DEPARTMENT OF COMMERCE
BUREAU OF FISHERIES
HUGH M. SMITH, Commissioner

FISH ISINGLASS AND GLUE

By George F. White

APPENDIX IV TO THE REPORT OF THE U. S. COMMISSIONER OF FISHERIES FOR 1917

Bureau of Fisheries Document No. 852

PRICE, 5 CENTS
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Washington, D. C.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

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COLLAGEN AND GELATIN.

Collagen, the mother substance of gelatin, is an albuminoid which occurs to a large extent in vertebrates and also in the flesh of cephalopods. It is the chief constituent of the white fibrils of connective tissue and is also found in bones, cartilages, ligaments, fish scales, etc. Collagens of different origins are not of identical composition; however, all show the characteristic albuminoid property of being insoluble in water and the ordinary protein solvents.

The most interesting and commercially important property of collagen is its power to be converted into gelatin by heating with water alone or in the presence of dilute acids. On the other hand, if gelatin is heated to 130° C. it is transformed back into collagen, so that there is a very intimate relation between the two substances. For practical purposes we may consider gelatin to be collagen which has been converted into a soluble form by combination with water. (Other changes have been noted, such as the evolution of ammonia, when collagen is treated with water.) The following table gives the composition of collagen, gelatins from various sources, and of fish glue, which is a crude form of gelatin:

Composition of Collagen and Gelatin.

	Carbon.	Nitrogen.	Hydrogen.	Sulphur.	Oxygen.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Collagen	50.75	17.86	6.47	....	[a]24.92
Gelatin from—					
Commercial source	49.38	17,97	6.80	0.7	25.13
Tendons	50.11	17.81	6.56	.26	25.26
Ligaments	50.49	17.90	6.71	.57	24.33
Cartilage	50.34	17.76	6.96	.58	....
Trachea	....	17.87	....	.70	....
Ear	....	....	....	.66	....
Air bladder	48.69	17.68	6.76	....	....
Fish scales	....	17.51	....	.52	....
Fish glue	48.69	17.68	6.76	....	....

[a] Includes sulphur; separate percentage not noted.

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Collagens are to a certain extent differentiated by the ease with which they are converted into gelatin. Thus the collagenous cartilage of the trachea is transformed at 100° C. into gelatin, whereas ear cartilage requires a temperature of 110°; the collagen of air bladders forms gelatin at room temperatures. In general, the formation of gelatin takes place most readily with fishes and amphibia, more slowly with birds, and very slowly with old animals. The presence of salts, for example, of sodium chloride in a concentration of 10 per cent retards the transformation.

Gelatin (French *gélatine*, Latin *gelata*, that which is congealed) is a colorless, amorphous substance which is transparent when in thin sheets. It does not dissolve in cold water, but swells in this medium. If treated with warm water, it dissolves to a sticky liquid which, if sufficiently concentrated, sets to a jelly on cooling. If gelatin is boiled with water for several hours (or simply digested with water for two days at a temperature of 37° C.), it is converted into a nongelatinizing form; further boiling transforms it into proteoses, peptones, and finally into acids, among which glycocoll is present in a characteristically large amount. This fact should be born in mind in a study of the commercial uses of gelatin, since prolonged boiling, especially in the presence of acids, changes it chemically and physically (the gelatinizing) and correspondingly the adhesive power is destroyed.

As a food, gelatin has little nutritive value, and should not be substituted for other proteins of the normal diet since not all of its nitrogen is in a form which can be utilized by the organism.

Gelatin, obtained as described above, should not be confused with the products derived from algæ and seaweeds of different varieties, especially those of the East Indies, China, and Japan. Thus the gelatinizing substances obtained from bird's nests, prized as a delicacy by the Chinese, and Bengal isinglass, or agar, yield carbohydrates in large amount and have no relation chemically to true gelatin.

FISH SOUNDS.

While the principal supply of gelatin is to-day obtained from the refuse of animal bones, hides, and hoofs in the slaughter and packing houses, the peculiar properties of the gelatin derived from fish sounds, called isinglass in the trade, makes this product of considerable commercial importance.

The fish sound (air bladder, or swim bladder) is a hollow sac, containing gas (oxygen, carbon dioxide, and nitrogen), situated in the abdominal cavity below the vertebral column. Its principal function is probably mechanical. Since it is compressible, it serves to regulate the specific gravity of the fish, enabling the latter to rise and sink or to maintain its position at a certain water level. In a few fishes it may take on the functions of the lung of higher vertebrates and may be considered to be the homolog of that organ.

The size of the air bladder varies to a great extent, being very small in some species, whereas in the sturgeon, hake, catfish, and carp it is highly developed. In some fishes the sound is practically loose in the abdominal cavity, while in others it clings closely to the backbone, the intestines, and the abdominal wall. The sound is made up of several tunics of which the inner layer is thin, often with a silvery luster, containing crystalline substances, sometimes covered with a pavement epithelium. The adjacent layer is thick and with a fibrous structure; it is the collagen contained in this layer which is the source of commercial isinglass.

Isinglass (probably a corruption of the Dutch huisenblas, German hausenblase, literally sturgeon's bladder) has for centuries been manufactured and exported from Russia. Several varieties of the sturgeon (*Acipenser huso* or beluga, *A. ruthenus* or sterlet, *A. sturio* or common sturgeon, *A. stellatus* or starred sturgeon), of catfish (*Silurus glanis*), and of carp (*Cyprinus carpio*), flourishing in the Volga and other rivers, in the Caspian and Black Seas, and in the Arctic Ocean, yield the well-known Russian isinglass.

Russian isinglass is generally brought to the great fair at Nijni Novgorod and from there finds its way, through the agency of Petrograd traders, to London and elsewhere. Other sources of supply than Russia are Brazil, Venezuela, the East and West Indies, Penang, Bombay, Manila, Nova Scotia, Newfoundland, and the United States. Russian isinglass is known in commerce as staple isinglass, and is sold as long and short staple, according to size.

Leaf isinglass (Astrakhan leaf, Saliansky leaf, Samovy leaf, etc.) is prepared by soaking the sounds in warm water, whereby dirt and mucous membrane are removed. The sounds are then opened and dried by exposing the inner membrane to the air; the dried sounds may be further treated by pounding and rubbing until the outer membrane is detached and separated from the purer, inner layer. Book isinglass is prepared in a similar manner, but the sounds are folded and covered with a damp cloth. Trimmings from the leaf or book are pressed into cakes or tablets or rolled into ribbons and sold as lower-grade isinglass. The trimmings from the sounds and other parts of the fish are often boiled in water until the gelatin dissolves and the filtered solution is evaporated to dryness. There is also cake isinglass, so called from its shape, although sometimes it is made in a globular form.

Long staple and book isinglass are the best varieties, a 2 per cent solution in hot water setting to a jelly when cold, and yielding only 0.05 per cent insoluble matter. Cake isinglass is dark colored and of unpleasant odor. A low grade of Russian isinglass, also sold under the above names, is manufactured from the peritoneum and intestines of the fish. Russian isinglass is imported into the United States in varying amounts from year to year.

Iceland produces an excellent grade of isinglass, which is obtained from cod and ling sounds, only a little inferior to the Russian product. Venezuela and Brazil export tongue sounds and lump and pipe isinglass which are obtained from Siluridæ and other less definitely characterized fish. Tongue sounds are oblong, tapering, and pointed at one end, of firm consistency, but otherwise poorer than the Russian product. From Penang and Bombay are exported tongue sounds and also purse sounds, so-called from their shapes and their fringed edges.

The value of the imports of sounds into the United States and countries from whence imported, according to the census of 1908 (Fisheries of the United States, 1908, p. 292), are given in the following statement:

Canada	$62, 365	British India	$4, 113
United Kingdom	22, 721	All other countries	3, 863
Venezuela	13, 907		
European Russia	6, 706	Total	113, 675

The production of fish sounds in this country has fallen off in the last few years, and the demand being good the value of the imports has increased. Norwegian cod sounds have been imported at different times.

North American isinglass is derived from the sounds of hake, cod, and squeteague, hake sounds being the principal source. A few years ago over 100 tons of hake sounds were obtained annually on the New England coast alone, but the production has fallen off considerably in recent years. Large amounts are imported from Canada and Newfoundland.

Hake sounds from fish caught in deep waters off the coast of Nova Scotia are large and of good quality. One ton of these fish yields 300 to 500 sounds, weighing from 40 to 50 pounds. Hake sounds from shallow waters are smaller and of a lower grade; 1 ton yields about 600 sounds, weighing approximately, 30 pounds. Hake sounds are easily detached from the backbone in dressing the fish on the fishing vessels, and then they are salted in barrels. Before salting they may be scraped and washed but these operations are usually omitted without much injury to the character of the isinglass manufactured from them. When delivered on shore, the sounds are slit open and thoroughly washed and the black outer membrane is scraped off. They are then dried in the air with precautions to prevent access to moisture, since they readily putrefy. The average hake sound yields about 85 per cent gelatin.

Cod sounds are smaller than those of hake and of poorer quality. One ton of fish yields 15 to 20 pounds of sounds. As they are more firmly attached to the backbone than are hake sounds, they are cut off with part of the backbone, scraped, washed, and salted. They are then washed and dried on shore. Cod sounds yield only about 50 per cent gelatin, so that they are much less valuable than hake sounds.

Sounds of the squeteague, which fish occurs along the Atlantic seaboard, are at present only little utilized. One ton of fish yields about 20 pounds of sounds, which are of as good quality as cod sounds. Over 30 years ago about 15 tons of dried sounds of the squeteague were sold annually, but the production since that time has dwindled to a negligible amount.

The production and value of fish sounds in the United States as reported in the census of 1908 (Fisheries of the United States, 1908, p. 43) are presented in the following table:

	Pounds.	Value.
Maine	23,000	$1,000
Fresh	20,000	900
Salted	2,800	100
Massachusetts (fresh)	73,000	3,100
United States	96,000	4,100
Fresh	93,000	4,000
Salted	2,800	100

The sounds of many fresh and salt water fishes are at present unutilized.

TILEFISH-SOUND TEST.

The sound of the tilefish (*Lopholatilus chamaleonticeps*) was tested by the writer to determine the character of its principal constituent and its possible utility. The sound was cut open and a portion treated as follows: After thorough washing with water the tissue was allowed to stand under a large excess of 0.1 per cent sodium hydroxide solution at room temperature so that mucin, hæmoglobin decomposition products, etc., might be dissolved. The residue was thoroughly washed with water and then subjected to the action of an active trypsin solution containing 0.2 per cent sodium hydroxide for 24 hours, the temperature being maintained at 37.5° C. and in the presence of chloroform to prevent putrefaction. The tissue was largely unaffected, and after washing with water was treated successively with alcohol and ether to remove any lipoids. The residue, after drying at 70° C., was creamy white, and thin layers were transparent.

On continued boiling with water, much more quickly by the addition of a trace of acid, the treated tissue dissolved and the solution set to a jelly on cooling. This fact, combined with its ability to withstand tryptic digestion, indicated the presence of collagen in the original tissue, and further tests confirmed this conclusion.

The collagen was rapidly hydrolyzed by pepsin in hydrochloric acid solution. It was found to be insoluble in dilute alkalies and acids but swelled in the latter on standing.

An aqueous solution of the collagen (obtained by boiling with water) was tested for gelatin as follows: The solution could not be coagulated by boiling, by mineral acids, acetic acid, lead acetate, or other metallic salts. It could be precipitated, however, by alcohol, picric acid, tannic acid in the presence of sodium chloride, or by potassium ferrocyanide in the presence of acetic acid. It gave a blue-violet biuret test, but no Adamkiewicz or xanthoproteic reaction. Millon's test gave only a slight precipitate with little color. These tests show the presence of gelatin and the absence of other protein matter.

The presence of collagen (rough experiments showed that over 90 per cent of the nitrogenous matter of the swim bladder is collagen), and the fact that it may be readily converted into gelatin allow the sound of the tilefish to be put to the same use as the sounds of the sturgeon, hake, and other fishes.

MANUFACTURE AND USES OF ISINGLASS.

Isinglass is manufactured by an exceedingly simple process. The industry was initiated in the United States in 1821, at Rockport, Mass., cleaned hake sounds being pressed into plates. In 1834 the procedure was somewhat improved, and the cleaned sounds, softened to the desired consistency by soaking in water, were converted into ribbon isinglass by being passed between solid rollers. The ribbons were then dried. In 1848 the solid rollers were replaced by hollow iron rollers, through which cold water could flow, and thus prevent the ribbons from softening and sticking to the iron, as they are apt to do, especially in warm weather. In 1873 a scraper was placed against the rollers to remove all isinglass adhering to them. The ribbons were made to the desired thickness by adjustment of the space between the rollers.

The manufacture of isinglass is best carried on through the cooler months on account of the softening and putrefying effect of a slight rise in temperature. The sounds received, generally, have been previously cleaned, perhaps scraped, de-salted, and air-dried. They are usually in a hard and tough condition, so they must be first immersed in water for several hours. Four to six hours may be required for the gelatin to absorb enough water to be sufficiently pliable to handle. The sounds may now be run into a cutting machine provided with a roller and a set of knives which chop the sounds into

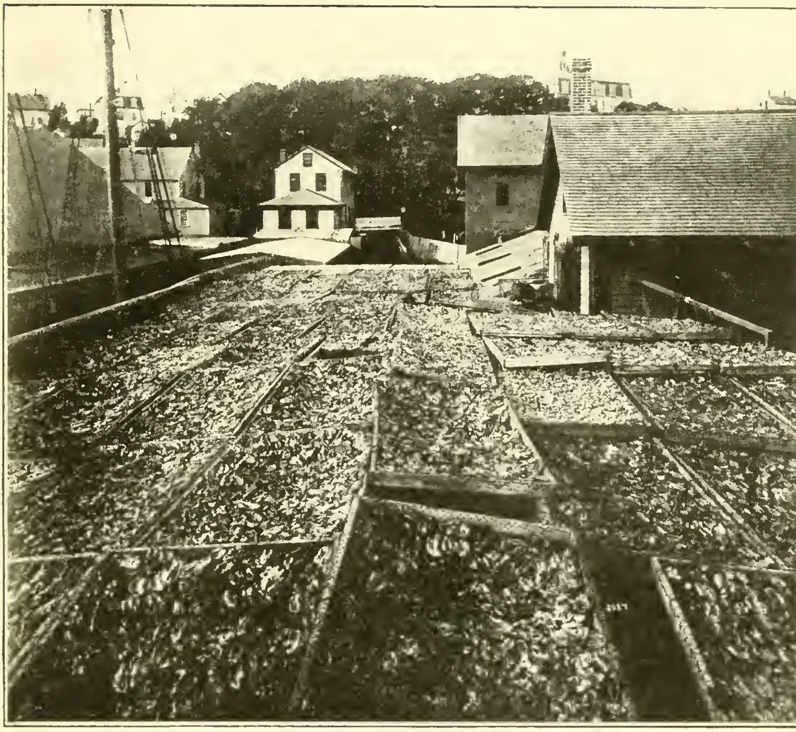

FIG. 1.—DRYING HAKE SOUNDS FOR ISINGLASS MANUFACTURE.

FIG. 2.—ROLLING HAKE SOUNDS FOR ISINGLASS.

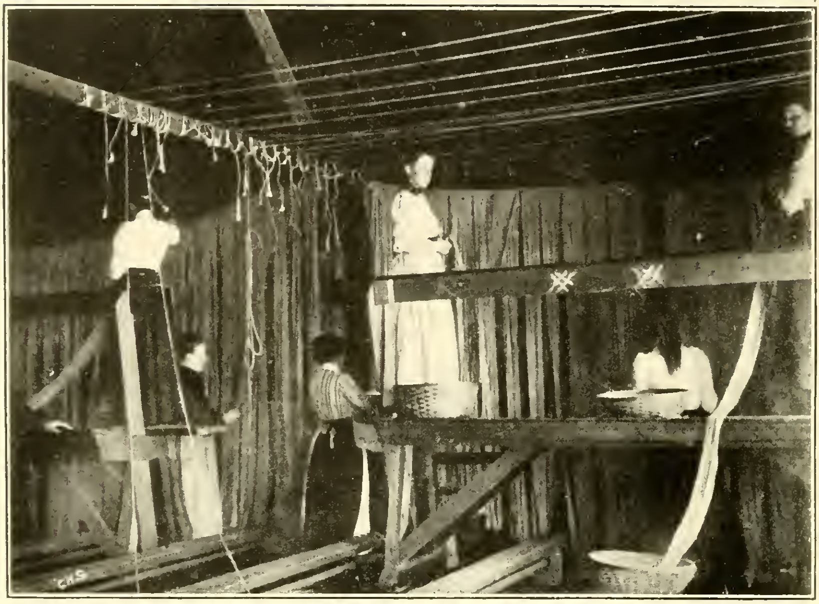

FIG. 1.—DRYING-ROOM OF ISINGLASS FACTORY.

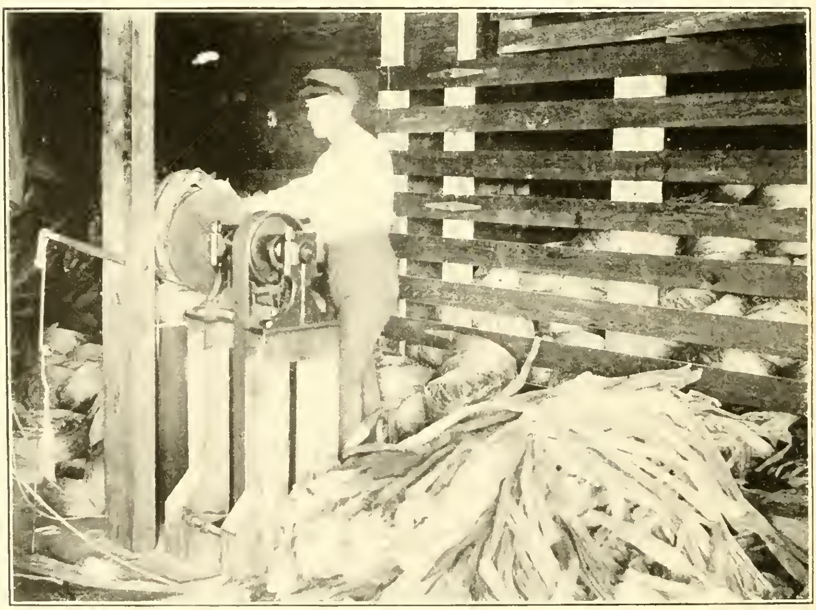

FIG. 2.—WOODEN SPOOL FOR ROLLING INTO COILS.

small pieces. This material is then further mixed and macerated between a set of iron rollers, from which it passes to so-called sheeting rollers. These are the hollow iron rollers, cooled by water and provided with a scraper, as mentioned above. The gelatin is converted into sheets one-eighth to one-fourth inch thick, 6 to 8 inches wide, and of variable length. These sheets are finally passed through ribbon rollers until the ribbons produced are one-sixty-fourth of an inch thick; the width is the same as that of the sheets. The ribbons are dried in a few hours by being suspended in moderately warm, light rooms; they are then rolled on wooden spools into coils weighing less than a pound each. About 20 per cent of the weight of the original sounds is lost during their conversion into isinglass.

A product called transparent or refined isinglass is manufactured by dissolving New England isinglass in hot water and spreading the solution to dry on oiled cloth. Very thin, transparent sheets are thus produced, and these yield an excellent grade of glue, but retain a rather pronounced fishy odor.

When the best grades of isinglass are treated with hot water, they swell uniformly, produce an opalescent jelly, and finally entirely dissolve. Isinglass is insoluble in alcohol, but readily soluble in most dilute acids and alkalies. When ignited, isinglass should yield no more than 0.9 per cent ash, whereas poorer grades of fish glue, or gelatin, yield from 1.5 to 4 per cent ash.

Isinglass has been adulterated by rolling a layer of gelatin between two layers of isinglass. Such adulteration may be detected by treating with water and observing the nature of the colloidal solution under the microscope. Isinglass retains its characteristic fibrous structure which is not present in a gelatin solution; the gelatin becomes more transparent than before, the shreds being disintegrated. Both of these effects would be observed in the adulterated article.

The results of the analyses of some different forms of isinglass are presented in the following table:[a]

Source of isinglass.	Ash.	Water.	Residue insoluble in hot water.	Source of isinglass.	Ash.	Water.	Residue insoluble in hot water.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
Astrakhan	0.20	16.0	2.8	Hamburg	1.30	19.0	2.3
	.37	18.0	.7		.13	19.0	5.2
	.20	17.0	1.0	Iceland	.60	17.0	21.6
	.80	19.0	3.0	East India	.78	18.0	8.6
	.50	19.0	.4	Yellow, unknown source	2.30	17.0	15.6
	.40	17.0	1.3				

It may be readily observed that the Russian isinglass (Astrakhan) is by far the best of those samples analyzed.

[a] Prollius, I. F.: Abs. Journal of the Chemical Society, p. 647. 1884. London.

The use of isinglass for edible purposes has become practically obsolete since the manufacture of gelatin on a large scale has become a function of the slaughter and packing houses. It was formerly utilized to stiffen jellies and jams and in the manufacture of confectionery, but has no peculiar medicinal properties. Some fish sounds have been esteemed as an article of food; thus it is said that fried cod sounds have a flavor resembling that of oysters similarly cooked.

Isinglass has long been used as a clarifying agent for beverages such as cider, wines, and malt liquors. The peculiar clarifying action is purely mechanical, those substances causing turbidity becoming entangled in the slowly sinking network of gelatinous material. This property is not possessed to the same degree by gelatin prepared from animal bones, hoofs, or hides, and such gelatin is far less efficient as a clarifier. English brewers of malt liquors prefer the Penang product, while Scottish brewers employ Russian leaf isinglass. English cider manufacturers generally use Russian long staple. American brewers formerly considered Russian isinglass as superior to other kinds, but later adopted the use of the ribbon isingless made from hake sounds in this country.

White wines are usually clarified by isinglass. The isinglass is allowed to swell in water and then in wine until it is practically transparent. It is thoroughly beaten with more wine, a little tartaric acid being eventually added; after filtering through linen it is stirred into the wine. One ounce of isinglass will usually clarify 200 to 500 gallons of wine in 8 to 10 days.

In the storage of beer after the primary fermentation all suspended particles do not settle in the stock tanks. This is true of starch granules, bacteria, some of the protein matter, etc. From storage the beer is run into chip casks where it is carbonated by charging with carbon dioxide directly or by the addition of young beer, and at the same time clarified or fined. This latter process is carried out by the addition of chips or of isinglass, or by filtration. When isinglass is employed, it is treated with sour beer, acetic, or other weak acid whereby it is not actually dissolved, but is "cut" by the acid. Finings thus prepared have an excellent clarifying action. One pound of isinglass will fine 100 to 500 barrels of beer.

Isinglass is the basis of some of the best adhesives. Although formerly used for postage stamps, envelopes, and gummed paper, the dextrins prepared from starch have largely taken its place. Mixed with two parts of alcohol a "diamond" cement is obtained, the cooled solution forming a white, opaque, hard solid. Dissolved in acetic acid another powerful cement is obtained, especially useful in repairing glass, pottery, and similar articles. Various modifications of these cements are prepared, particularly by the addition of some adhesive gum which will render the cement insoluble in water. Following is the formula for one of these: 10 grams isinglass, 5 grams gum ammoniac, 5 grams mastic, 80 grams alcohol. The isinglass and gums are dissolved separately in the alcohol and then heated together over boiling water. The excellent properties of isinglass as a glue may be illustrated by the fact that leather belts for machinery are repaired by the use of this agent. (In the trade it is often called Russian fish glue.)

Court plaster is made with isinglass as the adhesive. The proportions used are 10 grams isinglass, 40 grams alcohol, 1 gram glycerin, and water and tincture of benzoin in sufficient amount. The isinglass is dissolved in enough water to make the total weigh 120 grams. One-half of this solution is spread in successive layers, with the aid of a brush, on taffeta stretched on frames; each layer is allowed to dry before the next is applied. The second half of the isinglass solution is mixed with the alcohol and glycerin, and is applied to the cloth in a similar manner. The reverse side of the taffeta is covered with a layer of tincture of benzoin and allowed to dry. The above quantities are sufficient to cover a piece of taffeta 38 centimeters square.

Mixed with a gum, isinglass has been used as a size for textile goods, imparting a luster and stiffness to linens and silks. Combined with water, Spanish liquorice, and finely divided carbon, india ink may be made. A patent for waterproofing fabrics has been obtained by Van Winkle and Todd (English patent 20690, 1890), who recommend a combination of isinglass and pyroxylin dissolved in acetic acid; experience has shown that a bichromate must be added to the mixture or the isinglass rendered insoluble by formaldehyde for the mixture to be successfully used. Isinglass has in past years been used to adulterate milk, the addition of a small amount adding considerably to the body.

The manufacture of isinglass in this country is rather inconsiderable as compared with the supply of fish sounds. According to the census of 1908 ("Fisheries of the United States in 1908," p. 282), the value of the annual production of isinglass in this country was reported to be $150,000, all of this coming from Massachusetts.

FISH GLUE.

Glue is gelatin contaminated usually with various decomposition products such as gelatoses, peptones, and organic acids. The purer the gelatin the better glue it yields, so that a good glue should be as free as possible from other proteins, from hydrolytic splitting products, and from ash. Fish glue is usually made up into liquid glue, for which there is a reasonably large demand. The manufacture of mucilage and pastes of various sorts from the dextrins obtained from starch has largely limited the demand for fish glue so that enterprises based solely on this product have not been very profitable.

The manufacture of fish glue in this country has been confined practically to three States, Massachusetts, Maine, and California, 95 per cent of the value of the product being credited to Massachusetts. For 1908 the value of the entire output in the United States was $631,000; the value of the New England output was $611,000 and of the Pacific coast output $20,000.

In New England fish glue is made from cod heads, skins and bones, haddock residues, and all fish offal containing little or no oil, as this constituent is fatal to the production of a good glue. The refuse from salting factories forms a very large part of the source of supply, as salt codfish is prepared in considerable quantities in this region. The refuse from sturgeon and the skins and scales of menhaden and herring have been used. Green and Tower[a] have shown that 1 ton of menhaden yields 20 pounds of dry scales from which 10½ pounds of pure gelatin (containing 16 per cent moisture) may be obtained. In this connection it may be noted that the adhesive qualities of the "stick" obtained by the present methods of concentrating the waste liquors of the menhaden industry are due to the large percentage of gelatin present; this material as now manufactured has use only in the fertilizer industry, as it contains too much salt, oil, and foreign protein substance to be serviceable for glue. Many other fish residues are now unutilized; such is the case of the mullet of the southern waters, which yields an excellent quality of glue.

In the last few years whale blubber has been utilized for the production of glue. According to the German patent 131315, the blubber is chopped up, freed from most of the fat by pressing in the cold, and the remainder of the fatty matter is extracted by some solvent, as benzene. By this method all the fat is recovered and a fat-free dry residue consisting of tissue containing the gelatin is obtained, and this may be readily converted into glue.

Attempts to produce glue from the grayfish (*Squalus acanthias*) have not been successful on account of the large amount of oil and water in the fish, the difficulties attended with the extraction of the oil, and the presence of dark pigments in the skin which discolor the extracts. It is also probable that the skeleton contains only a small amount (if any) of collagen or glue-forming substance. The flesh of the smooth grayfish (*Mustelus canis*) contains gelatin-forming material and presents possibilities as a source of glue.

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[a] U. S. Fish. Com. Bull., 1901, p. 97–102.

MANUFACTURE AND USES OF FISH GLUE.

In the manufacture of fish glue the fish wastes are first washed thoroughly with cold water to remove dirt and blood from the fresh fish and salt from the salted fish. The washed material is allowed to drain, the washings being discarded, and then is subjected to the action of hot water or steam.

In the older methods of preparing glue the crude material was treated with water and the mixture boiled in open glue kettles for several hours until the collagen had all been converted into gelatin which dissolved in hot water. This method yields a fairly good glue if the raw materials are clean and fresh, but because of the lengthy time required for complete extraction the liquor obtained is usually dark colored and contains in solution many other protein substances than gelatin. Glue thus prepared is often a poor adhesive and is malodorous.

Newer methods of fish-glue manufacture involve heating the stock with steam under pressure in an autoclave so that the extraction proceeds rapidly and there is less time for decomposition of the fish protein to occur. In some plants the stock is placed in tall iron cylinders, steam-jacketed, and heated for several hours until the whole mass is thoroughly digested. By a better method, the stock is placed within the inner, perforated section of a double boiler. Steam enters the inner vessel from the outer, and the whole is heated under pressure. The glue liquor filters out of the inner vessel and may be drawn off from the outer jacket continuously. Sometimes an alternate action of steam and cold water on the stock is brought into play, and this process repeated until the extract is too dilute to be profitably worked up into glue.

The digested fish wastes may be filter pressed and the residue dried. The resulting product, containing 45 to 55 per cent protein matter, and 1 to 2 per cent oil, is a valuable by-product; in fact, on account of the demand for it, the scrap can be considered to be the main product of the industry and the glue to be of only secondary importance. At any rate, the manufacture of glue alone would not pay. The better grades of scrap are used for poultry food under the name "chum," while second grades are sold for fertilizer, for which there is always a good market.

The solutions running from the autoclaves or the filtrate from the filter presses are run into vacuum condensers, since the excess moisture in the glue liquor must be distilled off at as low a temperature as possible in order to prevent unnecessary decomposition of the dissolved gelatin. In general, vacuum evaporators consist of a spherical or cylindrical iron vessel, steam-jacketed and provided internally with steam coils immersed in the glue liquor. Sometimes, in modern plants, a type of evaporator used has revolving steam coils; the solutions are thereby uniformly heated and undue frothing from local superheating is prevented. The distilling head is provided with baffle plates and is connected with a vacuum pump and condenser. To conserve fuel, the steam from one evaporator is led through the coils and jacket of the next in a series, on the principle of multiple effect. After concentration to the desired consistency (fish glue contains usually about one-half its weight of water) the product (fish glue) is run while still hot through cloth filters into a receiving tank.

Since fish glue generally does not yield a very good jelly when cooled, on account of the presence of impurities, it is employed as liquid glue. To prevent the glue from gelatinizing at room temperatures an acid such as hydrochloric or acetic acid is added, and the adhesiveness of the material is little affected. Since it is not required that this liquid glue be heated or be applied to hot surfaces, there has been a reasonably large demand for it. It has been largely used as a size for straw goods, especially where it has been treated with sulphurous acid, since this latter agent bleaches the straw; it is also employed as a size for textiles. Good grades of fish glue are used for court-plaster, but isinglass is a better adhesive for this purpose. The greatest demand for fish glue comes from the general demand for a liquid adhesive.

Davidowsky [a] describes the manufacture of fish glue as follows:

> The principal point to be observed in the manufacture of fish glue is the removal of the skin, which is effected by means of dilute sulphuric acid. After the removal of the last traces of acid, the fatty matter of the fishes is saponified by treatment of milk of lime frequently renewed. After washing out the lime, the pulpy mass is placed in a solution of sodium hyposulphite, alum, and sodium chloride, and left for a few days. The liquor is drawn off and replaced by a mixture of solutions of alum, dilute sulphuric acid, and nitric acid. After macerating in this mixture for a few days, the mass is thoroughly washed and boiled to a glue, and the resulting product is clarified with sulphurous acid or alum.
>
> As will be seen, the entire process requires many chemicals, and besides, the yield of glue, which has no especially good qualities, is small. It is used as a substitute for isinglass for clarifying.

That the manufacture of fish glue alone is not very profitable may be seen from the fact that glue manufacturers do not rely on this one product as a source of profit. Thus, one Massachusetts company sells large quantities of fertilizer and also cod-liver oil. Another offers to the trade glue, ink, lubricating oil, paste, mucilage, and other products.

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[a] Davidowsky, F., 1905: "Glue, gelatin, animal charcoal, phosphorus, cements, pastes, and mucilage." Translated from the German by W. T. Brannt. Philadelphia.

Lambert[a] discusses fish glue and describes its manufacture as follows:

The fish offal is carried by conveyors to a series of washing tanks placed overhead, and thoroughly washed with water to remove the blood, etc. From thence it falls by gravitation into the digesters, and is heated with "live" steam for 10 hours. The oil and gelatinous water are drawn off by a pipe fixed to the bottom of each digester, into tanks, the oil skimmed from the surface, and the glue liquors clarified with a small portion of alum. On filtering they are concentrated in open vats provided with a steam coil, to a strength of 32 per cent dry glue, and then bleached with sulphurous acid. The residue in the digester is converted into guano.

Fish glue is a light brown viscous liquid with offensive odor and acrid taste. It forms a sticky mucilage when diluted with water, and as met with in commerce, already contains about one-half its weight of water and such liquid is weight for weight, only about equal to a dextrine in viscosity.

The ash of fish glue is comparatively high, about 4 per cent on body dried at 100° C. It is usually white in color, and has besides carbonates of calcium and potassium, some 5 to 10 per cent phosphate of calcium. Fish glue is said to assume a greenish-yellow color on boiling with potash and absorbs about 9 per cent of the caustic. Liquid gums of this class are easily distinguished by boiling with Fehling's solution, when they assume a violet color, and by the tannic-acid reaction. The best method to remove the unpleasant odor and taste of fish glue is to boil the solution in a little water with 1 per cent phosphate of sodium and to add 0.25 per cent of saccharine.

The offensive odor of fish glue may also be disguised by the addition of creosote, oil of sassafras or wintergreen, or other substance with a strong odor.

There have been several methods proposed for the testing of glue, none of which are perfectly satisfactory. Among the more common tests are those of the viscosity and consistency of the jelly formed. The adhesive power of the glue, however, does not depend on the character of the jelly entirely. Glue is sold with regard to its physical properties, especially its color; all fatty matter should be absent.

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[a] Lambert, T., 1905: "Glue, gelatin, and their allied products." London.

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