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复配食用胶在肉制品加工过程中的应用研究进展

Research progress on application of compound edible gum in meat products

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摘要:综述了复配食用胶在肉制品加工过程中的应用及其对肉制品品质影响的研究进展。复配食用胶在肉制品加工过程中应用,具有蛋白保护、凝胶保水、乳化稳定、品质提升、覆膜保鲜等作用,对肉制品品质的改善具有积极作用,但食用胶的种类和复配比例,以及其对改善肉制品品质的作用机理仍有待进一步深入研究。

关键词:复配食用胶;肉制品;研究进展

Abstract: The application of compound edible gum in meat processing and its effect on the quality of meat products were reviewed. The compound edible glue plays an important role in protein protection, gel water, emulsion stability, quality improvement and preservation. However, the proportion of species and distribution of edible gum and its action mechanism of improving the meat quality remains to be further studied.

Keywords: compound edible glue; meat products; progress

目前世界上肉制品种类丰富,主要包含香肠、丸子、肉糜脯等产品[1]。在肉制品中添加食用胶可以提高肌原纤维蛋白的功能特性,稳定挥发性风味物质[2-3]。食用胶又称亲水胶体,大多为多糖类物质[4],少部分为蛋白质的大分子物质[5],可溶于水,是一种在一定条件下可充分水化形成黏稠、滑腻或胶冻溶液的大分子物质。按照来源的不同,可分为天然亲水胶体和人工合成亲水胶体两类[6]。世界上允许使用的食用胶种类约为 60 种,中国允许使用的约为 40 种,其同时具有保护食品中的生物活性物质,产生抑菌作用[7],调节肠道能力,作为靶向药物等多种功能[8]。但添加单一胶体效果并不明显且具有局限性,复配胶可以产生协同效应,改善胶体凝胶效果,提升胶体机械强度[9-11]。相比于单一胶体,添加复配胶会使肉制品更加具有弹性和咀嚼性[12],并具有延长肉制品货架期等作用[13-14]。复配胶的适用范围较广,凝胶效果好,在工业化生产中,可以减少其他添加剂的添加量,降低生产成本[15-16]。在肉制品中添加复配食用胶可以起到凝胶保水、保护蛋白质、稳定混合分散体系的作用,还可以作为被膜剂,覆盖于肉制品表面[17],提升肉制品品质。文章拟综合分析近年来国内外有关复配食用胶在肉制品加工过程中的应用研究进展,为复配食用胶在肉制品加工中的应用提供参考。

1　复配胶对肉制品蛋白质的保护作用

食用胶的分子结构中含有强离子性基团,可与蛋白中氨基酸极性部分发生反应,将水溶蛋白、盐溶蛋白及后添加的其他蛋白更有效地结合在食用胶形成的凝胶体系中[18]。有研究[19]发现将黄原胶和魔芋胶复配可以促进分子间有序聚集蛋白质链的展开,改变蛋白质内部的微观结构,形成更加致密有序且牢固的网络凝胶结构,提高蛋白质与胶体联合的抗性作用,即使经过高温处理之后,凝胶结构能够很好的保持。表 1 中简单对比了几种单胶与复配食用胶在肉制品中保护蛋白质作用。

综上所述,在肉制品中添加复配胶可以增强胶体中的离子基团与蛋白质结合能力,保护蛋白结构,从而使蛋白质更好地留存于肉制品中,提升肉制品品质。从保护肉中蛋白质方面考虑,复配胶应用时应减少黄原胶的添加量,避免蛋白质在空间结构中析出。但复配胶对蛋白的保护机理还有待深入研究。

2　复配胶对肉制品凝胶的保水作用

食用胶体含有大量的亲水基团,通过氢键、诱导偶极、分子偶极和瞬间偶极等作用与水分子形成不易自由运动的大分子,在加热等过程中可以直接与周围的水分和蛋白质相互作用,提高分子间的键合作用有利于形成

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有序、稳定的空间三维网络结构,从而使肉糜制品具有良好的保水性[18]。周凤超等[4]、Wang 等[27]的试验也证明了复配后的胶体不易破碎,胶体间会产生更多的强阴离子性硫酸酯性基团,可以形成更多的氢键,氢键基团连接更加致密,空间结构均匀,结合更多的游离水以提高肉糜的保水性。Fan 等[28]通过试验发现复配胶体间亲水基团作用力增强,可以使水分更好地锁在肉糜中。汤嘉慧等[29]发现在鱼肉糜中加入复配 x-卡拉胶,凝胶可以与鱼糜中的肌原纤维蛋白发生交联从而强化鱼糜凝胶网络,使凝胶体结构变得光滑且均匀致密,从而提高肉糜的保水性。表 2 中列举了几种食用胶复配对肉制品凝胶保水作用的应用。

3　复配胶对肉制品的乳化稳定作用

食用胶复配后黏度增加,体系中的分散相不易发生聚集,因而可以使分散体系稳定。将其添加到肉制品中,可以起到表面活性剂的作用,可以降低体系表面的张力以达到乳化稳定的功能[4]。周凤超等[4]发现黄原胶、瓜尔豆胶复配可以在乳化体系中形成更强的静电作用,提高乳化稳定性。Pavan 等[41]通过试验发现瓜尔豆胶、黄原胶复配大大减缓了絮凝形成和相分离速度,增加了黏度,减少了液滴的运动,从而使乳化肉糜更稳定,但从肉中脂质氧化指标来看,复配胶体与单胶影响效果大体相同,应进行更长时间的脂质氧化测量,来确定允许添加复配胶的最佳浓度。Qiu 等[42]发现复配食用胶能够吸附到蛋白包覆的脂滴上,并形成一层厚的带电界面层,增加了水滴之间的空间和静电排斥力,提高乳化溶液的稳定。Bai 等[43]研究确定阿拉伯树胶和甜菜果胶复配具有较高的表面活性和较低的表面负荷,从而使界面张力较低,乳液黏度增大,具有良好的稳定性。Wang 等[44]发现果胶、黄原胶和瓜尔胶可以防止胶体混浊,提高乳化稳定性。表 3 中简单列出几种食用胶复配在肉制品乳化稳定作用的应用。

总之,食用胶复配可以提高分子间静电作用,尤其是复配黄原胶这种电负性食用胶,从而提高黏度,降低分子直径,使肉制品乳化作用更加稳定。但复配胶体对脂质氧化的影响有待深入研究,以便选择更好的复配胶体种类及用量。

表 1　食用胶对肉中蛋白质保护作用

Table 1　Protective effect of edible glue on protein in meat

种类	研究对象	优点	缺点	文献来源
卡拉胶	虾蛄肉糜	有效地将蛋白结合在卡拉胶形成的胶体体系中,使得凝胶特性呈良好趋势	温度超过 70 ℃效果才较显著	[20]
瓜尔豆胶	羊肉糜	可代替肉中部分脂肪	后期氧化程度较高,蛋白质损失严重,缩短了货架期	[21]
黄原胶	猪肉	肌原纤维蛋白的高压结构修饰增强了蛋白与黄原胶的相互作用	肌原纤维蛋白与黄原胶之间的复合物形成,干扰了高压对蛋白质二级和三级结构的影响	[22]
可然得胶、卡拉胶、黄原胶	猪肉	凝胶强度在 $m_{可然得胶}:m_{卡拉胶}=7:3$ 和 $m_{可然得胶}:m_{黄原胶}=5:5$ 时达到最大,比空白组分别提高了 83.34%和 88.28%,确定食用胶能与肌原纤维蛋白分子发生相互作用,将蛋白有效地结合在复配胶形成的胶体体系内,提高蛋白凝胶的质构特性,蛋白质间形成明显交联	黄原胶添加过多会导致凝胶强度降低,凝胶网络结构变差	[18]
可然得胶、魔芋胶	鱼肉糜	逐步开始和蛋白发生交联,有效阻止因变性而产生的聚集反应		[23]
瓜尔豆胶、黄原胶	猪肉	复配胶之间相互作用力加大,并且与蛋白分子间的作用力也增加,复配胶的添加导致乳化肉糜界面的蛋白质含量增加		[24]
魔芋胶、卡拉胶	鸡肉糜	复配胶抑制蛋白质氧化效果最好,凝胶强度增加		[25]
卡拉胶、寡糖	虾肉糜	卡拉胶寡糖对肌球蛋白和肌浆蛋白的结构有明显的保护作用,加强蛋白质聚集,抑制蛋白质氧化和羰基形成		[26]

表 2 食用胶对肉制品凝胶保水作用

Table 2 Water retention effect of edible gelatin on meat products

种类	研究对象	优点	缺点	文献来源
卡拉胶	猪肉糜		总压出汁液率变化不大，肉糜结构不紧致	[30]
结冷胶	鸡肉		随着水和结冷胶含量的增加，鸡肉面糊中更容易流动的水组分增加	[31]
亚麻籽胶、黄原胶、卡拉胶	牛肉	3 种食用胶两两复配后，样品的水分活度显著高于对照组，其中黄原胶与卡拉胶的复配效果最好	食用胶会降低牛肉的 a^* 值，导致酱牛肉色泽劣变	[32]
亚麻籽胶、瓜尔豆胶、魔芋胶	猪肉糜	胶体间的亲水基团更好地束缚住水分子，避免流失，亚麻籽胶添加量 0.50%、瓜尔豆胶添加量 0.40%、魔芋胶添加量 0.65%，所得猪肉肠出品率 98.97%、保水率为 90.26%、感官评分为8.14，产品弹性较好		[33]
魔芋胶、卡拉胶、黄原胶	猪肉	食用胶在凝胶形成过程中可以吸收体系中过多的游离水，因此常被用来提高肉制品的保水性。3 种亲水胶体都具有良好吸水性，彼此之间具有很强的协同增效作用，复配胶形成网络结构并填充在咸蛋清蛋白与肌肉蛋白形成的凝胶网络结构中，从而提高肉糜的持水能力。由肉糜制品的各种指标分析结果，确定复配胶的添加量 0.5%较为合适		[34]
卡拉胶、魔芋胶、瓜尔豆胶	猪肉糜	促进胶体形成网络结构，将水分更好地锁在三维网络中，给水分扩散造成阻力，提高了腊肠的保水性，但同时也延长了腊肠的干燥时间		[35]
魔芋胶、卡拉胶	驴肉	$m_{魔芋胶}$: $m_{卡拉胶}$ 为 1 : 4 时，两者协同效果最好，驴肉冻的弹性、咀嚼性、硬度达到最高。采用两种胶体复配的方法可改善传统肉皮冻常温下易析水、口感差的缺点，减少食用胶的使用量，提升产品品质		[36]
卡拉胶、瓜尔豆胶、刺槐豆胶	牛肉糜	复配胶总添加量为 0.8%的条件下，卡拉胶、刺槐豆胶、瓜尔胶的最佳比例分别为 0.47%，0.18%，0.15%，牛肉丸的持水性随复配胶添加量的增加显著增加		[37]
明胶、卡拉胶	鱼肉		两者复配后，凝胶持水率降低，尤其是配比为 7 : 3 时。这可能与体系中卡拉胶含量低，卡拉胶和明胶的相互作用会阻碍各自的螺旋聚集，造成凝胶网络结构形成不够密集有关	[38]
黄原胶、结冷胶、刺槐豆胶	牛肉糜	复配组明显提高牛肉饼的持水性，降低蒸煮损失率，减小牛肉饼的吞咽难度	但黄原胶添加过多，会使肉饼形状和外观较差	[39]
魔芋胶、卡拉胶	猪肉	魔芋粉本身具有较强的水结合能力，复配后在肉糜生产中对蛋白质凝胶化和水结合具有协同作用，魔芋粉与卡拉胶相互作用强烈，相互作用产生强大的弹性凝胶，其断裂强度比单独的卡拉胶高 4 倍		[40]

表 3　食用胶对肉制品乳化稳定作用

Table 3　Emulsifying and stabilizing effect of edible glue on meat products

种类	研究对象	优点	缺点	文献来源
明胶	牛肉糜		乳化稳定改善效果并不明显	[45]
刺槐豆胶(0.5%)、黄原胶(0.6%)	猪肉糜	使凝胶和脂肪的分离率更低，稳定性更好，提高了产品的出品率		[46]
可得然胶、魔芋胶	鱼肉糜	凝胶网络骨架的丝纤维更加致密和纤细，提高了凝胶的乳化稳定性		[23]
卡拉胶、褐藻胶	鸡肉肠	分子间相互作用，形成了更致密的三维空间结构，从而提高了复乳凝胶的热稳定性		[47]
卡拉胶、亚麻籽胶、黄原胶、魔芋胶	猪肉	低盐浓度下，胶体复配可以提高肌原纤维蛋白—食用胶混合物的乳化能力和凝胶的硬度、保水性		[48]

4　复配胶对肉制品品质的改善作用

复配胶除了能提高肉制品保水性，降低蒸煮损失外，还可以通过降低脂肪含量、减少食盐用量等改善肉制品品质。周士琪等[47]发现复配胶可作为脂肪替代物应用在鸡肉肠中，鸡肉肠中的脂肪含量随食用胶添加量的上升显著降低，在添加量为 60%时，脂肪替代效果最好，为脂肪替代物的进一步研究提供了理论依据。Zhao 等[49]发现在腌制肉糜时添加复配胶，可减少盐的用量，提高肉制品的品质，并使肉制品变得更加安全健康。此外，在肉制品中添加复配胶，可以使肉制品中蛋白质更好地结合，改善肉制品的品质特性，有利于肉制品工业的发展[50−52]。表 4 中简单列举了几种食用胶复配对肉制品品质改善作用的应用。

可见复配胶可以作为脂肪替代物，降低肉中脂肪含量，还可以减少食盐的添加量，为部分特殊人群提供更多的食用肉制品的选择。但目前中国关于复配胶添加对肉制品中风味物质的影响研究较少。

5　复配胶作为肉制品被膜剂的抑菌保鲜作用

食用胶可在肉制品表面与酸类物质、防腐剂共同作用，形成被膜剂，保护肉制品免受微生物、氧气的侵袭，达到防腐保鲜的作用[57−58]。复配胶作为肉制品被膜剂，可以使薄膜结构更均匀，抑制性能更好，有更好的隔水性、透明度和较快的溶解速度，从而得到更高质量的薄膜[59−60]，使其在肉制品中应用更广泛。Marwa 等[61]在干腌肉制品表面添加复配胶与壳聚糖制成的可食用膜，起到了明显的抗氧化作用和抑菌作用。复配胶可代替传统涂层，改善产品风味和外观。Cetinkaya 等[62]通过复配明胶和黄原胶，经过两步乳化法，确定复配食用胶制成的膜提高了保水性，降低了膜硬度，为肉制品保鲜应用提供了新的方式。表 5 中对目前食用胶复配作为被膜剂在肉制品保鲜中的应用进行简单介绍。

总而言之，复配胶制成被膜剂用于肉制品中，可以更好地起到抑制微生物，隔绝氧气，避免水分流失的作用，

表 4　食用胶对肉制品品质改善

Table 4　Edible glue improves the quality of meat products

种类	研究对象	优点	缺点	文献来源
魔芋胶 卡拉胶 黄原胶	鸡肉		随着食用胶浓度的增加而下降 凝胶回复性较低，成型度不好 随浓度变化不明显	[53]
卡拉胶、果胶	牛肉糜	复配胶的加入降低了苯乙醛、醛缩产物等美拉德反应中间体的含量。卡拉胶可以通过捕获肌酐和苯乙醛来抑制 PhIP(吡啶)的形成	卡拉胶与肌酐、卡拉胶与苯乙醛之间形成的加合物的结构值得进一步研究	[54]
卡拉胶、果胶	猪肉糜	通过这种方法获得的法兰克福香肠显示出 10%的脂肪，即与对照组(正常动物脂肪含量)相比减少了 50%，加工损失更少		[55]
卡拉胶、魔芋胶、黄原胶	牛肉糜	PhIP 降低了 90%以上、80%以上和 70%以上。脂肪含量明显降低，且咀嚼性较好		[56]

表 5 食用胶作为肉制品被膜剂保鲜

Table 5 Edible glue is used as a film to keep meat products fresh

种类	研究对象	优点	缺点	文献来源
明胶	鱼肉糜	抗氧化性较好,可以起到保鲜抗菌作用,将产品货架期延长 5 d 左右	涂膜的弹性厚度有待改善,成本较高	[63]
果胶、明胶	牛肉	果胶,明胶可食膜中以硫代巴比妥酸反应物质(TBARS)形式生成的氧化产物减少		[64]
黄原胶、卡拉胶	虾肉糜	确定其保质期可延长 4 d 左右,且能降低虾肉产生黑边病的概率		[65]
魔芋胶、卡拉胶	鸡肉糜	抑制鸡肉脂肪和蛋白质的氧化,抑制肉中微生物生长,显著延长了货架期,并保持肉制品气味良好,提高了消费者接受度		[25]
果胶、黄原胶	猪肉糜	更好地阻止肉制品与环境中水分交换,达到延长保质期的目的		[66]

复配胶被膜剂还具有更柔软的外观和质地,能够更好地为消费者接受,具有很好的发展前景。如何降低复配被膜剂的生产成本,降低脆性,改善其气味还有待研究。

6 总结与展望

食用胶复配可以增强分子间的键合作用,形成更稳定的空间体系从而对肉制品起到保护蛋白、提高凝胶保水性和乳化稳定性的作用,同时还可以替代部分脂肪,减少盐类添加量,提升肉制品品质,满足人们对健康的要求,复配胶还可作为肉制品被膜剂具有更好的抑菌保鲜作用,具有很好的应用前景。

目前食用胶的来源更加广泛,可添加到肉中的种类也在增加,因为其理化性质及功能性质的差异,明确复配胶产生协同作用的作用机理以及比例是今后的主要研究方向,添加复配胶对部分肉制品产生的色泽或形状的不良影响也有待改善,以便食用胶复配在肉制品中能大众化应用。

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(上接第 231 页)

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