Effects of preprocessing on the springness and rehydration of freeze-dried *Elopichthys Bambusa* fillets

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Abstract: *E. bambusa* fillets were freeze-dried to 36% moisture content after preprocessing by adding different concentration of salt and vinegar. The spingness of *E. bambusa* fillets was measured by Texture Analyzer,and the rehydration rate of them was evaluated by gravimetric method. The result demonstrated that vinegar content had no significant effect on the springness of *E. bambusa* fillets(p>0.05),while the highest springness value(0.925±0.001) for *E. bambusa* fillets was observed in 6%(w/v) salt solution concentration. However,the rehydration rate value of *E. bambusa* fillets was increased with increasing vinegar content up to 4%(v/v),after which a decrease trend was observed. Similar variation tendency was detected in salted *E. bambusa* fillets as well,and the highest rehydration rate value was 2.34%±0.01% in this experiment. Results of three levels of two-factor demonstrated that the springness and rehydration rate were (0.93±0.01) and 2.32%±0.02% respectively,pH was 5.53±0.01,total bacteria colony (TBC) was 6.5×10^{5}cfu/g,NaCl% was 3.86% under be preprocessed in 3% vinegar and 5% salt,which verified that we could get a kind of low salt food with good quality under these circumstance.

Key words: *Elopichthys Bambusa*(*E. Bambusa*);preprocessing;springness;rehydration rate

预处理对冻干鳜鱼片弹性和复水率的影响

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摘　要: 采用不同浓度的盐和醋对鳜鱼片进行预处理,冻干至水分含量为36%。通过质构仪测定分析了不同预处理条件下鳜鱼片的弹性变化,通过重量法分析了鳜鱼片的复水率变化。结果表明,醋对鳜鱼片的弹性影响没有显著差别(p>0.05),6%(w/v)的盐溶液处理后的鳜鱼片弹性最大,为(0.925±0.001);4%(v/v) 的醋溶液、6%(w/v)的盐溶液处理后的鳜鱼片复水率达到最高值,分别为2.03%±0.01%、2.34%±0.01%。两因素三水平实验结果表明,3%醋、5%盐浓度预处理的鱼片弹性和复水率分别为(0.93±0.01)、2.32%±0.02%,pH为5.53±0.01,菌落总数为6.5×10^{5}cfu/g,氯化钠含量为3.86%,表明这是一种品质较好的低盐制品。

关键词: 鳜鱼,预处理,弹性,复水率
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E. bambusa is a large carnivorous pelagic fish widely distributed in China. It grows fast,and the size is large with high quality meat. Such that,*E. bambusa* is believed to be a potential species for commercial production. As we know,cured fish is a kind of traditional aquatic product with unique flavor and popular demand in China. Adding salt(sodium chloride) is the most commonly technique to preserve and extend the shelf life of cured fish,but traditional fish curing salt content control much of the course is on practical experience[1],and sodium chloride in it generally arrived to 10% to inhibit the growth of most bacillus[1-3]. Salt is

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the primary cause of raised blood pressure and it is largely responsible for the rise in blood pressure that occurs in almost all adults as they grow older, thus study on the growing number of researchers dedicated that they need low salt food[4]. It is believed that salt can be reduced under acid condition [2], so more and more researchers focused on how salt and vinegar content or its resulting organic acids inhibit microbial breeding[5-8]. However, little information has been down on quality of fillets affected by salt and vinegar. The objective of this paper is to study on the springiness and rehydration of *E. bambusa* fillets affected by salt and vinegar content, in order to find the balance point of the salt content and texture quality of fish fillets to develop a commercial *E. bambusa* fillets.

1 Materials and Medthods

1.1 Collection of meat samples

The *E. bambusa*s (8750±129) g were obtained from a fish farm locate in Changde city, China, which had been raised in floating cages, fed on a commercial feed and small frozen fishes. Within twenty-four hours of catch, they were slaughtered, cleared of the scales and guts, filleted into the size of 8cm×8cm×2cm, and frozen at (-20±0.5)℃ for 2d.

1.2 Methods

1.2.1 Preparation of fillets The *E. bambusa*s fillets were preprocessed in different vinegar and salt solution for 15min, freeze-dried at different times in a freeze-drier (FD-1A, Peiking) to get different moisture content.

1.2.2 Sensory evaluation According to standard ISO 8586-1[9], a panel of seven judges was trained to evaluate the appearance of the fillets, the odor and the texture of the fish. As shown in table 1, 5 attributes were evaluated, and each one receiving a score on a continuous scale of points from 1~5.

1.2.3 Springiness Springiness of sample was evaluated at 25℃ using a Texture Analyzer (TA-XT2i, Stable Micro Systems, UK) with a cylinder probe of 5mm in diameter. Samples with bones removed were cooked for 10 minutes in steam, and filled into an acrylic container (4×4×3cm). The probe speed was fixed at 2.0mm/s with a test distance of 15mm, and upon compression the disc was returned to the initial starting point. From the resulting force-time curve, springiness was calculated as described by Bourne[10] and Jiang, *et al*[11] as equation (1):

$$P=\frac{F_2}{F_1} \qquad \text{Equation (1)}$$

Where P is the springiness of *Elopichthys* bambusa, F1 the first height of measuring in force-time curve, and F_2 is the second height of measuring in force-time curve.

1.2.4 Rehydration rate Freeze-dried Sample rehydration was performed in tap water at 40℃, 100min until samples were saturated. Percentage of rehydration was calculated using the equation (2)[12]:

$$R(\%)=\frac{W_r-W_1}{W_0-W_1}\times 100 \qquad \text{Equation (2)}$$

Where R is the rehydration rate (%), W_r the weight of rehydrated sample (g), W_1 the weight of freeze-dried sample (g), and W_0 is the weight of fresh sample (g).

1.2.5 General determination Determination of sodium chloride is according to SC/T 3011-2001, determination of pH is according reference[12], determinations of total bacterial counts (TBC) is according GB 4789.2-2010.

1.2.6 Statistical analysis In order to detect statistically significant differences, experimental values were compared using variance analysis and heuristics analysis to evaluate the influence of storage time on the parameters measured. The significance level was set at $p<0.05$. Values throughout the text are expressed as mean±standard deviation.

2 Results and discussion

2.1 Sensory analysis

Table 2 showed the average scores given by the panelists to each of the attributes examined on various moisture contents after incubated at (30±1)℃ for (72±3)h. Generally, the higher moisture content contained in food, the lower process cost it was, and the shorter shelf life of the food was. Thus, it was necessary to find the balance point between the moisture content and the shelf life of food. In table 2, the sensory scores, especially the odor and color, were negatively correlation to the moisture content. Fillets with 52.3% moisture content started to decay after three days of incubation. In contrast, fillets with 22.0% moisture showed

Table 1 Attributes assessed during the sensory evaluation of *E. Bambusa* fillets after freeze-drying

Parameter being assessed	Sensory Scores				
	5	4	3	2	1
Odor	Fish smell	Light vinegar	Vinegar	Strong vinegar	Rancid
Color	Fish color	White	Light gray	Gray	Dark
Muscle structure	Very compact	Compact	Light compact	Light separate	Separated
Springiness	Very elastic	Elastic	Light elastic	Not elastic	Hard
Adhesiveness	Fish adhesive	Too adhesive	Adhesive	Light adhesive	Not adhesive

Note: Means±standard deviation.

undesirable texture including springiness and adhesiveness, even having a longer shelf life. In searching for the optimal point for shelf life and texture/sensory feel for *E. bambusa* fillets, the target moisture range was chosen to be between 33.5% and 41.6%.

2.2 Texture measurements

The effect of salt and vinegar concentration on springiness of *E. bambusa* fillets with 36% moisture content were summarized in table 3. The result of single factor analysis of variance showed that vinegars content from 3% to 6% had no significant effect on the springiness of *E. bambusa* fillets ($p>0.05$), while concentration of salt solution had significant effect on it ($p<0.01$). Moreover, the springiness of *E. bambusa* fillets in 6% (w/v) salt solution showed the highest value (0.925±0.001).

The effect of salt and vinegar concentration on rehydration rate of *E. bambusa* fillets with 36% moisture content were summarized in table 4. The result of single factor analysis of variance showed that both vinegar and salt content had significant effect on it ($p<0.01$). Additionally, the rehydration rate value of *E. bambusa* fillets was increased with increasing vinegar content up to 5% (v/v), after which a decrease trend was observed. Similar variation tendency was detected in salted Elopichthys bambusa fillets as well, and the highest rehydration rate value was (2.34±0.01) in this experiment. Maurer and Rahman *et al*[14-15] reported that a lot of micropores could be formed in freeze-dried sample, and the surface and capillary suction led to its rapid moisture uptake, porosity, capillaries and cavities near surface enhance the rehydration process. Babić *et al*[13] suggested that sample thickness was critical for the determination of conditions of freeze-drying process in order to reach an adequate rehydration, quality and shelf-life of the freeze-dried chicken meat. When the thickness of fillets increased, the process had to be more difficult to obtain a quality product near to that of the fresh one, due to the difficulty of reaching an adequate rehydration of the product. This study showed 2cm was a suitable thickness of *E. bambusa* fillets in freeze-drying.

2.3 Interaction of vinegar and salt on *E. bambusa* fillets

Results of Table 3 and Table 4 indicated that no significant impact on the springiness of *E. bambusa* fillets with vinegar and salt significant, but we didn't know salt and vinegar exist at the same time, if the synergies on the springness of the fillets. Therefore, we compared the springness of fillets affected by 3% vinegar with no vinegar (Fig.1). Results showed that all the springness of fillets with 3% vinegar were improved, the peak value was in 5% salt treatment, reached to 0.929, higher han the springness of fillets with no vinegar. Then, the springness of fillets decreased with the increasing of salt content.

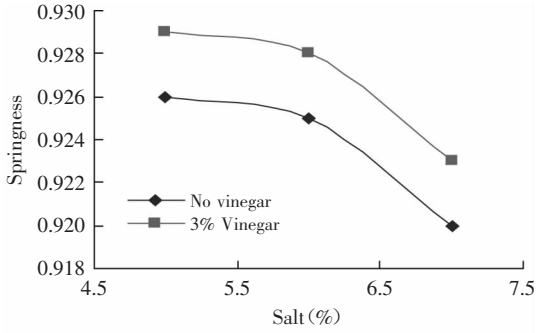

Fig.1 Springness of *E. bambusa* fillets on different vinegar and salt

Both salt and vinegar had significant impact on

Table 2 Sensory evaluations of *E. bambusa* fillets incubated at (30±1)℃ for (72±3)h on various moisture contents

Parameter being assessed	Scores on various moisture contents fillets			
	52.3%	41.6%	33.5%	22.0%
Odor	1.26±0.32	4.26±0.45	5.00±0.00	5.00±0.00
Color	1.45±0.42	4.37±0.21	5.00±0.00	5.00±0.00
Muscle structure	4.08±0.23	5.00±0.00	4.36±0.22	4.26±0.38
Springiness	3.96±0.32	5.00±0.00	4.05±0.26	1.96±0.33
Adhesiveness	4.11±0.15	5.00±0.00	4.28±0.17	1.75±0.18

Table 3 The springiness of *E. bambusa* fillets of 36% moisture in different vinegar and salt

Concentration	Vinegar				Salt			
	3%	4%	5%	6%	4%	6%	8%	10%
Springiness	0.916±0.001	0.901±0.001	0.914±0.001	0.913±0.001	0.913±0.001	0.925±0.001	0.913±0.001	0.892±0.001

Table 4 The rehydration rate of *E. bambusa* fillets of 36% moisture in different vinegar and salt content

Concentration	Vinegar					Salt				
	0	3%	4%	5%	6%	0	4%	6%	8%	10%
Rehydration rate (%)	1.40±0.01	1.97±0.01	2.03±0.01	1.50±0.01	1.85±0.01	1.40±0.01	1.45±0.01	2.34±0.01	1.43±0.01	1.24±0.01

fillets rehydration rates, so we designed three levels of two-factor experiment, which vinegar content was 3%, 4%, 5% and salt content was 4%, 5%, 6% (Fig.2). Results indicated that the rehydration rates of fillets increased with increasing of vinegar content (from 3% to 5%) and salt content (from 4% to 6%). The highest rehydration rate of fillet was 5.35, which founded in 5% vinegar and 5% salt. With the further rise of salt concentration, fillets rehydration rates declined slightly. Besides, rehydration rate of fillet treated by 3% vinegar was 1.96, lower than 5% vinegar treatment, but its flavor was better than 5% vinegar treatment, which had no obviously sour. These results were in agreement with the idea of Zhang et al[16], who believed that the flavor of fish product was affected by salinity and acidity. Thus, 3% vinegar, 5% salt was optimum curing condition on *E. bambusa* fillets.

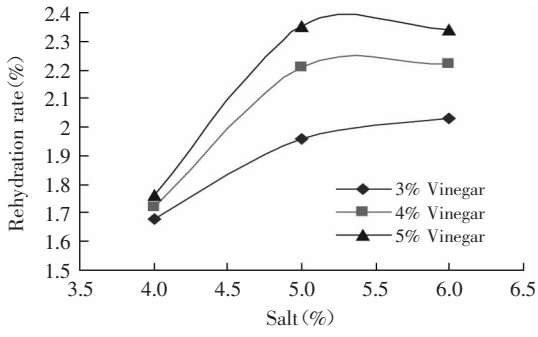

Fig.2 Rehydration rate of *E. bambusa* fillets on different vinegar and salt

2.4 Quality of *E. bambusa* fillets

According to the result of above, we cured the fillets in 3% vinegar and 5% salt solution fifteen minutes, freeze-dried to 36% moisture content and determined its related indicators (Table 5).

The springness and rehydration rate was (0.93±0.01) and 2.32%±0.02% respectively suggested that the texture was in the ideal range, while pH was (5.53±0.01) meant the fillet had no sour, TBC was 6.5×10^5 cfu/g indicated that microbiology was in safe range, NaCl was 3.86%±0.01% demonstrated that the fillets was low salt product. All these results verified that the quality of *E. bambusa* fillets was fairly good under these circumstance, and which was in accordance with the texture being best when salinity rang was from 3.8%~10.2%[16]。

3 Conclusion

The result of the sensory evaluations indicated that *E. bambusa* fillets within the moisture range between 33.5% and 41.6% had better texture/sensory feel without preservatives. Within the range between 3% and 6%, vinegar had no significant effect on the springiness of *E. bambusa* fillets ($p>0.05$). Salt concentration significantly affected the springiness of *E. bambusa* fillets ($p<0.01$) with the springiness reaching the highest value of (0.925±0.001) under a 6% (w/v) salt solution. The rehydration rate of *E. bambusa* fillets was influenced by both the salt and vinegar concentration, with peak values of (2.03±0.01) under 5% (v/v) vinegar and (2.34±0.01) under 6% (w/v) salt solution, respectively. All springness of fillets treated by different salt content could be improved by 3% vinegar, and the peak value was in 5% salt treatment. The rehydration rate was affected significantly by both salt and vinegar content, low salt fillets with good quality could be got if it was treated under 3% vinegar and 5% salt. Which promoted the traditional food processing by scientific control to prepare the traditional flavor food with nutrition and healthy.

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Table 5 Quality of *E. bambusa* fillets in 3% vinegar and 5% salt on 36% moisture

Indicator	Springness	Rehydration rate (%)	pH	TBC (cfu/g)	NaCl (%)
E. bambusa fillets	0.93±0.01	2.32±0.02	5.53±0.01	6.5×10^5cfu/g	3.86±0.01

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微生物的酱醪FN高于对照样品，添加*T. halophilus*的酱醪TA高于其他各组样品，而采用3种微生物共培养的酱醪对FN和TA没有显著变化。同时通过GC-MS分析了酱醪挥发性组分变化，发酵第125d后，与对照组相比，添加耐盐微生物后酱醪2-甲基丁醇、1-辛烯-3-醇、乙酸异戊酯、苯甲醛和四甲基吡嗪含量显著增加。研究结果表明，添加耐盐微生物有利于多种风味物质的生成，可显著改善酱油风味。关于耐盐乳酸菌和酵母菌在酱醪发酵中的作用机制及风味形成机理还有待进一步研究。

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