# Process effect, pollution analysis, and product quality comparison of wet-blue prepared from seawater vs. industrial water based on benchmarking method

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**Process effect, pollution analysis, and product quality comparison of wet-blue prepared from seawater vs. industrial water based on benchmarking method**

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**Abstract**

To reduce the freshwater intake in the leather-making industry, seawater was used instead of industrial water to prepare the wet-blue. Firstly, the main components and key indicators of the seawater after simple pre-treatment and the industrial water were compared and analyzed; then, using wet-salted bovine hide as raw material and industrial water as a benchmarking, the process effects of seawater of soaking, liming, deliming, softening, pickling, and chrome tanning, as well as the different pollutants content in the different discharged waste liquid, and the performances of resulted wet-blue were investigated. Furthermore, the properties of the obtained crust and finished leather were also investigated. The experimental results show that compared to conventional industrial water, the application of seawater in leather-making had better soaking and liming process effects; and except for the high content of chloride ions, the content of other pollutants in the waste liquids were relatively close; and the obtained wet-blue, crust, and finished leather also had better sensory performance and physical-mechanical properties. All these experimental results indicated that using seawater instead of industrial water to prepare the wet-blue was feasible, which provided a new approach to solving the problem of freshwater resource shortage in the leather-making industry.

Keywords: leather engineering; seawater; wet-blue; crust; upper leather

## 1. Introduction

Water is the source of life, the basis of ecology, and the essential of leather-making[1]. In terms of the traditional leather-making process, each processing 1 ton of cow salt wet skin, the water consumption is about 45-60 $m^3$, and the discharge wastewater is about 40-55 $m^3$; from the salt wet hide to wet-blue, the water needs to be about 30-40 $m^3$, the discharge wastewater is about 27-36 $m^3$[2]. Therefore, water-saving technology has become a hot spot and has achieved remarkable results. For example, Xingye Leather Technology Co. Ltd., at present, for every 1 ton of cattle salt wet hide processed, only about 20-25 $m^3$ of

water is needed, and the wastewater discharged is about 18-22 $m^3$; which from the salt wet hide to wet-blue, it needs about 12-15 $m^3$ of water, about 10-12 $m^3$ of wastewater discharged; the water consumption of wet-blue and leather is reduced by about 57.1% and 61.4%, respectively.

However, water-saving technology cannot solve the problem of water shortage in leather-making. At the same time, freshwater resources are in short supply, accounting for only 2.5% of the total water, while seawater accounts for the highest proportion in the world, reaching 97.5%[3]. In theory, seawater is an inexhaustible source of water. So, is it possible to make leather from seawater? In the process of leather-making, soaking, pickling, and other processes need to be added to inhibit the growth of bacteria or improve the moisture of the water. Therefore, in theory, at least some of the production water can be replaced by seawater. Therefore, here cattle salt wet hide was used as rawhide to prepare the wet-blue with seawater (HS), and the wet-blue prepared by industrial water (GS) as a benchmark. The processing effect, the content of pollutants in waste liquid, and the properties of the wet-blue, crust, and upper leather were compared. It should be noted that to investigate the feasibility of leather-making by seawater, seawater was used in all the processes of pre-tanning and tanning plate.

The results showed that the wet-blue prepared from HS had better process effects and less pollution. The contents of pollutants in the waste solution were not changed obviously except that the chloride ion content was about 3 times that in the general GS. The softness and apparent density of the wet-blue, crust, and leather made from HS are lower, and the physical-mechanical properties of tear strength, elongation at break, tensile strength, disintegration strength, and collapse height are superior to those of GS. After dyeing-finishing processing, the difference between the two becomes smaller, and they all have excellent dry-finishing properties. The results show that the seawater process effect is good, has a good ability to adapt to the subsequent process, and has a good application prospect, which provides a new feasible way to reduce the use of leather-making water.

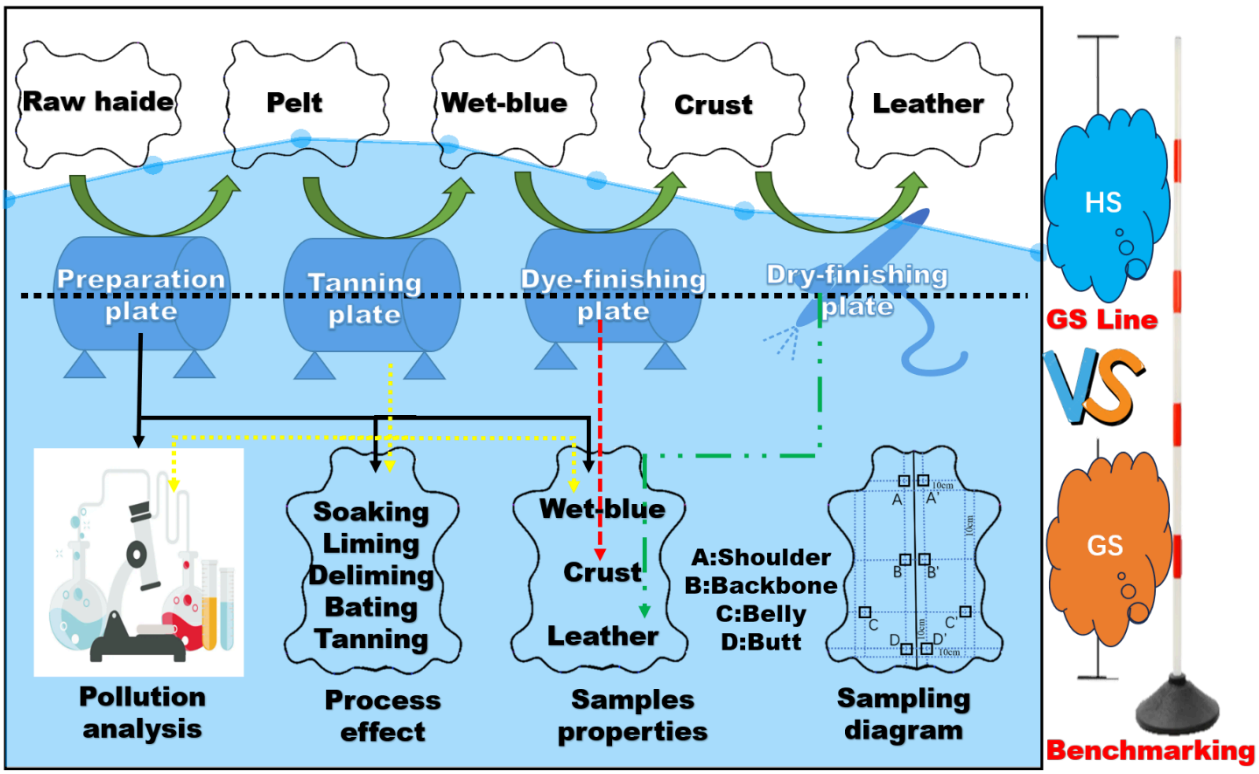



Fig.1 Schematic diagram

2. Material and Methods

2.1 Materials and equipment

Cattle salt wet hide, from Ford Morgan, USA; HS, taken from the South Sea (about 24.51° N, 118.57° E), China; GS, taken from Jinjiang, Fujian Province; all related chemical materials were selected from Stahl, Trumpler, LANXESS and other renowned leather chemical companies.

Drum 3250×300, Fushan Fengnian Leather Machinery Co., LTD; drum 800×400, Wuxi Xinda Light Industry Machinery Co., LTD.; GLRZ-4R3200, Nantong Silui Machine Manufacturing Co., LTD.; wrestling drum IGN, Wuxi Derun Light Industry Machinery Factory; Seawater detector, JH-HSS800, Qingdao Jinghong Environmental Protection Technology Co. , Ltd.; Horizontal plate machine (340×1800×22), Guangdong Jiangmen Taili Leather Machinery Co., LTD. Computer tensile testing machine GT-TCS2000, rupture strength testing machine GT-7013, friction decolorization testing machine GT-7034, softness instrument GT-303, thickness gauge GT-313-A, Go-tech testing machines inc.

2. Preparation of Samples

2.2.1 Preparation of the wet-blue

The preparation of the wet-blue is made by the process of pre-tanning and tanning plate process of cattle shoe upper leather, as shown in Table 1.

Tab. 1 Preparation and tanning plate process of cattle shoe upper leather

| Processes | Materials | Amount/% | T /℃ | T /min | pH | remarks |
|---|---|---|---|---|---|---|
| Pre-soaking | Water<br>NaCl/Na2CO3<br>W-100/ES-10M/ XY-1 | 200<br>2/0.3<br>0.15/0.3/0.1 | 18-20 | 30/30×2<br>+10/50×8 | 6.5-8.0 | Drain,<br>trim |
| Main-soaking | Water<br>NaCl/Na2CO3<br>W-100/ES-10M/ XY-1<br>NB/NaHS | 150-180<br>1.5/0.2<br>0.15/0.3/0.1<br>0.1/0.15 | 18-21 | 30/30×6<br>+10/50×12 | 9.0-9.5 | Drain |
| liming | Water<br>HLV/B12<br>Na2S/NaHS/Ca(OH)2<br>W-100/K-06 | 130-150<br>0.05/0.8<br>1.2/0.9/2.5<br>0.05/0.1 | 18-23 | 10/20×3<br>10/20×10<br>+10/50×12 | 13-14 | Drain,<br>split |
| Pre-delimiting | Water<br>DLE/W-100 | 150<br>0.4/0.05 | 28-29 | 20 | 9.0-10 | Drain |

| Processes | Materials | Amount/% | T /℃ | T /min | pH | remarks |
|---|---|---|---|---|---|---|
| Main-deliming | Water<br>DLE/Na2S2O5 | 70-80<br>1.4/0.2 | 28-29 | 20 | 8.8-9.0 | |
| Bating | U5 | 0.15 | | 25 | 9.0-9.2 | Washing |
| Pickling | Water<br>NaCl<br>HCOOH/H2SO4 | 70<br>7<br>0.6/1.2 | 18-20 | 10<br>30 | 2.7-2.9 | |
| Taning | B1/HCOONa<br>Cr/Cr powder<br>BF/BF<br>NaHCO3<br>water | 0.15/0.5<br>3/3<br>0.2/0.2<br>0.3<br>150 | 38-40 | 30<br>30+90<br>60+180<br>30<br>240 | 3.5-3.7<br>3.6-3.7 | Washing<br>Ts > 95 |

2.2.2 Preparation of the crust

The preparation of the crust adopts the dyeing-finishing plate process of cattle upper leather, as shown in Tab. 2.

Tab. 2 Preparation process of the crust (dyeing-finishing plate)

| Processes | Materials | Amount/% | T /℃ | T /min | pH | remarks |
|---|---|---|---|---|---|---|
| Dehumidification | water<br>Formic acid/OC | 300<br>0.3/0.3 | 40 | 60 | 3.3 | Drain,<br>Washing |
| Retanning | water<br>OXB/Q307<br>OS/XNL/JHY/FS/HB<br>HCOOH/ B1<br>Cr/ BO<br>HCOONa/NaHCO3 | 100<br>1.5/3<br>2/1/4/2/2<br>2.5/1<br>3/2<br>1.5/0.5 | 30 | 30<br>60+60<br>20+20<br>60<br>20/60 | 3.3<br>4.0 | Drain |

| Processes | Materials | Amount/% | T /℃ | T /min | pH | remarks |
|---|---|---|---|---|---|---|
| Neutralization | water<br>XNL/ HCOONa<br>$NaHCO_3$ | 150<br>1.5/1.5<br>1.0 | 30 | 30<br>60 | 4.8 | Drain,<br>Washing |
| Filling-dyeing | Water<br>PR/B4<br>PN/OS/ME<br>Dyestuff/Formic acid | 80<br>3/3<br>5/3/3<br>2-4/1.0 | 30 | 60<br>30<br>60/30 | 4.0 | Drain |
| fatliquoring | water<br>V2/505/CK<br>ZLN/DB/OPE<br>Formic acid | 150<br>3/2/2<br>1/2/1<br>1.0 | 50 | 60<br>30 | 3.5 | Drain |
| Colouring | water<br>Formic acid<br>dyestuff<br>DMT/XGS | 200<br>0.1<br>1.0<br>0.5/0.5 | 50 | 10<br>10<br>20<br>20/10 | 3.5 | Drain,<br>Washing |

2.2.3 Preparation of the crust

The preparation of the leather adopts the drying-finishing plate process of cattle upper leather, as shown in Tab.3.

Tab.3 Preparation process of the upper leather (drying-finishing plate)

| № | Materials | Base/% | Top/% | Feel/% | Keys of process operation |
|---|---|---|---|---|---|
| 1 | Water | 300 | 100 | 100 | 1. Crust: according to the conventional process, dry and finish, then return to oil, drop soft, and stretch the plate;<br>2. Spray: base coat × 2;<br>3.Press plate: 187#,80 ° C /50Kg/2 ';<br>4. Spray: base coat × 2;<br>5. Spray: top coat × 2;<br>6. Hot finish: 110℃/20Kg/20Kg;<br>7. Slam, stretch board, and shake soft;<br>8. Spray: feel × 1;<br>9. Hot finish: 110℃/20Kg/20Kg<br>10. Finished products. |
| 2 | PT-6806 | 50 | | | |
| 3 | RC 2349 | 150 | | | |
| 4 | RU 73-901 | 150 | | | |
| 5 | Promul 59 | 100 | | | |
| 6 | SB 150 | 100 | | | |
| 7 | SB 300 | 100 | | | |
| 8 | Filler FD | 30 | | | |
| 9 | 4570-AA | 50 | | | |
| 10 | S-C | 50 | | | |
| 11 | WF 5230 | 10 | 20 | 20 | |
| 12 | Pigment | 120 | | | |
| 13 | BAYDERM 3041 | | 100 | | |
| 14 | AKU | | 10 | | |

3. Test

Test sample sites such as shoulder, backbone, belly, and butt are shown in Fig.1, which was taken according to GB/T39364-2020 [4]. The sample to be tested is prepared and adjusted according to QB/T 2707-2018[5]. Test results were weighted according to 1:7:1:1 for neck: back: abdomen: buttocks.

2.3.1 Process effect

According to process requirements, manual evaluation is adopted. By experienced engineers according to the process implementation and the actual situation of the sample obtained by the corresponding process according to the index evaluation, the best effect is 5 points, and the worst is 0 points.

2.3.2 The pollutant content in the waste liquid

Tab.4 The test method of pollutant content in the waste liquid

| № | Test indicators | Test method | Remarks |
|---|---|---|---|
| 1 | COD | HJ 828-2017 | |
| 2 | $NH_3$-N | HJ 535-2009 | |
| 3 | T-N | HJ 636-2012 | |
| 4 | T-S | GB/T 16489 | Liming |
| 5 | T-Cr | GB/T 7466 | Tanning |

2.3.3 Sample test indicators and methods

Tab.5 The test indicators and methods of the sample

| № | Test indicators | Test method | Remarks |
|---|---|---|---|
| 1 | Softness | GB/T 39371-2020 | |
| 2 | Density | GB/T39500-2020 | |
| 3 | Tear strength | QB/T 2711-2018 | Thickness QB/T 2709-2018 |
| 4 | Elongation at break | QB/T 2710-2018 | Tensile strength |
| 5 | Bursting displacement | QB/T 2712-2018 | Bursting strength |
| 6 | Dry/wet rubbing | GB/T 40920-2021 | |
| 7 | Fastness to folding | QB/T 2714-2018 | |

3. Results and Discussion

1. Comparison components

In addition to water, seawater also includes dissolved major elements (with concentrations greater than 1 mg · $L^{-1}$), trace elements, organic matter, and gas components. Major elements account for approximately 99.9% of the total salt content, mainly including cations such as $Na^{+}$, $K^{+}$, $Ca^{2+}$, $Mg^{2+}$, $Sr^{2+}$, anions such as $Cl^{-}$, $Br^{-}$, $F^{-}$, $SO_4^{2-}$, $HCO_3^{-}$, $CO_3^{2-}$, and $H_3BO_3$ molecules.

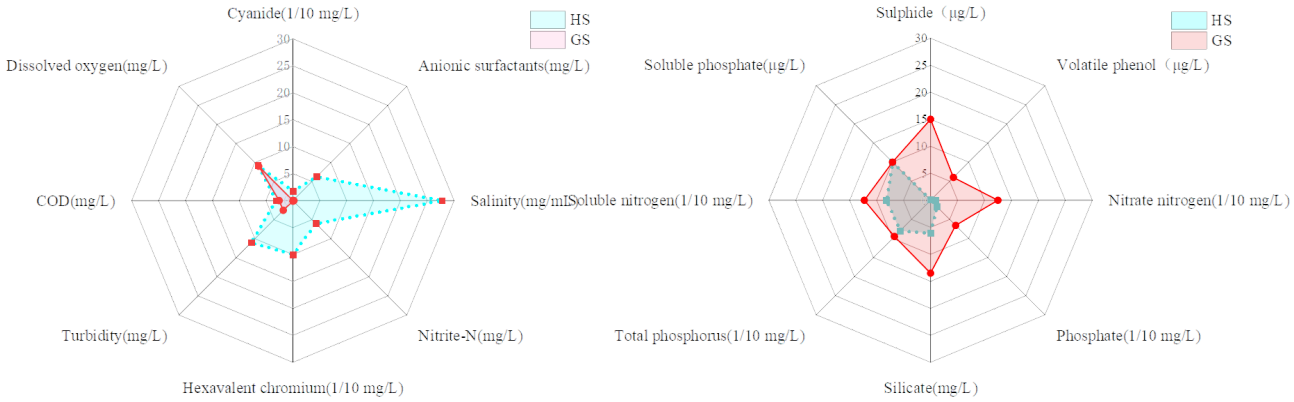



Fig.2 Comparison components： HS vs. GS

To compare the water quality of HS and GS, the sulfide, hexavalent chromium, total phosphorus, volatile phenol, dissolved oxygen, soluble total phosphorus, nitrate nitrogen, nitrite nitrogen, turbidity, salinity, conductivity, COD, phosphate, anionic surfactant, soluble total nitrogen, cyanide, and silicate were tested and the results are shown in Fig.2. The salinity and conductivity of HS are much higher than those of GS because HS contains more soluble salts. The turbidity of HS is higher than that of GS because it contains more suspended solids. GS does not contain nitrite nitrogen, but the content of soluble total nitrogen and nitrate nitrogen is higher than that of HS. The silicate content in GS is relatively high, possibly because silicate is the main component of soil[17], while GS mostly comes from surface water and groundwater, which have a high silicate content due to infiltration and other reasons. Except for the chloride ion content, there is little difference in other indicators of HS and GS.

In leather-making, salt needs to be added to the soaking and pickling to promote the dissolution of collagen fiber stroma or prevent acid swelling. HS contains a large amount of salt, so using HS instead of GS can reduce the use of salt and production costs, but it may also reduce the adsorption of collagen fibers due to excessive sodium and chloride ions. HS also contains a lot of metal ions and organic compounds, which can cross-link and fill collagen fibers in leather, thereby improving the compactness and fullness of leather. However, due to their coordination ability, they may hinder the infiltration of subsequent materials.

2. Process parameter

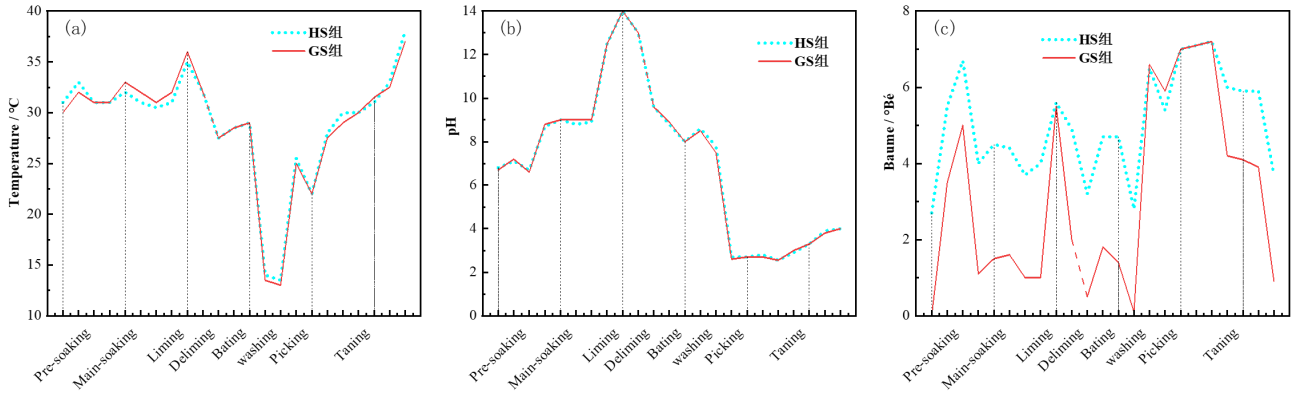



Fig.3 Comparison of process parameter: HS vs. GS

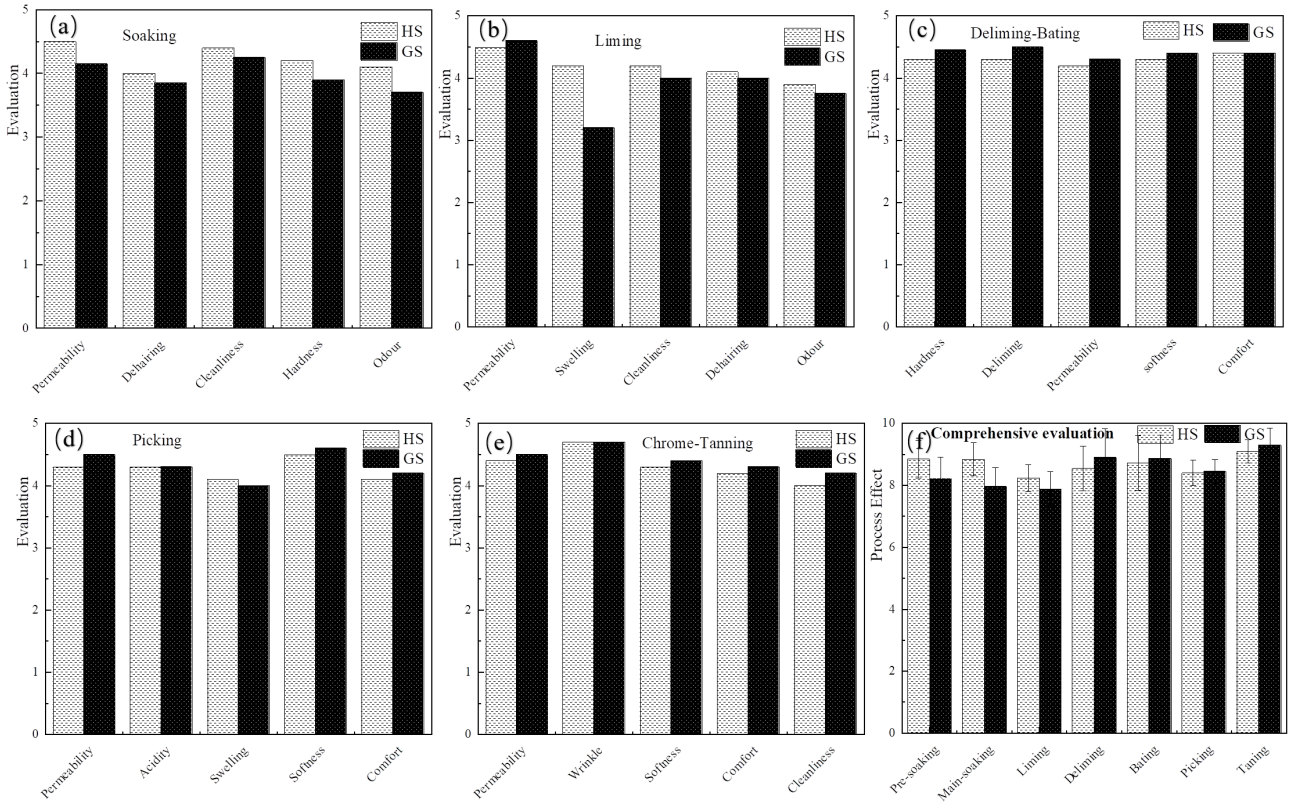
To ensure the comparability of the experimental results, strict control was carried out on the process parameters, striving to maintain consistency in all parameters except for water. From Fig.3, the temperature and pH of the HS and GS remain the same, while the Baume degree varies significantly due to differences in the two waters. The Baume degree of the HS was greater than that of the GS, while the two groups did not differ significantly after the pickling. In the early stage, the high Baume level in the HS was due to the higher salinity of HS. In the later stage, more salt was added to the GS to prevent acid swelling. Thereby soaking, liming, deliming-softening, pickling and chrome tanning may be affected by the salt content in HS, resulting in a difference in process efficiency.

3.3 Process effect

Process effect refers to the achievement of process objectives. Each process such as soaking, liming, deliming, bating, pickling, and chrome tanning, has selected no less than 5 key evaluation indicators. For instance, permeability, cleanliness, hardness, dehairing, and odor were selected to evaluate the process effectiveness of the soaking process. From Fig.4a, for soaking, the evaluation indicators of using HS are better than GS, which indicates that soaking with HS has better process effects and superiority. Meanwhile, compared with GS, the process used HS has better process effects in liming processes, and pickling is the same while deliming-bating and chrome tanning are slightly worse (Fig.4b-4e), but they all have reached the expected.

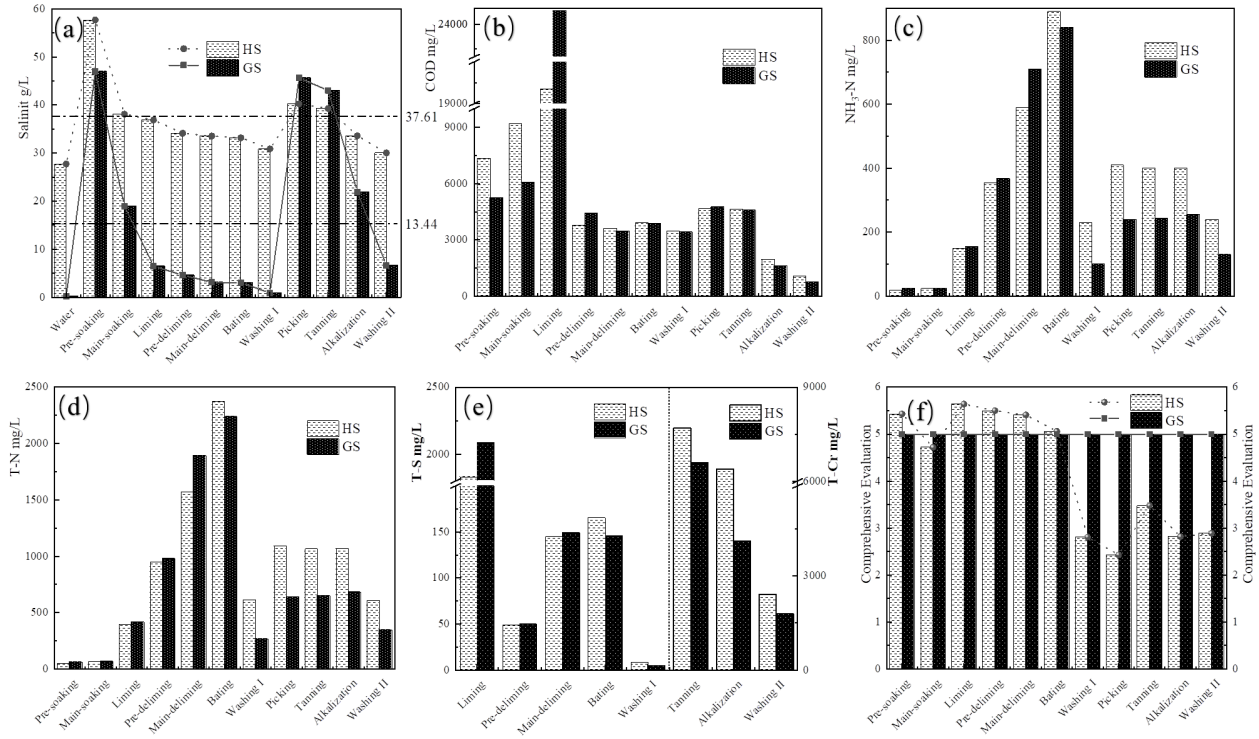
In tolerate the comprehensive effect of the relational process, the evaluation indicators were normalized and weighted, and the results are shown in Fig.4f. Obviously, the process effects to prepare the wet-blue used HS has better soaking and liming, worse deliming-bating and chrome-tanning, and relatively close pickling, but all meet the requirement of the process, which is consistent with the analysis of individual

processes. The




process effect shows that it is feasible to use HS instead of GS to prepare the wet-blue.

Fig.4 Comparison of process effects: HS vs. GS




4. Pollutants Analysis

Fig.5 Comparison of salinity, contamination and comprehensive evaluation： HS vs. GS

The difference between HS and GS is the chloride ion content. The salinity of HS is about 2.5-3.5%[6], and the experiment used is 27.7 g/L. Due to the presence of sodium chloride, the chloride ion content in the waste liquid will increase. From Fig.5a, the chloride ion content in HS wastewater (37.61 g/L) is significantly higher than that in GS wastewater (13.44 g/L), the chloride ion content in HS wastewater is about three times that of GS wastewater. However, the increase in chloride ions during the whole process is 9.88g/L and 13.21g/L, respectively, which is related to the relatively small amount of HS used. It may be related to the addition of approximately 7% sodium chloride in the pickling process.

COD, $NH_3$-N, total nitrogen (T-N), sulfide (T-S), and chromium ions (T-Cr) are key indicators for evaluating leather-making wastewater. From Fig.5b-5e, HS wastewater has higher COD in soaking and liming, $NH_3$-N and T-N in bating, pickling, and chrome-tanning, T-S in bating, and T-Cr in chrome-tanning, but the difference is not significant. To analyze the contamination of the relational process wastewater, the evaluation indicators were normalized and weighted, and the results are shown in Fig.5f. Taking the bating as the dividing point, the HS comprehensive evaluation effect in the previous process is relatively good, while the subsequent process such as pickling and chrome-tanning is relatively poor. The former due to the presence of different components in seawater[7], may have a better effect on removing useless tanning materials; the latter due to the components in seawater may react with tanning agents, resulting in a decrease in their activity and further leading to slightly inferior tanning effects. Compared with GS, in terms of pollution analysis in different processes, the overall effect of HS is better, and the difference between the two is not significant.

5. Properties of the wet-blue

The sensory requirements of the wet-blue are generally uniform blue surface and incision color; the grain is firm, not loose, with no residual hair, chrome spots, creases, red heat plaque, and other general defects; the inner surface clean, with no meat residue, pollution-free; natural soft [8]. To describe the convenience, the wet-blue prepared HS and GS are referred to as $W_1$ and $W_2$ respectively; the crust obtained after the dyeing-finishing plate is referred to as $C_1$ and $C_2$ respectively; the leather obtained after the drying-finishing plate is referred to as $L_1$ and $L_2$ respectively. Both $W_1$ and $W_2$ have uniform blue, no sliding, no loose, soft, and firm, and there is no significant difference between the two wet-blue.

From Fig.6a, the softness of $W_1$ is slightly lower than that of $W_2$, which is related to the mild loosening effect of HS on fibrillar fibers. The softness of the abdomen is relatively high, followed by the back and buttocks, and the neck is low, which may be related to the poor location of the rawhide and the knitting of collagen fibers. For experimental cattle hide, the neck is the most tightly woven collagen fiber, followed by the buttocks and back, and the difference is not significant, while the abdomen is relatively loose[10]. The apparent density of $W_1$ is slightly higher than that of $W_2$ (Fig.6b), and the water vapor permeability of $W_2$ is higher than that of $W_1$(Fig.6c), which is still related to the degree of knitting and looseness of collagen fibers.

In terms of tear strength, tensile strength, elongation at break, and bursting strength and displacement, $W_1$ was stronger than $W_2$, although the difference was slight in different parts (Fig.6d-6h). The physical and mechanical properties are all related to the tightness and evenness of the collagen fiber bundle[11]. The collagen fiber of $W_1$ weaving is more compact, and the degree of uniformity is relatively higher, so the physical and mechanical properties are better.

$T_s$, $T_d$, $T_{p1,}$ and $T_{p2}$ of $W_1$ are slightly lower than $W_2$, which may be related to the chromium content. The average chromium content of $W_1$ was 2.18%, lower than that of $W_2$ (2.31%). The reason may be due to the poor expansion of HS, the rubber fibril cannot fully open to expose the internal groups such as carboxyl

and amino groups, so the binding amount of chromium is affected, and the crosslinking degree is low. Meanwhile, both $T_s$ of $W_1$ and $W_2$ are greater than 100℃, and the chloride ion content and common metal ion content are lower[10]. Therefore, there is no obvious difference between the two wet-blue.

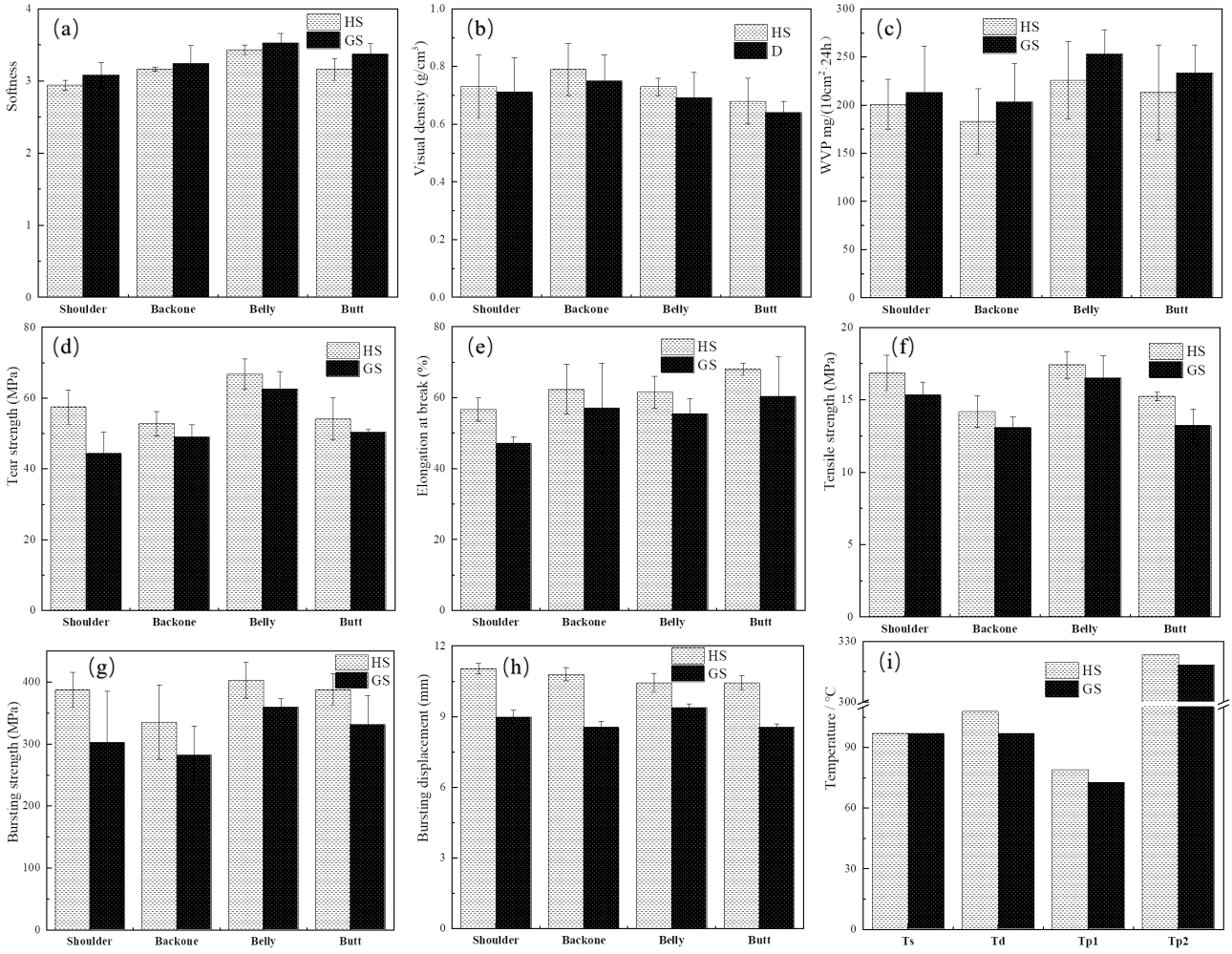


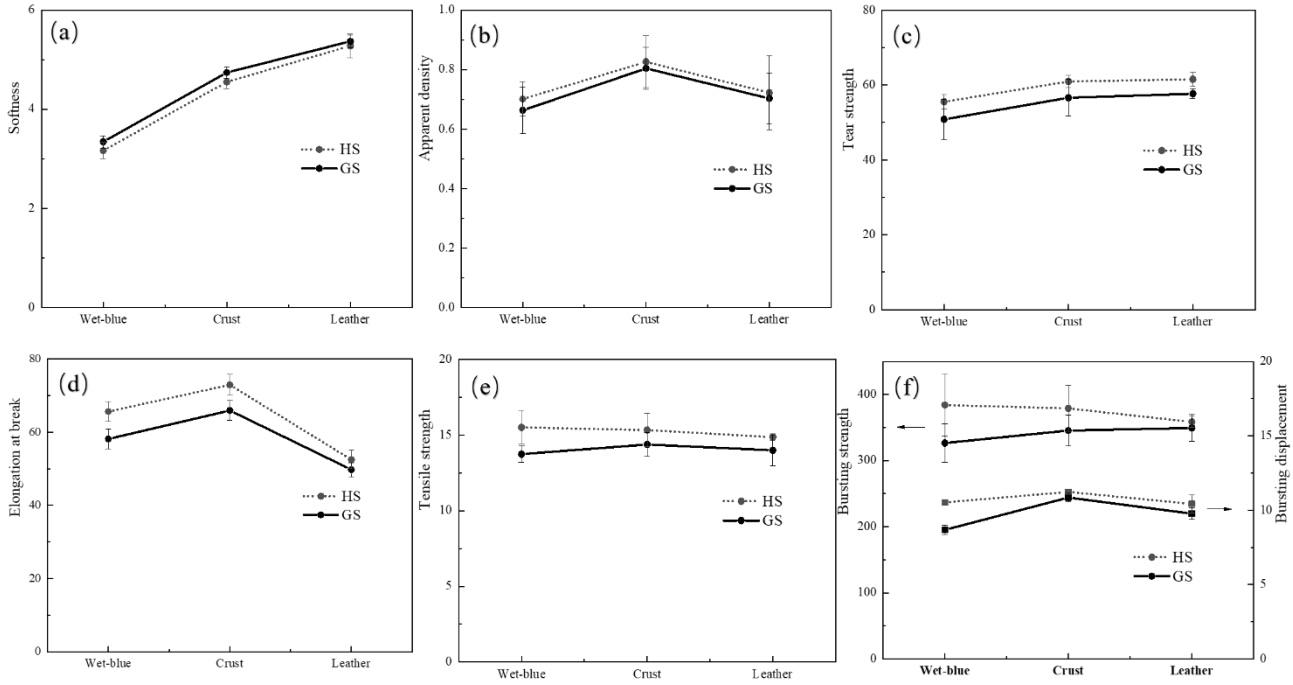

Fig.6 Comparison of the wet-blue： HS vs. GS

6. Performance of the crust and finished leather

The retanning, filling, fatliquoring, dyeing, and other processes of the dyeing-finishing plate have a great impact on the composition and structure of the crust, such as increasing the tanning effect, making up the defect, and giving characteristics[12]. After drying, making soft, flat, and other processes of the drying-finishing plate, the moisture content of leather is controlled at 14-16%, the appearance and feel are also significantly improved, and the softness, fullness, and elasticity are improved.

From Fig.7a-7b, the softness of $C_1$ is relatively low, while the apparent density is relatively high. The softness of $L_1$ is slightly lower than $L_2$, but it is very close, which indicates that both the dyeing-finishing and drying-finishing plate process can effectively improve the sensory properties of leather. From the wet-blue to crust and to leather, the softness is improved, but the apparent density increased after the dyeing-finishing plate treatment and decreased after the drying-finishing plate treatment. Possibly because of introduced retanning agents, fillers, fat liquor, and dyes into the space of the rubber fibril, thus increasing its density; while drying and softening, the water loss between the rubber fibril causes its density to decrease[13].

From Fig.7c-7f, tear strength, tensile strength, elongation at break, and bursting strength and displacement of $C_1$ and $L_1$ are higher than $C_2$ and $L_2$ respectively. However, the difference between $L_1$ and $L_2$ is reduced, which indicates that the composition, structure, and physical and mechanical properties of the two are close. Compared with the wet-blue, the physical and mechanical properties were significantly improved. The physical and mechanical properties of $L_1$ are slightly better than $L_2$, which may be related to the process characteristics. In the relevant processes of $W_1$, the salt existing in HS has a certain inhibition effect on the collagen fibrin, so that the degree of looseness is slightly lower than that of traditional process, so that its physical and mechanical properties are better. At the same time, these advantages are still retained after the dyeing-finishing plate and the drying-finishing plate, so that the final product has better physical




and mechanical properties.

Fig.7 Comparison of the wet-blue, crust and leather： HS vs GS

7. Coating properties

To further investigate the processing properties of $W_1$, the coating properties of $L_1$ and $L_2$ in different parts were compared (Tab.6). As can be seen from Tab.6, whether it is $L_1$ and $L_2$, or shoulder, backbone, belly or butt, dry rub resistance has reached 5, wet rub resistance has reached 4-5, and the folding fastness of the coating has reached 50,000 times without cracks. This shows that the use of $W_1$ or $C_1$ will not affect the subsequent drying-finishing operation, and will not affect the related properties of the coating. After testing, the key performance indicators of $L_1$ meet the requirements of QB/T 1873-2010.

Tab.6 Comparison of leather coating properties

| Samples | Test site | Dry rub (grade) | Wet rub (grade) | Flexing resistance (50,000 times) |
|---|---|---|---|---|
| $L_1$: from HS | Shoulder | 5 | 4-5 | No cracks |
| | Backbone | 5 | 4-5 | No cracks |
| | Belly | 5 | 4-5 | No cracks |
| | Butt | 5 | 4-5 | No cracks |
| $L_2$: from GS | Shoulder | 5 | 4-5 | No cracks |
| | Backbone | 5 | 4-5 | No cracks |
| | Belly | 5 | 4-5 | No cracks |
| | Butt | 5 | 4-5 | No cracks |

## 4. Conclusion

To reduce the use of fresh water in the leather industry, the wet-blue was prepared by HS, and GS was used as a benchmark. The main components analysis of HS and GS shows that except for chloride ions, there is no significant difference in other components, which could meet the requirements of leather-making. Compared to GS, the process effect of HS has been better in soaking and liming, slightly worse in deliming-bating and chrome-tanning, and relatively close in pickling, but both have achieved the expected. The pollutant content in the discharged waste liquid showed that the content of chloride ions in HS wastewater was about 3 times that of GS, but other pollutants had not changed significantly. Compared with GS, in terms of pollution analysis in different processes, the overall effect of HS is better, the difference between the two is not significant, and the pollutant content is in the normal range.

There is no obvious difference between the two wet-blue. The performance test showed that the shrinkage temperature and softness of $W_1$ were lower, while the apparent density and the physical and mechanical properties such as tear strength, tensile strength, elongation at break, and bursting strength and displacement were better than those of $W_2$. The differences among the shoulder, backbone, belly, and butt, but the difference is not obvious; the crust and leather have the same trend, but the difference gradually becomes smaller. The shoe's upper leather prepared from HS has excellent coating properties, dry rub resistance of 5, wet rub resistance of 4-5, the folding fastness of the coating to 50,000 times without cracks, and the key performance indicators that could meet the requirements of QB/T 1873-2010. This shows that the preparation of the wet-blue from HS is feasible, which provides a new possibility for reducing the use of fresh water in leather-making and rational utilization of seawater resources.

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## 6. References

[1]Zhan H., Guo Y., Yang Y., et al. Review on the development of seawater utilization in China [J]. Water Resources Development Research, 2012, (12): 40-43.

[2] China Leather Industry Association. Technology roadmap of water saving and emission reduction in leather industry [M]. 2015.

[3] Jamil F, Ali H., Khiadani M. Concise summary of existing correlations with thermophysical properties of seawater with applications: A recent review [J]. Applied Thermal Engineering, 2023, 227:120404

[4] GB/T39364 Leather Chemical, physical, mechanical, and color fastness test sampling site [M]. 2020.

[5] QB/T 2707 Preparation and Adjustment of Leather Physical and Mechanical Test specimens [M]. 2018.

[6] Wu Y. Salt content and distribution characteristics of seawater [J] Earth, 2002, (6): 14-15

[7] Zeng J., Long S., Bao L., et al. Analysis of main components and trace elements in seawater near Shanghai [J]. Marine Environmental Science, 2012, 31 (2): 186-189

[8] Niu Z., Yang Y., Cai C., et al. A method for preparing wet-blue using seawater[P] ZL202011421123: China.

[9] Chen M., LI Z., YU F., et al. Quantitative characterization of leather softness based on flexural stress and compressibility principle [J]. China Leather, 2006, 35(21): 33-36.

[10] WEN H., Key technology and evaluation of ecological design and manufacture of cattle shoe upper leather [D]. Sichuan University. Chengdu, 2022.

[11] Huang X., Chen H. Study on mechanical properties of different raw materials and different leather products [J]. Western Leather, 2006, 28(10): 14-16.

[12] Black M, Canova M, Roudier S. Best available techniques (BAT) reference document for the tanning of hides and skins [M]. Luxembourg: Publications Office of the European Union, 2013.

[13] Sizeland K., Edmonds R., Basil-Jones M., et al. Changes to collagen structure during leather processing [J]. J Agric Food Chem, 2015, 63(9): 2499-2505.