与花生四烯酸；驼血中饱和脂肪酸占全部脂肪酸含量的 60.89%，单不饱和脂肪酸所占比例为 21.32%，多不饱和脂肪酸所占比例为 17.05%，长链脂肪酸所占比例为 47.5%，中链脂肪酸所占比例为 52.5%，奇数碳脂肪酸所占比例为 36.13%。驼血中富含人体中所需的各类矿物质，其中钠 ( $5300\pm 2300$  mg/kg) 和钾 ( $1600\pm 100$  mg/kg) 含量高于其他家畜，铜与锌比率为 0.05。

## Determination of some physical and chemical indicators of Bactrian camel blood

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**Abstract:** In this work, the contents of amino acids, fatty acids and minerals in the blood of Alxa Bactrian camel were determined by liquid chromatography and mass spectrometry. The results showed that : 34 kinds of amino acids were obtained after hydrolysis of camel blood, of which lysine was the highest ( $27.82\pm 1.86$  g/L), followed by arginine ( $23.60\pm 4.17$  g/L) and aspartic acid ( $22.41\pm 1.26$  g/L). The essential amino acids in camel blood account for 41.01% of the total amino acids, and the ratio of essential amino acids to non-essential amino acids is 0.69, which conforms to the reference protein model proposed by FAO / WHO. Nineteen kinds of fatty acids were detected in camel blood, including oleic acid, linoleic acid and arachidonic acid with higher bioactive components. The saturated fatty acids accounted for 60.89% of all fatty acids in camel blood, monounsaturated fatty acids and polyunsaturated fatty acids accounted for 21.32%, polyunsaturated fatty acids accounted for 17.05%, long chain fatty acids accounted for 47.5%, medium chain fatty acids accounted for 52.5%, odd carbon fatty acids accounted for 36.13%. Camel blood is rich in all kinds of minerals

needed by human body, among which sodium and contents were generally higher than that of other livestock, and the ratio of copper to zinc is 0.05.

### 3. 果胶-乳清蛋白混合比例和 pH 对体系流变学特性的影响

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**摘要:** 本文以果胶-乳清蛋白混合体系为研究对象, 采用 Haake RS6000 流变仪对钙离子诱导条件下, 果胶-乳清蛋白混合体系凝胶形成及流变学特性的影响因素进行研究。结果表明, 随着果胶和乳清蛋白添加量的增加, 混合体系黏度增强。在一定的乳清蛋白浓度下, 溶液随着 pH 值的增加黏度逐渐减小, 当 pH=7、乳清蛋白体系浓度 4% 时, 黏度最大 (2.304Pa·s)。果胶-4% 乳清蛋白体系能被  $\text{Ca}^{2+}$  诱导形成凝胶, 随着  $\text{Ca}^{2+}$  浓度增加, 黏度值逐渐增大, 最高值出现在 100 Mmol/L 处。果胶-4% 乳清蛋白混合体系呈现剪切稀化现象。

#### **Effects of mixture ratio and pH on the rheological properties of mixed pectin-whey protein system**

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**Abstract:** This paper aims to gain an understanding of the gelation mechanism of mixed whey protein-pectin system. The effect of whey protein (WP) concentration, pectin concentration, value of pH and  $\text{Ca}^{2+}$  on the gel formation and rheological properties of mixed pectin-whey protein system were studied by Haake RS6000 rheometer. The results showed that the viscosity of mixture decreased gradually with the increase of pH value, and reached viscosity maximum (2.304Pa·s) at pH 7. Pectin-4% WP system could be induced by  $\text{Ca}^{2+}$  to form gel. With the increase of  $\text{Ca}^{2+}$  concentration, the viscosity increased, and the highest value appeared at 100 Mmol/L.

According to the rheological characteristics, with the increase of shear rate, the viscosity of mixture decreased gradually, indicating that mixed whey protein-pectin system is pseudoplastic fluid.

#### 4. 非电解微酸性次氯酸水对青椒贮藏品质的影响

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**摘要:** 为了探究不同浓度非电解微酸性次氯酸水对青椒贮藏品质的影响, 以青椒作为原材料, 实验采用浓度分别为 20 ppm、40 ppm、60 ppm、80 ppm 的非电解微酸性次氯酸水, 浸泡时间分别为 5 分钟、20 分钟。在室温下贮藏 16 天, 并研究探讨贮藏期间青椒的失重率、色泽变化、可溶性固形物的含量、抗坏血酸的含量、叶绿素的含量、可滴定酸的含量。结果显示, 不同浓度非电解微酸性次氯酸水均可以有效抑制青椒各种品质的下降, 但是浓度为 40 ppm 可以更好减缓青椒失水萎蔫, 抑制了青椒转红的速度及其他品质的快速下降, 从而可以较好的保持青椒的品质, 延长其运输贮藏期, 减少由此带来的经济损失。

#### **Effect of non-electrolytic slightly acidic hypochlorous acid water on the storage quality of green pepper**

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**Abstract:** In order to explore the effect of non-electrolytic slightly acidic hypochlorous acid water of different concentrations on the storage quality of green pepper, green pepper as raw material, the non-electrolytic slightly acidic hypochlorous acid water of 20 ppm, 40 ppm, 60 ppm and 80 ppm was used in the experiment, soaking time is 5 minutes, 20 minutes. Storage at room temperature for 16 days, the weight loss rate, color change, soluble solid content, ascorbic acid content, chlorophyll content and

titratable acid content of green pepper during storage were studied. The results showed that different concentrations of non-electrolytic slightly acidic hypochlorous acid water can effectively inhibit the decline of various qualities of green pepper, however non-electrolytic slightly acidic hypochlorous acid water of 40ppm can better slow down the water loss and wilting of green pepper. It inhibited the speed of turning green pepper into red and the rapid decline of other qualities. Thus can keep the quality of green pepper better, prolonging the transportation and storage period, reduce the economic loss.

## 5. 黑枸杞复合果酒加工工艺探究

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**摘要:** 本实验以黑枸杞和葡萄为主要原料, 根据复合果酒的加工工艺, 添加一定量的白砂糖、柠檬酸、维生素 C 等辅料, 通过感官评定的方法, 调制出一款营养价值较高, 口感、风味、色泽、组织状态均上乘的复合果酒。考虑发酵温度、初始糖度、酵母添加量三个因素设计单因素实验确定最佳参数。通过设计正交实验得出产品原辅料的配比及产品的最优的加工条件: 黑枸杞汁和葡萄汁的复合调制比例为 7:3, 最佳发酵温度为 20°C, 最佳酵母接种量为 0.04%, 最佳初始糖度为 25%, 最适 pH 值为 4.5, 发酵 12h 后可获得酒度为 9.5%vol 的产品。

### **Research on processing technology of black wolfberry compound fruit wine**

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**Abstract:** In this experiment, black lycium ruthenium and grapes were used as the main raw materials. According to the processing technology of compound fruit wine, a

certain amount of white granulated sugar,citric acid,vitamin C and other auxiliary materials are added.Through sensory evaluation method,a nutritional value is high,taste,A complex fruit wine with superior flavor,color and texture.Single factor experiment to determine the optimal parameters considering three factors:fermentation temperature,initial sugar content and yeast addition.The optimal fermentation conditions of black lycium rutheniumm compound wine were obtained by orthogonal test:the compoosite ratio of black sap juice and grape juice was 7:3,the optimal fermentation temperature was 20°C, and the optimal yeast inoculum was 0.04%.The initial sugar content is 25%,the pH value is 4.5,and the product with the alcohol degree of 9.5% vol could be obtained after 12 hours of fermentation.

## 6. 降胆固醇亚麻籽蛋白酶解肽的分离纯化及结构鉴定

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**摘要:** 本文选择蛋白酶 Protease M 对亚麻籽蛋白进行酶解, 得到具有降胆固醇活性的亚麻籽蛋白酶解肽, 并对其进行分离纯化及结构鉴定。经 Protease M 对亚麻籽蛋白酶解至 4 h 时获得的亚麻籽蛋白酶解肽降胆固醇活性最高为 52.87%; 继续采用超滤技术将其分离为分子量 <3kDa、3-5kDa、5-10kDa、10-30kDa 和 >30kDa 的五个组分, 发现分子量 <3kDa 的组分降胆固醇活性最高为 70.96%; 再经 DA201-C 型大孔树脂对分子量 <3kDa 的组分进行吸附后经不同浓度的乙醇进行洗脱, 发现 75% 乙醇洗脱分离的组分具有最高的降胆固醇活性, 达 79.84%; 采用高效液相色谱 (RP-HPLC) 对其进一步分离纯化, 选择降胆固醇活性最高为 85.72% 的 RP-HPLC 分离组分 F9 经基质辅助激光解吸电离飞行时间质谱 (MALDI-TOF-MS/MS) 进行结构表征, 从中鉴定出四个降胆固醇亚麻籽肽, 氨基酸序列分别为 IPF、IPAF、IPPF 和 FLVIP。

## Isolation and Identification of Hypocholesterolemic Peptide Derived from Flaxseed Protein

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**Abstract:** the protease Protease M was selected for enzymatic hydrolysis of linseed protein, and the linseed proteolytic peptide with cholesterol-lowering activity was obtained, and the peptide was separated, purified and identified. The highest cholesterol-lowering activity of the linseed proteolytic peptide obtained by Protease M to linseed proteolysis for 4 h is 52.87%; continue to use ultrafiltration technology to separate it into molecular weight <3kDa, 3-5kDa, 5-10kDa, 10- For the five components of 30kDa and >30kDa, the highest cholesterol-lowering activity of the component with a molecular weight of <3kDa was found to be 70.96%; then the components with a molecular weight of <3kDa were adsorbed by DA201-C macroporous resin and then subjected to different concentrations of ethanol. After elution, it was found that the fraction separated by 75% ethanol had the highest cholesterol-lowering activity, reaching 79.84%; it was further separated and purified by high performance liquid chromatography (RP-HPLC), and RP with the highest cholesterol-lowering activity of 85.72% was selected. -The HPLC separation component F9 was characterized by matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF-MS/MS), and four cholesterol-lowering linseed peptides were identified. The amino acid sequences were IPF, IPAF, IPPF and FLVIP.

## 7. 马铃薯冲调营养粉喷雾干燥工艺的优化

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**摘要:** 本研究以马铃薯雪花粉为主要原料, 搭配乳粉、大豆蛋白和南瓜粉, 通过喷雾干燥技术制备马铃薯冲调营养粉, 并对其工艺进行优化。首先通过响应面



实验优化原料和辅料配比，最佳结果为(以 100 g 马铃薯全粉的质量为基准)：乳粉、大豆蛋白、南瓜粉分别占马铃薯全粉的 18.13%、9.06%和 8.15% (w/w)。在此基础上，通过正交试验优化助干剂和喷雾干燥工艺参数，助干剂海藻酸钠、麦芽糊精、羧甲基纤维素钠的最适添加量分为 0.3%、9%和 0.4% (w/w)，喷雾干燥的最佳工艺参数依次为进风温度 200℃、泵速为 15 r/min 和物料浓度 16% (w/v)。该条件制备的马铃薯冲调营养粉得粉率为 32.77%，水分含量为 4.57%，蛋白质含量 13.50%，氨基酸总量为 206.92mg/100g。所得马铃薯冲调营养粉营养价值高、冲调性好，可接受度强。

## Optimization of Spray Drying process for Potato Blending Nutritional Powder

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**Abstract:** In this study, potato blending nutritional powder was prepared using potato flour as the main raw material, together with milk powder, soy protein and pumpkin powder, by spray drying technology, and the technology was optimized. First of all, the ratio of raw materials and auxiliary materials was optimized by response surface methodology. The optimal result was (based on the mass of 100 g potato flour) : milk powder, soy protein and pumpkin powder accounted for 18.13%, 9.06% and 8.15%(w/w) of the potato flour, respectively. On this basis, the drying aids and spray drying process parameters were optimized by orthogonal test. The optimal addition levels of drying aid sodium alginate, maltodextrin and sodium carboxymethylcellulose were 0.3%, 9% and 0.4% (w/w). The optimal spray drying process parameters were air inlet temperature of 200℃, pump speed of 15 r/min and material concentration of 16%(w/v) in sequence. The yield of potato blending nutritional powder prepared under the above conditions was 32.77%, the water content was 4.57%, the protein content was 13.50%, and the total amino acid content was 206.92 mg/100g. The obtain potato blending nutritional powder has high nutritional value, good blending property and

strong acceptability.

## 8. 限制性酶解结合大孔树脂吸附脱色对葵花籽蛋白结构及功能特性的影响

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**摘要:** 葵花籽蛋白是一种营养价值较高的植物蛋白, 具有氨基酸组成平衡、生物效价高、过敏性低等特点, 但颜色深和较差的功能特性限制了其在食品工业中的应用。本研究采用限制性酶解结合大孔树脂吸附的方法对葵花籽蛋白进行脱色, 首先对脱色工艺进行优化, 获得颜色洁白的葵花籽蛋白, 在此基础上探讨了限制性酶解结合大孔树脂吸附脱色对葵花籽蛋白功能特性及结构的影响, 主要结论如下:

1、葵花籽蛋白最佳脱色工艺为: 采用碱性蛋白酶限制性酶解 10 min, 再用 AB-8 型大孔树脂在吸附温度 20 °C、pH 7.0、树脂添加量 12% 的条件下吸附脱色 120min, 在此工艺条件下葵花籽蛋白的白度值(L\*值)由 55.7 提高至 86.3, 由深灰色变成浅白色, 可获得颜色洁白的葵花籽蛋白。

2、进一步探讨了限制性酶解结合大孔树脂吸附脱色对葵花籽蛋白结构和功能特性的影响。限制性酶解结合大孔树脂吸附脱色后葵花籽蛋白分子量逐渐降低, 平均粒径也逐渐变小; 在电子显微镜下葵花籽蛋白由大片状、表面较紧实状逐渐变成较小的碎片状、表面呈疏松多孔状; 内源荧光呈现先增加后降低的趋势;  $\alpha$ -螺旋和  $\beta$ -转角含量显著降低,  $\beta$ -折叠和无规则卷曲含量显著增加; 此外, 限制性酶解结合大孔树脂吸附脱色后葵花籽蛋白的溶解性、乳化性及乳化稳定性、起泡性都显著提高。表明了限制性酶解结合大孔树脂吸附脱色使葵花籽蛋白分子量变小, 结构由紧实状变成松散状, 进而使其溶解性提高, 乳化性、乳化稳定性、起泡性、泡沫稳定性和持油性等功能特性得到显著改善。

## **Effect of Restriction Enzymatic Hydrolysis Combined with Macroporous Resin Adsorption and Decolorization on the Structure and Functional Properties of Sunflower Seed Protein**

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**Abstract:** Sunflower seed protein is a kind of vegetable protein with high nutritional value. It has the characteristics of balanced amino acid composition, high biological potency, and low allergy. However, its deep color and poor functional properties limit its application in the food industry. In this study, the method of restriction enzyme digestion combined with macroporous resin adsorption was used to decolor sunflower seed protein. First, the decolorization process was optimized to obtain sunflower seed protein with white color. On this basis, the restriction enzyme digestion combined with macroporous resin was discussed. The effect of adsorption and decolorization on the functional properties and structure of sunflower seed protein, the main conclusions are as follows:

1. The best decolorization process for sunflower seed protein is: use alkaline protease restriction enzyme digestion for 10 minutes, and then use AB-8 type macroporous resin to adsorb and decolorize under the conditions of adsorption temperature of 20°C, pH 7.0 and resin addition amount of 12% 120min, under this technological condition, the whiteness value ( $L^*$  value) of sunflower seed protein is increased from 55.7 to 86.3, from dark gray to light white, and white sunflower seed protein can be obtained.

2. The effect of restriction enzyme digestion combined with macroporous resin adsorption and decolorization on the structure and functional properties of sunflower seed protein was further discussed. With the increase of the degree of hydrolysis, the molecular weight of sunflower seed protein gradually decreases after the restriction enzyme digestion combined with macroporous resin adsorption and decolorization, and

the average particle size gradually decreases; under the electron microscope, the sunflower seed protein changes from a large sheet to a compact surface. Gradually become smaller fragments, with a loose and porous surface; endogenous fluorescence shows a trend of first increasing and then decreasing;  $\alpha$ -helix and  $\beta$ -turn content significantly decrease, and  $\beta$ -sheet and random curl content significantly increase; in addition, With the increase of the degree of hydrolysis, the solubility of sunflower seed protein gradually increased after restriction enzymatic hydrolysis combined with macroporous resin adsorption and decolorization, while the emulsification and emulsification stability, foaming, foam stability and oil retention first increased and then decreased. It shows that restriction enzymolysis combined with macroporous resin adsorption and decolorization reduces the molecular weight of sunflower seed protein, and the structure changes from compact to loose, thereby increasing its solubility, emulsification, emulsification stability, foaming, and foam stability. Functional properties such as performance and oil retention have been significantly improved, but too long restrictive enzymatic hydrolysis time makes the molecular weight too small and the structure is too loose. Although the solubility is significantly improved, the emulsification, emulsification stability, foamability, foam stability and retention. Functional properties such as oiliness are significantly reduced.

## 9. 不同提取方法对马铃薯果胶特性的影响

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**摘要:** 目前我国果胶的生产情况不容乐观, 不仅种类少、生产效率低, 凝胶性能也相对较差, 因此需要寻找新的果胶来源。内蒙古地区马铃薯的产量高, 加工生产后的马铃薯渣由于生产季节集中, 产量巨大且难以利用, 如果不及时处理极易腐败发酵形成恶臭。马铃薯渣的低利用率、高废弃率不仅是对生物资源的浪费, 还会造成严重的环境污染。但可以作为良好的果胶来源。本文以马铃薯渣为研究对象, 以提高薯渣的资源化利用及丰富果胶来源为目的, 将其作为生产果胶的原

料,通过不同方法提取马铃薯果胶并对所提果胶的理化性质、流变特性、结构组成及功能特性进行比较分析,研究结果如下:

(1) 分别采用酸法、酶法和盐法对果胶进行提取,得到的工艺优化结果如下:盐析法的果胶提取率最高,工艺条件为:沉析时间为 40 min,沉析温度为 50℃,沉析 pH 为 5,硫酸铝用量为 15%;酶法果胶的提取率相对较低,其工艺条件为:提取温度为 50℃,提取时间 pH 为 5,提取时间为 4 h,酶添加量为 0.5%,料液比 1:15 g/mL。

(2) 不同方法提取的马铃薯果胶其理化指标检测均符合国家标准。除酶法的果胶其组织色泽为淡黄色粉末外,其他两种方法的果胶均为白色粉末状,酶法的水分含量最高为  $11.3 \pm 0.01$ ;盐法的灰分含量最高为  $4.12 \pm 0.01$ ;不同方法提取的马铃薯果胶的 pH (25℃) 范围为 4.25~4.62,无明显差异,酯化度范围为 27.6~34.61,均为低酯果胶,其中酸法的果胶酯化度较高为  $34.61 \pm 0.01$ ,半乳糖醛酸含量均低于 65%。

(3) 通过对果胶的流变学研究得知,不同方法提取的马铃薯果胶其流体性质均为典型的非牛顿流体,机械外力对盐法的果胶影响较大,对酶法的果胶影响较小;pH、蔗糖和钙离子的添对果胶的黏度有影响,其中 pH 的改变对于酶法的果胶其黏度的影响显著( $P < 0.05$ ),蔗糖添加量对酸法的果胶的影响显著( $P < 0.05$ ),钙离子添加量对盐法的果胶的影响显著( $P < 0.05$ )。酶法的成胶性最快,而酶法和盐法这两种方法提取的果胶的凝胶性较酸法好。

(4) 分子量和单糖组成结果表明,马铃薯果胶的分子量依次为酸法 1,0240 Da,酶法 1,4593 Da,盐法 1,1669 Da。酸法的果胶主要由葡萄糖、半乳糖、阿拉伯糖以及少量的鼠李糖和木糖组成,酶法的果胶主要的单糖组成为葡萄糖和半乳糖,盐法的果胶主要的单糖组成为葡萄糖、半乳糖、阿拉伯糖。

(5) 通过红外光谱和 SEM 扫描电镜对果胶结构进行检测,结果表明,三种方法提取的马铃薯果胶均含有多糖吸收峰,其结构中存在吡喃糖单元并且同时含有  $\beta$ -糖苷键, $\alpha$ -糖苷键。不同方法制备的马铃薯果胶结构存在明显差异,果胶提取剂的性质和沉析方式会影响果胶的结构。

(6) 通过测定果胶的抗氧化活性与市售柑橘果胶对比,结果表明,不同方法制备的马铃薯果胶的 DPPH 自由基清除率、羟自由基清除率和超氧阴离子清

除率均高于市售柑橘果胶，果胶的超氧阴离子清除能力均不高，其中盐法的果胶的羟基自由基清除能力和超氧阴离子清除能力高于其他两种方法，酸法的 DPPH 自由基清除能力高于其他两种方法，但差异不显著。

### **Study on Effects of extraction methods on characteristics of potato pectin**

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**Abstract:** At present, the production situation of pectin in China is not optimistic. It is not only of few types, low production efficiency, but also relatively poor gel properties. Therefore, it is necessary to find new pectin sources. The potato production in Inner Mongolia is high. The residue produced after processing is very large and difficult to use due to the concentration of production seasons. If it is not treated in time, it is easy to putrefy and ferment to form malodor. The low utilization rate and high waste rate of potato residue not only waste biological resources, but also cause serious environmental pollution. But it can be used as a good source of pectin. In this paper, potato residue is taken as the research object, in order to improve the resource utilization of potato residue and enrich the pectin source, it is taken as the raw material for pectin production, potato pectin is extracted by different methods, and the physicochemical properties, rheological properties, structural composition and functional properties of the extracted pectin are compared and analyzed. The research results are as follows:

(1) Pectin was extracted by acid method, enzyme method and salt method respectively, and the optimized results were as follows: the extraction rate of pectin by salting-out method was the highest, and the technological conditions were as follows: precipitation time was 40 min, precipitation temperature was 50°C, precipitation pH was 5, and aluminum sulfate dosage was 15%; The extraction rate of pectin by enzymatic method is relatively low. The technological conditions are as follows: extraction temperature is 50°C, extraction time pH is 5, extraction time is 4h, enzyme addition amount is 0.5%, and solid-liquid ratio is 1:15 g/mL.

(2) The physical and chemical indexes of potato pectin extracted by different

methods meet the national standards. Except the pectin by enzymatic method, its tissue color is light yellow powder, the pectin by other two methods is white powder, and the highest moisture content by enzymatic method is  $11.3\pm 0.01$ ; The highest ash content of salt method is  $4.12\pm 0.01$ . The pH(25°C) of potato pectin extracted by different methods is in the range of 4.25~4.62, with no obvious difference. The esterification degree is in the range of 27.6~34.61, all of which are low ester pectin. The esterification degree of pectin by acid method is higher than  $34.61\pm 0.01$ , and the content of galacturonic acid is lower than 65%.

(3) Through the rheological study of pectin, it is known that the fluid properties of potato pectin extracted by different methods are typical non-Newtonian fluid. Mechanical external force has greater influence on pectin extracted by salt method and less influence on pectin extracted by enzyme method. The addition of pH, sucrose and calcium ions has an effect on the viscosity of pectin, among which the change of pH has a significant effect on the viscosity of pectin by enzymatic method ( $P<0.05$ ), the addition of sucrose has a significant effect on pectin by acid method ( $P<0.05$ ), and the addition of calcium ions has a significant effect on pectin by salt method ( $P<0.05$ ). Enzymatic method has the fastest gelling property, while enzymatic method and salt method have better gelling property than acid method.

(4) The molecular weight and monosaccharide composition showed that the molecular weight of potato pectin was 1,0240 Da by acid method, 1,4593 Da by enzyme method and 1,1669 Da by salt method. Acid pectin is mainly composed of glucose, galactose, arabinose and a small amount of rhamnose and xylose. Enzymatic pectin is mainly composed of glucose and galactose. Salt pectin is mainly composed of glucose, galactose and arabinose.

(5) The structure of pectin was detected by infrared spectrum and SEM scanning electron microscope. The results showed that the potato pectin extracted by the three methods all contained polysaccharide absorption peaks, and the structure contained pyranose units as well as  $\beta$ -glycosidic bonds and  $\alpha$ -glycosidic bonds. The structure of potato pectin prepared by different methods is obviously different. The properties of

pectin extraction agent and precipitation method will affect the structure of pectin.

(6) The antioxidant activity of pectin was measured and compared with that of commercially available citrus pectin. The results showed that DPPH radical scavenging rate, hydroxyl radical scavenging rate and superoxide anion scavenging rate of potato pectin prepared by different methods were higher than those of commercially available citrus pectin, and the superoxide anion scavenging capacity of pectin was not high. Among them, hydroxyl radical scavenging capacity and superoxide anion scavenging capacity of pectin prepared by salt method were higher than those of other two methods, while DPPH radical scavenging capacity of acid method was higher than those of other two methods, but the difference was not significant.

## 10. 苹果山楂复合果酒加工工艺探究

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**摘要:** 本实验的原料为苹果和山楂, 配料为白砂糖, 柠檬酸等, 依据复合果酒的加工工艺, 对苹果山楂复合果酒的加工工艺进行探究。通过感官评定的方法, 调制出一款具有保健功效, 口味纯正, 果香浓郁的复合果酒。选择发酵温度、初始糖度、酵母菌添加量、pH 值四个主要因素设计单因素试验来确定最佳参数。通过设计正交实验推断出产品质量最好时的加工条件: 最佳发酵温度为 25°C, 0.015% 为最合适酵母添加量, 最佳初始糖度为 24%, 最适 pH 值为 4.5。

### **Research on Processing Technology of Apple and Hawthorn Compound Fruit Wine**

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**Abstract:** The raw materials of this experiment are apple and hawthorn, and the



ingredients are white granulated sugar, citric acid, etc. According to the processing technology of compound fruit wine, the processing technology of apple haw compound fruit wine is explored. Through the method of sensory evaluation, a compound fruit wine with health care effect, pure taste and rich fruit aroma is prepared. The single factor experiment was designed to determine the best parameters by selecting four main factors: fermentation temperature, initial sugar content, yeast addition and pH value. By designing orthogonal experiments, we can infer the processing conditions when the product quality is the best: the optimal fermentation temperature is 25 °C, 0.015% is the most suitable yeast addition, the optimal initial sugar content is 24%, and the optimal pH value is 4.5.

## 11. 蒙菊花茶中黄酮提取工艺优化及其抗氧化性的研究

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**摘要:** 对蒙菊花茶的黄酮提取工艺进行优化, 并对其黄酮提取液的功能特性进行探讨。结果表明, 蒙菊花茶最优黄酮提取条件是料液比为 1:80 g/mL, 乙醇浓度为 60%, 提取时间为 1 h, 提取温度为 70°C。该提取条件下的黄酮含量为  $13.68 \pm 0.38\%$ 。蒙菊花茶的黄酮提取液具有一定的抗氧化活性与降尿酸功能, 其黄酮提取液在 10 mg/mL 时 DPPH·清除率 ( $88.58 \pm 1.81\%$ )、·OH 清除率 ( $62.73 \pm 1.05\%$ ) 和还原力 ( $2.58 \pm 0.03$ ) 最强; 蒙菊花茶黄酮提取液的 XOD 抑制率为  $64.79 \pm 1.01\%$ , 说明蒙菊花茶具有较好的抗氧化性及降尿酸功能。

### Optimization of Flavonoid Extraction Process and Functional Properties in Mongolian Chrysanthemum Tea

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**Abstract:** In this paper, the flavonoid extraction process of Mongolian chrysanthemum tea was optimized, and the functional properties of its flavonoid extract were discussed. The results are as follows: The ratio of material to liquid is 1:80 g/mL, the concentration of ethanol is 60%, the extraction time is 1 h, and the extraction temperature is 70°C. The flavonoid content under the extraction conditions was  $13.68\pm 0.38\%$ . The flavonoid extract of Mongolian chrysanthemum tea has certain antioxidant activity and uric acid-lowering function. Its flavonoid extract has the strongest DPPH· clearance rate ( $88.58\pm 1.81\%$ ), ·OH clearance rate ( $62.73\pm 1.05\%$ ) and reducing power ( $2.58\pm 0.03$ ) at 10 mg/mL. The XOD inhibition rate of flavonoid extract of Mongolian chrysanthemum tea was  $64.79\pm 1.01\%$ . The results showed that Mongolian chrysanthemum tea has better antioxidant and uric acid-lowering functions.

## 12. 降胆固醇亚麻籽肽提取工艺优化

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**摘要:** 高脂血症是引发动脉粥样硬化和冠心病等心血管疾病的主要因素, 降低人体血浆胆固醇水平是主要的防治手段, 抑制胆固醇吸收是预防高脂血症发生的重要途径。本文对亚麻籽中提取的肽进行研究, 优化了其酶解工艺并进行了分级制备。

采用 Protease M 水解亚麻籽分离蛋白制备亚麻籽降胆固醇活性肽, 通过单因素实验和正交实验确定最佳制备工艺。采用超滤技术对最佳酶解工艺下制备的亚麻籽酶解物进行分离, 并进行降胆固醇活性评价。结果表明: 最佳制备工艺条件为: 加酶量 1.5%、底物质量分数 2.0 %、酶解温度 50°C、酶解时间 3h, 在此条件下酶解肽的胆固醇胶束溶解度抑制率为 53.19%; 分子量分布显示 $\leq 1\text{kDa}$  组分所占百分比最高, 达 65.54%; 超滤分离结果显示相对分子质量 $\leq 1\text{kDa}$  的组分降胆固醇活性最强, 胆固醇胶束溶解度抑制率达 72.39 %; 氨基酸分析结果表明, 超滤后分子量  $\leq 1\text{kDa}$  组分的总疏水性氨基酸含量较超滤前提高了 15.97 %, 赖氨酸/精氨酸的比值明显低于超滤前, 这可能是其降胆固醇活性强于超滤前的主

要原因。

## **Optimization of extracting technique of the Cholesterol-lowering Effect of Flaxseed Peptide**

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**Abstract :** Hyperlipidemia is the main factor for cardiovascular diseases such as atherosclerosis and coronary heart disease. Reduction of blood lipid level is the main method to prevent hyperlipidemia. The important strategy of reducing the plasma cholesterol level is regarded as lowering cholesterol. In the experiment, the enzymolysis process of flaxseed peptide was optimized and graded preparation was carried out. Then this study investigated the effect and mechanism of the inhibition of flaxseed peptide, to evaluation of the Cholesterol absorption inhibiting ability of flaxseed peptide with cholesterol-lowering experiment in vitro. The preparation of flaxseed cholesterol lowering peptide by hydrolysis of flaxseed protein isolate with proteasem was studied. The optimal preparation process was determined by single factor experiment and orthogonal experiment. The enzymatic hydrolysate of flaxseed was separated by ultrafiltration technology and its cholesterol lowering activity was evaluated. The results showed that the optimum preparation conditions were as follows: 1.5% of enzyme, 2.0% of substrate, 50 °C of enzymolysis temperature and 3 hours of enzymolysis time. Under these conditions, the inhibition rate of cholesterol micelle solubility (cmsir) of enzymolysis peptide was 53.19%, and the percentage of components with molecular weight distribution of  $\leq 1\text{kDa}$  was the highest, reaching 65.54%. The ultrafiltration separation results showed that components with relative molecular mass  $\leq 1\text{kDa}$  have the strongest cholesterol-lowering activity, and the inhibition rate of cholesterol micelle solubility is 72.39%. The amino acid analysis results showed that the total hydrophobic amino acid content of the components whose molecular weight was less than or equal to 1 kDa after ultrafiltration was 15.97%

higher than that before ultrafiltration, and the ratio of lysine to arginine was lower than that before ultrafiltration significantly, which may be the main reason why the cholesterol lowering activity of the components was stronger than that before ultrafiltration.

### 13. 复合生物可食性保鲜剂对冷却驴肉保鲜效果及货架期的研究

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**摘要:** 本文以冷却驴肉为研究对象, 筛选了延长冷却驴肉货架期及保鲜效果的复合生物可食性保鲜剂浓度配方。分析了冷却驴肉的优势菌相, 主要为肠杆菌(*Enterobacterium*)、酵母菌(*Yeasts*)、乳酸菌(*Lactobacillus*)和微球菌(*Micrococcus*), 根据菌属特性选用聚赖氨酸(polylysine, PL)、乳酸链球菌素(Nisin)、壳聚糖(Chitosan)、D-异抗坏血酸钠(D-sodium erythorbate)为复合生物可食性保鲜剂保鲜成分。设计正交实验(L<sub>9</sub>(3<sup>3</sup>))筛选保鲜剂最佳浓度配比, 检测冷却驴肉在第0天到第18天的储藏期内菌落总数(TNC)、挥发性盐基氮(TVB-N)、pH、感官品质, 并观察其肌肉组织微观结构, 以验证所用保鲜成分对冷却驴肉肌肉组织的影响。结果表明, 在聚赖氨酸浓度为0.02%、乳酸链球菌素浓度为0.06%、壳聚糖浓度为1.5%、D-异抗坏血酸钠浓度为0.1%的条件下, 保鲜剂能够有效抑制微生物生长, 保鲜效果最佳, 稳定产品品质并使货架期达到18天及以上。

#### Study on the effect and Shelf life of compound bioedible preservative on cooling Donkey meat

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**Abstract:** In this paper, the concentration formula of compound bioedible preservative was selected to prolong the shelf life and keep fresh of cooled donkey meat. Analyzes on the advantages of the cooled meat bacteria, mainly for *Enterobacterium*, *Yeasts*,

*Lactobacillus* and *Micrococcus*, according to the bacterial characteristics choose polylysine, streptococcus, chitosan, D-sodium erythorbate for composite biological fresh ingredients are edible fresh-keeping agent. Orthogonal experiment ( $L_9(3^3)$ ) was designed to screen the optimal concentration ratio of preservative, detect the total number of colony (TNC), volatile basic nitrogen (TVB-N), pH, and sensory quality during the storage period from day 0 to day 18, and observe the microstructure of the muscle tissue, so as to verify the effect of the preservative ingredients used on the muscle tissue of the cooled donkey meat. The results showed that under the conditions of 0.02% polylysine concentration, 0.06% streptococcus concentration, 1.5% chitosan concentration and 0.1% D-sodium erythorbate concentration, the preservative agent could effectively inhibit microbial growth, maintain the best preservation effect, stabilize product quality and make the shelf life reach 18 days or more.