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OBJECTIVE AND METHODOLOGY

The objectives of this study are to provide the necessary information and analysis to enable Norfico to evaluate market opportunities for its fish gelatin.

The geographic scope for the research is Western Europe with data and insights on the other regions on an as-gathered basis.

Our analysis and appraisal of the market for fish gelatin are based on the findings of primary interviews conducted between October 2001 and March 2002. Also available non-confidential data in Kline's database and technical literature have been reviewed.

MARKET VOLUME

Global consumption of gelatin is estimated at approximately 250,000 tonnes in 2001. Consumption is highest in Western Europe which accounts for approximately 110,000 tonnes or 44 % of the total as shown below:

Estimated global consumption of gelatin by region, 2001		
Region	**Volume, tonnes**	**% Of total**
Western Europe	110,000	44
United States	80,000	32
Other	60,000	24
Total	**250,000**	**100**

Gelatin is currently sourced from beef bone, hide, pigskin and, more recently, pig bone. Fish is also a source of gelatin and small commercial volumes are available on the market. Research is underway currently to produce gelatin from poultry bones or skin.

In Western Europe, gelatin from pig skin and pig bones now accounts for 58% of the total volume. Despite the BSE crisis, beef gelatin still accounts for most of the balance as illustrated in the following table:

West European Consumption of gelatin by source, 2001		
Source	**Volume, tonnes**	**% Of total**
Pig	63,500	58
Beef	46,000	42
Fish	500	<1
Total	**110,000**	**100**

The high volume of beef gelatin still used is due to the preference for beef gelatin for encapsulation in pharmaceutical applications and the higher bloom required in the photographic industry.

Pigskin gelatin has taken over as the most widely used gelatin in the market. The shift in the market towards porcine gelatin over the past ten years was in reaction to BSE which hit the gelatin market very hard. The gelatin producers welcomed legislation on geographic source of raw material in order to allay fears over beef gelatin. European producers source beef bones and hides from

countries which are certified as free of BSE. Currently, North and South America, are classified as good sources.

Pigskin gelatin offers an option on avoiding BSE completely but there is a problem at times with availability of source material. Pork meat is less popular so fewer pigs are slaughtered, so there is less skin available. A few years ago the price of pig skins rocketed as there was very high demand in Russia for pigskin. Pigskins are used in the snack food industry, meat industry and as pork scratchings in Mexico.

Volumes of **fish gelatin** are relatively minor and are included in the other category. Total volume of fish gelatin consumed in Western Europe is estimated at about 500 tonnes. Global consumption of fish gelatin is believed to be in the region of 1,000 to 1,500 tonnes. Currently, this is a niche market with volumes sold mainly into food and pharmaceutical applications. Key limiting factors are the perceived lack of availability and security of supply of raw material. This united production means that pricing levels remain relatively high, thus limiting consumption even more.

KEY GELATIN PROPERTIES

GENERAL CHARACTERISTICS

The key characteristics which define the behaviour of gelatin in a final product are determined by several physical and chemical parameters of the particular grade. Key characteristics include:

- ?? Gelling power
- ?? Viscosity
- ?? Foamability
- ?? Melting point
- ?? Color
- ?? Odor

In addition to the influence of the source, the production process will also affect the properties such as gelling ability and viscosity. Beef bone is typically produced using an alkaline process and these grades are referred to as B type gelatins. Pigskin and beef hide are produced using an acidic process and are called A types. Fish gelatin is an A type.

Bloom value is a measurement of the gelling power and the firmness or strength of the resulting gel. The bloom value is determined by measuring the strength of the gel formed by a specified concentration, 6.67% of gelatin, maintained at 10 °C for a specified time period, eighteen hours. After this period a texture analyzer is used to measure the force or weight required to depress a plunger 4mm into the gel. Should 150g be required, then the bloom value is specified as 150. Gelatin generally falls between 50 and 300 bloom strength.

Gelling power is one of the key functions of gelatin. The gelling power varies depending on the grade and is measured in terms of bloom value. The higher the bloom value, the greater the ability to form gels and the stronger the gel strength will be. Less gelatin is required to give the same level of gelling as for a low- or medium bloom gelatin. Therefore the higher the bloom value, the higher the quality. The higher bloom grades tend to have higher melting points and less odor or color. Bloom value varies between 100 and 300. The speed of gelling will also vary by grade.

Viscosity is another key criterion of gelatin grades. In general the higher the bloom, the greater the viscosity but various combinations of bloom and viscosity are available. Beef bone grades tend to have higher viscosity. Viscosity is determined by measuring the flow time of a 6.67% solution of gelatin through a U-tube viscosimeter at 60 °C. Viscosity measurement is given in millipoise units and varies between 20 and 70 mps.

Foamability is important for some applications. In general pigskin grades tend to have better foaming properties. The foam density and strength required will

depend on the application. Gelatin lowers the surface tension, allowing for the incorporation of air, and stabilizes the foam once aerated. Gelatin will also prevent crystal formation of sugars in the foam and maintain smoothness in texture.

Melting point varies depending on the grade and affects the processability of the gelatin and perhaps more importantly the sensory properties. Lower melting point gelatins dissolve faster in the mouth, thereby releasing the flavours more quickly for an instant taste sensation. Lower bloom grades tend to have lower melting points. For most applications, gelatin is required to be solid at room temperature so that the final product holds form even when removed from the fridge. Gelatin melting point can be quite fuzzy over a window of temperature. This property is used in soft gel encapsulation as it allows for sealability of the two halves of the soft gelatin capsules by controlling the temperature.

Some grades of gelatin are hydrolyzed to give a greater solubility and to make the gelatin easier to handle.

Color and odor are important. The gelatin should be as clear as possible in solution. Clarity is measured using a turbidimeter. In many applications a slight yellow colour is acceptable but a brownish tinge is unacceptable in ingestible applications. The gelatin should be without odor. In addition no odor should be generated by its incorporation into the final product.

Conductivity is a key parameter in photographic applications and grades of the highest purity with minimal or no conductivity are required. De-ionized grades have an advantage because of their low conductivity.

pH will also effect the properties of the gelatin. pH is measured using a pH meter on a 1% solution and typically for gelatin solutions falls between ph4.5 and 6.5.

Types of fish

Fish gelatin is different to other gelatins in behaviour and characteristics. Fish gelatin can be sourced from cold or warm water fish. The type of gelatin will vary depending on the fish type and the production process. The fish type can be used to classify fish gelatin in two broad classifications:

?? Cold water fish gelatin which does not have bloom

?? Warm water fish gelatin which has bloom

Cold water fish gelatins are particularly different as the melting point is below 10 °C. Therefore, it makes no sense to talk of bloom of cold water fish gelatin as bloom is measured at room temperature and cold water fish gelatin is a liquid at room temperature and gels at 10 °C. **Cod** is a typical cold water fish source of gelatin.

Cold water fish gelatin has the same range of amino acids as beef and pig gelatins but the levels of proline and hydroxyproline are lower. These amino acids are believed to be responsible for the H-bonding and the gelling characteristics. Cold water fish gelatin can be used in applications which do not require bloom or gelling, in which the function of gelatin lies in its other abilities such as prevention of syneresis and texturization. Higher molecular weight grades of cold water fish gelatin are more similar to gelatin from other animals but do not gel at room temperature. However, they can be used in frozen or refrigerated products which are consumed quickly following removal from the fridge or defrosting.

Gelatins with low melting points could also be used in dry products (such as micro-encapsulation). Presuming a favorable pricing structure they could be used in large volume, consumer-price driven products such as low fat spreads and yogurts. In these products, often cold-water soluble grades of pigskin gelatins are used which are available at a price premium of approximately 25%. Alternatively, normal grades are used as in yogurts and considerable agitation is required to prevent clumping. Fish gelatins with low melting point would be easier to incorporate.

Warm water fish gelatin can have a bloom value of 200-250. **Tuna** for instance is regarded as a good source but the skin can be fatty and gelatin must be fat-free. **Tuna or tilapia** gelatins have a melting point of 25-27 °C, therefore are suitable for products at low room temperature. These gelatins more closely resemble bovine or pig gelatin which melts at 32-35 °C. Warm water fish gelatin grades can therefore more readily compete in the traditional gelatin markets.

A key limiting factor in the production of fish gelatin is:

?? The availability of raw materials

Producers have found it difficult to source adequate quantities of particular fish type on a guaranteed basis. This primarily applies to warm water fish. Supplies

of cold water fish skins are easier to find. Other gelatins are produced from certified sources and it can be:

?? Difficult to obtain certification on the fish raw material

Certification is required for the traceability which has become a key word for food additives especially from animal sources.

Also some producers have found it difficult to remove:

?? Residual odor

In some cases the product is odor-free when produced but when formulated into end-products the odor returns or off-flavours are generated.

Producers so far have found it difficult to offer the same:

?? Range of bloom strengths

as is available with bovine or porcine gelatins.

The viscosity can also be problematic as:

?? Viscosity of current grades tends to be very high. Viscosity is regarded as an intrinsic characteristic and therefore is difficult to change

Fish gelatin is *kosher* as long as the fish has scales and fins. How the fish dies is not of importance.

Prices for fish gelatin vary considerably in the market from €12 to €18/kg. Under current conditions, producers of fish gelatin may find it difficult to lower the prices due to the low yield from fish skins and the lack of economy of scale in the production process.

APPLICATIONS FOR GELATIN

Gelatin is used in a wide variety of applications including ingestible and pharmaceutical applications as well as in many technical applications. Gelatin is available in several grades and the source and grade will determine the specific physical and chemical behaviour. Local conditions such as temperature and pH will also affect the properties of the gelatin in the final product. Gelatin competes with several other food additives but gelatin has some specific advantages which give it unique behavioural properties. Two key properties are:

- ?? Formation of elastic, thermoreversible gels
- ?? Dissolution at body temperature

Other properties include:

- ?? Incorporation of air or foaming and Foam stabilization
- ?? Emulsion stabilization/prevention of separation/fat separation stabilization
- ?? Improvement of flow properties
- ?? Control of crystal formation
- ?? Film formation/coating ability
- ?? Texturization
- ?? Fat substitution
- ?? Water-binding
- ?? Improved mouthfeel
- ?? Thickening
- ?? Adhesion

The following table lists the major applications and functions for gelatin by category type:

Application/Function of Gelatin		
Category	**Application**	**Function**
Food	Bakery	Gelling. stabilization, emulsification
	Confectionery	Chewiness, texture, foam stabilization,
	Low-fat spreads	Fat reduction, mouthfeel, creaminess, spreadability
	Meat products	Cohesion Water-binding
	Dairy	Prevention of syneresis, stabilization, texturization
Pharmaceutical	Hard capsules	Film/hard gel capsule formation
	Soft capsules	Film/softgel capsule formation
	Plasma expanders	Water-binding, colloidal solution
	Coating	Film formation
	Woundcare	Moisture/wound exudates formation Haemostatic effect due to promotion of clotting
Photographic		Support of silver halide systems
Microencapsulation	Vitamins/additives	Encapsulation to ensure light and oxygen protection
Cosmetics	Delivery systems	Soft-gel capsules
Technical	Paintball	Soft-gel capsules which split immediately on impact
	Electro-plating	Uniformity of coating deposition, viscosity control
	Microencapsulation	Coacervation microencapsulation of dyestuffs Fragrance carrier

MARKET VOLUMES

The food industry accounts for the greatest volumes of gelatin, with consumption estimated at 70,000 tonnes or 64% of the total in Western Europe. The pharmaceutical industry is the second most important application, consuming volumes in the region of 20,000 tonnes or 18% of the total volume. The photographic industry also consumes large volumes. Other applications include microencapsulation, cosmetics, electroplating, paintball, and adhesives. Volumes consumed are shown by application in the following table.

Estimated consumption by application in Western Europe, 2001		
Application	**Volume, tones**	**% of total**
Food	70,000	64
Pharmaceutical	20,000	18
Photographic	10,000	9
Other	10,000	9
Total	110,000	100

FOOD

Consumption of gelatin by the food industry is estimated at 70,000 tonnes in Western Europe. The food industry uses mainly pigskin gelatin, having changed in the past ten years from a predominance of beef gelatin. There are some applications where the properties of beef gelatin can not be matched by porcine grades and therefore beef gelatin has not been completely dropped by the food industry. Such applications include sweets such as wine gums.

At this point in time, only minor volumes of fish gelatin are used, as the cost is prohibitive for many foods. Current applications are believed to include health beverages and dietetic foods.

Gelatin, a very traditional food ingredient, is used in a wide variety of foods. Its neutral-taste, coupled with its excellent properties in gelling, stabilization, binding, and emulsification make it an ideal food additive for many foods. In addition gelatin is almost unique in its ability to stabilize foam, a key requirement in many confectionery items and chilled and non-chilled desserts and creamed products.

In more recent years another key function of gelatin has been identified and developed. Its performance in giving fat-like properties allows gelatin to replace some of the fat content in many applications. One of the main product groups in which this property is used is in low-fat table-margarine and spreads. A number of low-fat and light products on the market are based on gelatin.

Gelatin is a protein which is low in calories. It can be used in foodstuffs to raise the protein level. In body-building foods, this is a specific functional reason for

adding gelatin. Gelatin can also be used to reduce carbohydrate levels in foods for diabetics.

The major food use sectors for gelatin are:

- ?? Bakery
- ?? Confectionery
- ?? Ice-cream and chilled desserts
- ?? Yogurt and dairy products
- ?? Low fat spreads
- ?? Beverages
- ?? Meat and tinned meat products

In the past flavoured gelatins were widely used as desserts but this application has decreased dramatically

Confectionery

Confectionery is probably the largest application for gelatin currently. Gelatin is used to make sweets such as wine gums, gummy bears, fruit chews, marshmallows and licorice. The function of gelatin varies depending on the product type. In marshmallows, gelatin stabilizes the foam. In fruit chews and licorice gelatin gives texture and chewiness. In wine gums and gummy bears the gelling properties are key and a bloom strength of 260-280 is required. The type of gelatin used will depend on the final product properties. Key consumers in this market are Haribo and Cadbury-Schweppes.

Dairy products

Yogurt has been a major application area for gelatin. The gelatin acts as a protective colloid and prevents the yogurt splitting or separating into two layers. The gelatin is also used to control the texture. Many yogurts based on gelatin are presented in ‘set’ form, which holds shape. In mousse desserts the foaming pattern can be controlled with gelatin, depending on the density or airiness required. In cream cheese gelatin is used for creaminess and to alter the spreadability. In ice-creams gelatin can control crystal formation and drip properties. On chilled desserts, gelatin will stabilize the foamed or whipped cream so that it does not collapse when defrosted.

Bakery products

For home bakery applications, gelatin is available as powder or in sheet form. The main volumes of gelatin are used in industrial bakery applications. Instant or cold water soluble grades are used in bakery applications where a temperature increase is undesirable, for example, in cream products. The function of gelatin is to bind, gel or stabilize. Gelatin gives good mouthfeel leading to a pleasant sensation or melt-in-the-mouth feeling.

Low fat spreads

Low fat spreads have gained considerable share of the butter and table margarine market in the past ten years as consumers increasingly look to low fat foods for a healthy diet. Gelatin has strong advantages due to its functionality (excellent gelling) and as it melts in the mouth, there is smoothness due to the melt-down in the mouth. This is optimal with gelatin and competitive products can not match gelatin in this feature. Due to BSE and an increase in the supply to the consumer market of products which are suitable for vegetarians, marketers such as Unilever and Raisio have sought to substitute the gelatin. Raisio has switched to pectin in many of its Benecol products. Unilever has developed patents on non-gelatin spreads but the company is still the largest consumer of gelatin for this application. The addition rate for gelatin is high at about 2%

Meat products

Gelatin has been used for centuries to produce aspics for meat, fish and sausage products. At one time gelatin was widely used for injection into cold cuts to increase the protein content. Due to its water-binding properties, gelatin increases the moisture level, leading to a lower priced cold cut with good sliceability. However, the use of gelatin in this application has been curtailed and the rate of added protein to cold meats is now controlled as consumers desire a higher quality product. Gelatin is still widely used in the production of tinned meat and meat products where the gelatin provides adhesion of the meat pieces. Also typically there is a layer of aspic or clear jelly on the surface when the can is opened. These products are regarded in Western Europe as of lower quality but they are produced in Europe for the Far Eastern market. In cooked sausages, gelatin provides fat reduction and binding properties. In meat products, such as pork pies, gelatin gives cohesion and binding.

Beverages

Gelatin can be used in the clarification of wine and juices. In fact, for many years hausenglassen or isinglass, a fish by-product, has been used in the clarification of certain wines.

Nondissolved substances in clear drinks are undesirable as they can cause cloudiness or in wines affect the taste. Gelatins with lower gelling ability or low bloom are added as powders to the beverage and cause undesired particles to aggregate and clump into particles which then precipitate out. At one time this practice was fairly widely used on juices but this technology has been replaced by mechanical processes such as ultrafiltration techniques. Bentonite and colloidal silica are used as well for juice and wine clarification, but their use has also dropped. The juice industry switched, about ten 10 years ago, before BSE was an issue. The disadvantage was that gelatin could not be 100% removed, traces could be found in the juice. The industry wanted to be able to say 100% PURE on the label: residual gelatin would preclude this.

PHARMACEUTICAL

Consumption of gelatin in pharmaceutical applications in Europe is estimated at approximately 20,000 tonnes. This volume represents some 40% of the total market for pharmaceutical applications world-wide. Consumption of fish gelatin is negligible in this application.

The pharmaceutical industry still consumes mainly beef gelatin which accounts for at least 60% of consumption in this application. Pigbone has to some extent meet the requirements and has quickly gained market share.

Gelatin is used in several pharmaceutical applications including:

- Hard capsules
- Soft capsules-excluded from scope
- Coatings
- Plasma expanders
- Woundcare–see below

Hard capsules

Gelatin is used to make hard capsule shells for pharmaceutical applications. These capsules are made as two halves which are closed, one over the other, after filling with drug in powder form. Drug material can also be in paste form. Hard capsules can also be used to contain liquids if sealed after filling but they are rarely used for medicines which are in liquid form after cooling. Hard capsules are used mainly for ethical pharmaceuticals and prescription medicines as they do not provide tamper-proofness. The over-the-counter (OTC) market prefers soft capsules which are sealed. Hard capsules are more expensive to make than tablets due to the lower rate of production. Ethical pharmaceutical houses often make new medicines in hard capsule form first as they are easier to formulate and therefore give a faster time to market and longer exploitation of patent period. Following successful introduction, the products are often reformulated in tablet form to reduce prices.

Gelatin is the predominant material used to make hard capsules. In recent years, there has been considerable research into the identification of a non-animal based material for the capsule wall. The main reason is that non-animal based material can be marketed as vegetarian and in line with the practices of all religions and populations. The only material identified which can meet the requirements in terms of flexibility, strength, ease of handling, dissolution at body temperature is HPMC. HPMC is used to a limited extent to make hard capsules but its use has been curtailed by the high price of the empty capsule shells and the lower rate of throughput on capsule filling. Currently, HPMC is estimated to account for approximately 10% of the hard capsule market

Bovine bone gelatin is preferred in this application as a high bloom and viscosity is required. In the past, bovine bone was used almost exclusively but today bovine hide and porcine gelatin are also used. Pigbone grades of gelatin are also available.

The market for hard capsules is very concentrated with few players operating on a global basis. Capsugel is the leading producer of hard capsules worldwide. Accucaps and Shionogi are also important players.

Soft capsules

This application is excluded from the scope so limited information only is provided.

Beef bone gelatin is the most frequently used type in the production of soft capsules but pigbone gelatin has gained considerable market share despite its recent market entry in the last couple of years. At one time beef bone gelatin accounted for almost all gelatin used in this application but currently accounts for about 65%. Pigbone, beef hide, pigskin and fish gelatin account for the balance.

Fish gelatin has been used to a minor extent for soft capsule formation particularly for the French market which has stricter controls on the type of gelatin which can be used for nutritional supplements. An advantage of fish gelatin is the lower melting point, resulting in a faster dissolution in the mouth with no residual 'chewy' shell wall.

Coatings

The pharmaceutical coatings market uses very little gelatin in Western Europe. But in the United States, following contamination of analgesic capsules an application for gelatin coating was developed. TYLENOL from McNeil/J&J and EXCEDRIN from Bristol Myers Squibb were at one time sold in hard capsules, as hard capsules had a connotation of ethical medicines and therefore a greater level of efficacy. Unfortunately, a number of deaths occurred following contamination of the capsules with cyanide and all supplies had to be withdrawn from the market. Having trained consumers to expect a red and yellow capsule to relieve headache and pain, J&J/McNeil was faced with either changing the product form or developing an alternative which looked similar. The problem was resolved by using capsule shaped tablets which are treated with a final coating, red for one half, yellow for the other. BMS followed the example of its competitor. This coating is believed to be based on gelatin and some considerable volumes are used in the United States.

Plasma expanders

Plasma expanders are used to replace blood loss and restore blood volumes and pressure to adequate levels. At one time albumen expanders were the products of choice but due to the expense and limited availability of albumin, colloidal solutions have been developed for this application. Gelatin is used to some extent in this application. B Braun markets GELFUSIN which is a 4% solution of succinylated gelatin. The gelatin is a bovine bone. Aventis Pharma is also believed to produce a gelatin plasma expander, following its acquisition of Behringwerke from the former Hoechst. This product is marketed under the name HAEMOCCEL and is based on a degraded and modified gelatin.

Players in the plasma expanders market include Aventis Pharma, B Braun, BPL, Fresenius, Pfrimmer, and Pharmacia Upjohn.

The volumes of gelatin used in this application are extremely small but prices are believed to be higher due to the purity required. Plasma expanders are generally administered in intensive care units, casualty wards and surgical operating rooms to vulnerable patients. Microbiological count is a key specification. The high purity grades of gelatin used in this applications are treated and in some cases chemically modified by the pharmaceutical house to give specific properties.

PHOTOGRAPHIC

Consumption of gelatin in photographic applications is estimated at approximately 10,000 tonnes. This industry uses predominantly beef gelatin with minor consumption of porcine grades, no fish gelatin is being used.

The photographic industry has used gelatin of high purity as a key component of photographic films and papers for many years. It is used in black and white and color photography. Gelatin is added as a protective colloid in photographic emulsions (with silver halide and water) to prevent the grains or microcrystals from aggregating and clumping. The photosensitive silver halide microcrystals are formed using silver nitrate and a halide salt. Gelatin is unique in providing binding, gelling and film-forming properties in the emulsion which is then coated onto photographic films and papers to form transparent, durable coatings of even thickness. Several layers are applied to the film or paper. Gelatin is also used in final coats.

During the photographic development process, gelatin allows for specific rates of deposition and chemical development due to its colloidal properties. Gelatin also stabilizes coupler and dye emulsions which are utilized especially in color photographic products. Gelatin's properties are required for high-speed photographic films, especially to reach the high sensitivities required for color films and medical X-ray products.

Grades of gelatin used in photographic applications are highly specific,-very often customers require tailor-made grades. Bovine bone gelatin accounts for over 90% of consumption. High purity grades are used in this application as impurities can lead to such problems as fogging of the film. Product specifications are amongst the highest of all applications, often even higher than pharmaceutical grades. High bloom grades are preferred and the industry has traditionally worked almost exclusively with bovine bone grades. A typical specification would be as follows:

Bloom value	160 minimum
Viscosity	6-8 mps
pH	5-7 not so critical as can be adjusted
Transmission	>85% measured at 450nm
	>90% if measured at 620nm
Conductivity	<200mS/cm, deionized grades preferred

Moisture max 13%

Heavy metal <10ppm in total, <2ppm for Fe, Cu, Zn, Pb, Hg

The gelling point is key as coatings must set after application. The industry frequently speaks of its requirement for 'hard' gelatin. Batch-to-batch consistency is a primary concern as a slight variation can have a very negative effect on the photographic product. Gelatin is a key component and is expected to continue to hold its position of importance to the photographic industry. No other hydrocolloid can offer the required properties and versatility. Consumers are researching gelatins constantly in order to improve their products. Increased functionality in available grades is welcomed.

The photographic industry is very concentrated with a small number of players, operating on a global basis. Key consumers of gelatin in the photographic industry include Agfa, Kodak, Fuji, and Ilford. Fuji and Kodak are reported to account for almost 50% of the global consumption in this application.

In the past Agfa produced approximately 3,000 tonnes of bovine bone gelatin in Germany but this plant was sold last year to DGF Stoess. Fuji is believed to produce bovine bone gelatin in India.

WOUNDCARE

Gelatin is used in two main types of woundcare:

- ?? surgical/dental sponges
- ?? hydrocolloid dressings

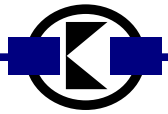
These applications are discussed below:

Surgical/dental sponges

Gelatin, in sponge-form, is used as a haemostatic agent to control bleeding following surgical procedures. Gelatin sponges facilitate clot formation and reduce blood loss. The first haemostatic agent used in this capacity was based on fibrin foam, derived from blood plasma. After World War Two, the shortage of blood donations led to a scarcity of fibrin and sparked the drive to find an alternative. Pharmacia developed a haemostatic agent made from specially treated porcine-derived gelatin called Gelfoam, which proved to be as effective as fibrin foam.

Gelatin foam for haemostasis must have good strength and handle ability. It must be able to withstand sterilization and be completely non-friable as it is used within the body. The product must be completely resorbable by the body. The foam is often cut into specific sizes or shapes which can be molded when wet to adapt to the cavity to be treated. The gelatin sponge must not cause any inflammation and be completely nonallergenic.

To make the sponge, gelatin is foamed with nitrogen and then spread onto plates. Constancy of viscosity is critical to maintain uniformity of density across the foam. The foam is then hardened and strengthened by cross-linking at 130-



140 C for three hours. This latter processing step can serve as the sterilization step, alternatively, the product can be gamma-sterilized.

The gelatin sponge can be based on bovine or porcine gelatin. Most producers use porcine gelatin but some bovine gelatin is also used. Hydrolyzed grades are often preferred. The key players in gelatin sponges are Ferrosan, (whose product is distributed by J&J/Ethicon), B Braun and Pharmacia Upjohn. Ferrosan and Pharmacia use porcine gelatin. B Braun has two products, one for dental applications based on porcine gelatin and a second based on bovine bone gelatin for surgical procedures.

Hydrocolloid dressings

Hydrocolloid dressings containing gel-forming agents, such as sodium carboxymethylcellulose (NaCMC) and gelatin. These agents are combined with elastomers and adhesives and applied to a carrier - usually polyurethane foam or film, to form an absorbent, self adhesive, waterproof dressing. In the presence of wound exudate, hydrocolloids absorb liquid and form a gel, the properties of which are determined by the nature of the formulation.

Hydrocolloid dressings have grown as these advanced dressings are perceived to offer advantages of moist-healing and increased wear time. Moist wound healing, where the wound is not allowed to dry out, is seen as the preferred method of treatment for many types of wound and especially for ulcers which can take several months to heal. The dressings can be left in place for several days, unlike conventional dressings which are changed daily. This benefits the cost of treatment as it reduces nursing care, in addition it also improves patient comfort.

The field of advanced woundcare continues to grow and many new types of dressing have been introduced which compete with gelatin-based hydrocolloid dressings such as alginates, polyurethane foams, and films.

Players in the advanced woundcare market include Coloplast, Convatec, Hartmann, Lohmann, and Smith & Nephew. Woundcare producers tend to adopt a particular technology, for example, Smith & Nephew, having acquired the professional woundcare business of Beiersdorf, has considerable expertise in polyurethane and therefore tends to focus on this product for its dressings. Convatec focuses on combination dressings, using more than one polymer, often in different layers and uses gelatin in a number of products.

Woundcare products are controlled by the European Directive on Medical Devices. All new products must be assessed and once approved receive a CE registration mark. Extensive testing and clinical evaluation must be carried out to prove the safety and efficacy of the product. Current users of gelatin in this application are reluctant to change the type of gelatin as they would have to reregister which results in considerable expenses in redoing clinical trials and other administration.

Gelatin for woundcare applications must be Pharmacopoeia grade as a minimum requirement. Compatibility with skin tissues without any allergic reaction or sensitivity is vital. The grades must be completely free of smell. For

hydrocolloid dressings, gelatin is often used as a dry powder and should be compatible with the other polymers used such as CMC and pectin.

MICROENCAPSULATION OF PHARMACEUTICAL/FOOD INGREDIENTS

Gelatin can be used to microencapsulate oxygen- and light-sensitive ingredients such as vitamin A and E. The vitamin value of these chemicals is quickly reduced unless they are protected. Micro-encapsulation increases the shelf life of the vitamins. In addition the microencapsulated form behaves as a dry powder and is easy to handle and administer. The powders can be easily dissolved in hot or cold water. Cold-water solubility is required for effervescent vitamin preparations which are very common for vitamin C.

Gelatin has been used for some years in this application. Bovine, porcine and fish gelatin can be used. Hoffmann-La Roche holds several patents on the use of fish gelatin in the microencapsulation of vitamins and is believed to be a considerable consumer currently with volumes in the region of 300 tonnes.

PAINTBALL

Paintball is a soft gel encapsulation application. This application is well-established in the United States where several thousand tonnes of gelatin are used for paintball production. Pigskin grades of gelatin are believed to be used predominantly. In Western Europe this leisure pursuit is exploding in terms of popularity. Paintballs are imported from the US but are also produced in Europe now too by a couple of encapsulators such as RP Scherer and Pharmagel. The paintballs must be flexible, perfectly spherical to move through the gun chamber, must break on impact but not inside the gun. The melting properties are key as in hot weather the paintballs can become soft and then lose their spherical shape or leak.

COSMETICS

The cosmetic and toiletries market uses small amounts of gelatin in softgel bath pearls. The market is quite seasonal with higher volumes produced in time for Christmas gift pack sales. The encapsulation is predominantly contracted to specialized encapsulators. A small number of cosmetics houses have shown interest in the use soft gels for unit doses of oxygen or light-sensitive skin treatments, especially in the field of anti-aging. The capsules have a twist-off tab to release the treatment. Use of softgels other than for bath products is minor in the cosmetics and toiletries industry.

Minor volumes of fish gelatin have been used in softgel bath pearls. The advantage of fish gelatin in this application is related to the melting point-as the melting point is lower the gelatin is unlikely to leave a rim around the waterline following bathing.

There may be potential for gelatin in cosmetics beyond delivery systems. In haircare and skincare, the use of proteins is growing. Proteins are generally hydrolyzed into smaller more absorbable units or peptides. Most of the proteins

are vegetable-derived but keratin and collagen are fairly widely used. Gelatin contains all but one amino acid used in the body and therefore it could potentially offer advantages in cosmetics.

OTHER

There are several technical applications for gelatin in various industries such as printing, paper-making, dyes, electroplating and polymerization. In the paper and printing industries gelatins are used in paper-sizing and in photogravure, and screen printing processes. Gelatins can also be used for binding purposes in special papers, such as fiduciary papers and bank notes, papers for bonds, securities and certificates. In electroplating applications gelatin gives a uniform and smooth deposition of the coating.

Technical applications for gelatin based on microencapsulation include the microencapsulation of dyes, used in carbonless copy paper. Gelatin is also used for the microencapsulation of fragrances, especially for use in flyers in advertising samples.

The current manufacturers are developing and promoting new applications for gelatins and gelatin hydrolysates. DGF Stoess is promoting the use of gelatin hydrolysates as plant leaf fertilizers due to the slow degradation which offers gradual release of amino acids and nitrogen. Another novel application is the use of methacrylated gelatin in barrier coating. The methacrylated gelatin is cross-linked by UV-hardening which results in a coating with good oxygen and moisture barrier properties, making it suitable for food flexible packaging, a fast growing market. The use of proteins to reduce the aggressivity of surfactants used in personal and clothing detergents is being investigated by several players in the proteins market. Gelatin is also believed to have potential in this area as its melting point will allow for complete dissolution during normal showering or wash cycles and gelatin is also biodegradable so built-up is not a problem.

PRICES FOR GELATIN BY APPLICATION

Prices for gelatin vary by source and by application but they key determining factors for price tend to the bloom value and the viscosity.

Prices in the photographic industry, which predominantly use bovine bone gelatin, vary widely depending on the grade. Average prices are far higher than for other applications due to the level of purity and testing required. Specialty grades can be as high as €12-13 as illustrated below:

Application	Price range, €/kg	Typical price, €/kg
	Bovine/porcine gelatin	
Cosmetics	4-5	4-5
Food	3-4.5	3.5
Pharmaceutical	4.5-8	5-6
Photographic	7-13	8-9
	Fish gelatin	
All applications	12-18	12-18

MAJOR IDENTIFIED PROCESSORS OF GELATIN AND FISH GELATIN

There are more than 10 gelatin producers in Europe. The leading producers are DGF Stoess, SKW, Delft Sobel and Tessenderlo. The larger producers of gelatin use many different sources and employ both acidic and alkaline processes.

The most important producer of fish gelatin world-wide is Norland in the United States/Canada. Many of the traditional producers of gelatin in Western Europe have invested in the production of fish gelatin to some extent.

Four current producers of fish gelatin, all of which are players in other gelatin types, were identified in Western Europe:

?? Croda

?? SKW

?? Miquel Junca

?? Figli di Lapi

Two other producers in Europe, Weishardt and Reinert have also produced fish gelatin but do not do so on a continuous basis.

The following table gives an indication of the production locations and the types of gelatin produced for the main identified gelatin producers:

Production of gelatin in Western Europe						
		Source of gelatin				
Company	**Production locations**	**Pigskin**	**Pigbone**	**Beef bone**	**Beef hide**	**Fish**
Croda	UK	X		X	X	X
Delft Sobel	NL		X			
DGF Stoess	D, S, UK	X	X	X	X	
Figli di Guido Lapi	I	X			X	X
Geistlich	CH a	X				
Miquel Junca	E	X			X	X
Reinert Gruppe	D	X				
SKW	B, F, E	X	X	X	X	X
Tessenderlo	B, D, UK					
Weishardt	France Slovakia	X			X	

a Ceased production in 2001

Croda Colloids

Croda produces gelatin in the United Kingdom from a variety of sources including bovine-hide and bone, porcine and fish. The company supplies to all applications.

Croda started to look at fish gelatin about ten years ago. In the late 1990s alot of interest developed in the market for fish gelatin. Initially, Croda offered fish gelatin as a niche product for the kosher market for the Jewish Orthodox community. Due to the new level of interest found in the market, the company now foresees an opportunity to build it up to a reasonable level, fuelled by continued incidence of BSE leading to a further switch from beef gelatin.

Croda was not willing to reveal the type of fish used as source of gelatin or provide an estimate of production volumes other than to confirm production volumes are still at niche level. The company is reported to be producing from cold water cod and warm water tilapia, with interest focused mainly on warm water fish. The company indicated its product had very different properties to grades offered by Norland. Gel strength range offered by Croda varies from 150 to 240 bloom value. Problems with taste are believed to have been overcome but odor is not completely absent.

SKW Biosystems

SKW Biosystems will be acquired by Delft/Sobel from Degussa. The deal is expected to be finalized by the end of March 2002. SKW Biosystems is currently the leading supplier of gelatins world-wide, accounting for approximately 20% of the global market. SKW is the number one player in pharmaceutical and photographic applications and ranks second in the food industry. In the food industry, SKW's main focus is in the area of confectionery. Beef bone and hide, pigskin and bone sources are used, for the production of some 50,000 tonnes of gelatin.

SKW also produces fish gelatin from fish skins. The company is using a variety of cold and warm water species. It is understood that the company has a particular interest in tuna fish skins as its source. SKW regards its fish gelatin as a niche product and production volumes are small, probably not more than 100 tonnes. The company does not anticipate strong growth for fish gelatin due to the lack of availability of raw materials and high production costs due to low yields.

SKW is also researching the use of poultry skins or bones as a source of gelatin but does not supply poultry gelatin commercially at this time.

Miquel Junca

Miquel Junca is located in Spain and produces approximately 4,000 tonnes of gelatin per annum. Pigskin is the main source of raw material. About 5 years ago the company started to produce fish gelatin in anticipation of a switch from beef gelatin. But market uptake has been slow and the company now produces less than 100 tonnes of fish gelatin. The grade is similar in viscosity to pigskin grades but the bloom value is lower, reported at maximum 180.

Miquel Junca has found greatest interest in fish gelatin from France. The main application areas are dietetic food with low sugar content and pharmaceutical capsules. The company does not expect fish gelatin to account for a great share of its production in the future as it has found a strong limiting factor to be the availability of raw material.

Figli di Guido Lapi

The Italian company Figli di Guido Lapi produces approximately 2,500 tonnes of gelatin from calfskin and also from pigskin. The company also claims to have commenced production of an odorless, tasteless fish gelatin very recently. Due to the high price, the expectation for volume growth is limited but the company anticipates some interest in niche markets.

Reinert Gruppe

Reinert produces approximately 6,000 tonnes of pigskin gelatin. The company attempted to market fish gelatin and invested in some new equipment for the production of fish gelatin under high pressure. However, the product, although tasteless when dry, gave off-flavours once incorporated into foodstuffs. The company could not find any interest in its product, even in the fish products industry.

Fibrogen

Fibrogen is an American-Finnish company and is offering 'synthetic' gelatin to the market as a development product. The company has developed a method to express the genes for collagen with prolyl hydroxylase so it can produce recombinant collagen and gelatin.

Fibrogen is working on several development projects including the use of recombinant or synthetic gelatin for vaccines as a stabilizer. Also the company has development projects on gelatin use in plasma expanders, hard and soft capsules, gel tabs and woundcare. This product has not yet been commercialized but the success of current projects has led to an expectation of an imminent step in that direction. As recombinant gelatin will be very expensive the company has initially targetted the higher end of the pharmaceutical market.

In due course other areas such as food and nutraceuticals will be considered. The company plans eventually to target functional foods, protein sources in addition to traditional functions for gelatin.

Fibrogen has also considered photographic applications due to the need for a more homogenous, reproducible product. Recombinant gelatin, as it is synthetic, will have a defined amino acid characterization, molecular weight, structure and other parameters. All other gelatins are natural and so can vary by species or due to diet by age etc. Batch to batch consistency and reproducibility can be very difficult to achieve. This offers scope for recombinant gelatin to enter this market

Research on recombinant gelatin is based in Finland and development in US.

Weishardt

Weishardt operates two factories for gelatin production. One in France producing from pigskin exclusively, producing up to 10,000tonnes and a second in Slovakia producing up to a max of 2,500tonnes from beefskin. The company has plans to increase the capacity in Slovakia - the limiting factor is the dryer which has a capacity up to 2,500 tonnes.

Weishardt decided two years ago to attempt the production of gelatin from fish. A batch was produced two years ago which is now being sold off in small volumes. Weishardt's product is priced at about €18/kg. The company has no plans for another production batch as the high price is limiting sales.

Norland Products

Norland is believed to be producing approximately 500 tonnes of fish gelatin. Norland has 5 to 6 different grades. Currently, Norland markets its products for food, and pharmaceutical applications. Norland can vary the molecular weight of the fish gelatin and is known as a supplier of high quality, high viscosity fish gelatins. Grades are kosher. Norland is believed to be supplying Hoffmann-La Roche for microencapsulation applications. The company also has activities in UV adhesives and fibre optics.

Norland products are produced at a sister plant, Kenney & Ross, in Nova Scotia, Canada. The company has been producing fish gelatin for forty years and has been marketing fish gelatin for ingestible applications for twenty years. Norland has done considerable work in the characterization of its gelatins. Typically, its grades have lower proline and hydroxyproline levels than other grades available on the market.

Norland sources its fish gelatin from cold, deep water fish such as cod, haddock and pollock.

Norland sells its products directly to customers in Europe. The main application areas are food and pharmaceutical. Norland indicates that it can only grow its business for cold water gelatin by finding its own markets as its grades can not compete directly with bovine or porcine gelatins.

Photosensitive applications seem to be a key focus of Norland's activities. The company has developed considerable expertise in the use of fish gelatins in photoresists (light sensitive coatings) for the electronic industry-in televisions and color video cameras. Photoengraving applications were the first applications researched by Norland. Volumes used in these applications are minor.

The following table lists the major applications where Norland's fish gelatin is being used:

Product	Application	Information
Dry Fish Gelatin	Food Pharma	Dry product Sourced from cod, haddock, Pollock Low melting point Suitable for liquids, dry goods, frozen or refrigerated products
High molecular weight fish gelatin	Food Pharma	Dry product Sourced from skins of cod, haddock, Pollock Higher viscosity, films tougher films Suitable for frozen or refrigerated or dry products
HiPure	Hair-conditioning protein Silver emulsion support Photoresist coating Graphic arts coating Leather finishing chemicals	Liquid, high molecular weight Suitable for particle suspension, Forms tough coatings Coatings can be rendered water-resistant Deionized (ash<0.1%) No cysteine, little methionine so low sulfur
Photoengraving Glue	Light sensitive applications eg photoresists	High purity Can be made light sensitive with chromium salts Can be rendered insoluble
High Tack Fish Glue	Adhesives	

MAJOR IDENTIFIED CONSUMERS OF FISH GELATIN

There is believed to be only one big consumer of fish gelatin currently in the market: Hoffmann-La Roche for microencapsulation. The company is estimated to account for 60% of the total European fish gelatin consumption, purchasing approximately 300 tonnes annually.

FOOD

Fish gelatin is used to a limited extent in food applications. It is regarded as a niche product as the industry can not support the higher price for general commodity type products. Low melting point grades are used in high energy drinks (e.g. Nutricia FORTSIP and Fresenius Kabi PROVIDE XTRA) and some refrigerated or frozen products such as yogurt or sour cream. Fish gelatin is also used in icing.

PHARMACEUTICAL

Minor volumes of fish gelatin are used to make softgel capsules. Most encapsulators have developed the expertise to handle fish gelatin in the sophisticated process but it is tackier than other gelatins and therefore harder to handle. Encapsulators include RP Scherer, Banner Pharmacaps, Medicaps, Gelkaps, Swisscaps, and Eurocaps. Fish gelatin soft capsules are most popular for nutrition supplements for the French market.

No research of fish gelatin for hard capsules was identified

MICROENCAPSULATION

Hoffmann-La Roche is believed to be the biggest consumer world-wide of fish gelatin. Fish gelatin is used in its microencapsulation of vitamins and other pharmaceutical additives such as azoxanthine. Fish gelatin may also be used in the microencapsulation of colorants. Fish gelatin is not used for microencapsulation of vitamins for animal feed applications. The company holds four or five patents on the use of fish gelatin in this application. These patents are reported to be tight and preclude other players from using fish gelatin in a similar capacity. Current demand is believed to be met largely by Norland.

PHOTOGRAPHIC INDUSTRY

Fuji Photo is currently researching grades of fish gelatin. The aim of the research is to identify a gelatin grade with improved functionality rather than a desire to move away from bovine gelatin. In fact, most of the consumption is expected to continue to be dominated by bovine bone gelatin. An advantage of fish gelatin is that it is deionized which leads to lower conductivity. Grades of fish gelatin under research are free of reducing impurities as these would interact with the silver ions. A concern of Fuji is the batch production cycle for

fish gelatin as batch-to-batch consistency is considered greater for continuous production programs.

Fuji is not sufficiently advanced in this research program to give an indication of the likelihood of success. Initially a couple of specific applications are being researched. The company indicated that, should there be an economic advantage in using fish gelatin it would consider using it more widely, should it prove successful.

WOUNDCARE

No consumers or researchers of fish gelatin were identified in the woundcare industry. B Braun is using some bovine gelatin and therefore is interested in considering alternatives. Synthetic agents are the primary target but fish gelatin might also be considered.

COMPETITIVE PRODUCTS

Gelatin has strong competition in the food industry from various agents, many of which are vegetable-sourced. In pharmaceutical and photographic applications, alternatives are difficult to find. The following table lists competing products which are currently used or under research.

Materials which compete with gelatin by application		
Food		
	Low fat spreads	Pectin
	Yogurt	Pectins, starches, dairy proteins Enzyme to react with milk proteins
	Icecream	Carrageenan, CMC, alginates, carob and guar gums
Pharmaceutical		
	Hard capsules	HPMC
	Soft capsules	HPMC-a Carrageenans-a Starches-b
	Coating	HPMC Povidone Acrylates Other cellulosics
	Plasma expanders	Albumen Dextrans Hetastarch Whole blood
Woundcare	Combination dressings	CMC, pectin, alginates,
Microencapsulation		Fats, oils Maltodextrins, starches Alginates

a-under development

b-recently commercialized

ADVANTAGES OF GELATIN OVER COMPETITVE PRODUCTS

Gelatin is regarded as close to unique in its ability to fulfill the requirements of many industries. Key advantages include:

- ?? Excellent gelling properties, reversible gel formation
- ?? Highly manipulative-available in a wide variety of grades with various combinations of Bloom vale and viscosity
- ?? Transparent
- ?? No smell, no effect on taste of end-product
- ?? Reasonable availability in sufficient volumes
- ?? Relatively inexpensive
- ?? A wealth of data available on compatibility with a wide range of medicines and nutritional supplements
- ?? Melts over a temperature range allowing a window of temperature for the sealing/fusion process in soft gel encapsulation
- ?? Good aerating and foam stabilization properties
- ?? Biocompatible and biodegradable in woundcare

Attitudes to consumption of gelatin have been strongly influenced by BSE over the past ten years. Concern over BSE and animal-derived ingredients is expected to continue to affect the attitudes for some time to come.

In **food** applications where gelatin's properties are not unique, it has been replaced to some extent by other hydrocolloids. Often a combination of other agents is required in order to fulfill the multi-functional behaviour of gelatin. In applications such as ice-cream which was once a big application area for gelatin, formulators have achieved properties such as mouthfeel, creaminess, crystal formation control and other desired effects with other agents. However, in some ice-cream products such as ice-lollies, properties such as drip control are difficult to master without gelatin.

The beverage industry had changed from using gelatin for clarification long before BSE was a serious issue as newer methods allowed for the labeling of 'PURE'.

Jelly, as a dessert, was once a big application especially in the UK, (some 8,000 tonnes), but its consumption has almost completely disappeared, partly due to BSE but also due to the introduction of more sophisticated dessert products and growth in ready-to-serve puddings. (Jelly is still a big application south of the equator.)

However, the food industry appreciates the technical advantages and versatility of gelatin and were it not for BSE, gelatin would have enjoyed a healthy growth pattern over ten years as the sophistication of food preparations has led to an ever-increasing demand on the functionality of the additives and ingredients. Proof of its appreciation of the properties of gelatin, is evident in the switch by some parts of the food industry from bovine gelatin to porcine grades rather than dropping gelatin completely or dropping products which could only be made with gelatin. In such applications where the properties such as texturization and foam or cream stabilization could not be met by other control agents, the industry now uses porcine grades. Some food manufacturers have shifted to porcine gelatin as a temporary measure and eventually plan to avoid it completely once alternatives are found.

As some traditional applications for gelatin decreased, new applications appeared especially in the field of low fat products. Gelatin as a protein is low in calories, and melts in the mouth to give excellent sensory properties resembling fat, making it ideal for low fat products. In low fat spreads gelatin was very widely used at one time and is still used today. However, the sector of the population which looks for low fat products is often the sector which is most concerned over food ingredient sourcing. Also low fat products based on gelatin are not suitable for vegetarians. Therefore, the low fat spread market is moving to other agents.

The **pharmaceutical** capsule market regards gelatin as unique and considers it to be the ideal raw material for capsule formation. However, the industry is actively looking for alternatives with film forming properties which offer the same flexibility, ease of handling, and dissolution profiles. The only major

disadvantage of gelatin is the animal nature of the source. Vegetarians will choose tablets over capsules to avoid gelatin. Muslims and Jewish populations have specific practices too. Therefore, as they are based on gelatin from beef and pigs, capsules can not be offered on a global basis to encompass all races and minorities of the populations.

In **photographic** applications gelatin is expected to continue to be a key component of photographic products. Its behaviour and gelling properties have proved unique in allowing for the development of a wide variety of black and white and colour products. No other agent has matched gelatin in its functionality in this application.

The photographic industry is under little pressure due to BSE or the animal-origin of gelatin. Bovine bone will continue to be the main grade used. Consumption of gelatin will remain in line with general development in the photographic industry. The shift to digital photography will lead to some decrease in gelatin consumption but gelatin is also used in digital photography. The net effect may lead to only a slight lessening in volumes used.

The **cosmetics** industry is not very concerned by the use of gelatin in bath pearls with the exception of BodyShop in the UK which highlights the use of animal-derived gelatin in its bath pearls as the only animal-sourced ingredient used in the BodyShop product range. Gelatin is used mainly in bath pearls which are extension products in fragrance and body ranges, often sold seasonally directed at the gift market. The gelatin shell is not a key ingredient in terms of marketing and many consumers are not even aware of the presence of gelatin in the shell.

Protein use in cosmetics swayed dramatically some years ago towards vegetable-based proteins. Use of keratin and collagen was expected to drop completely out of the market but the industry found this did not happen and keratin and collagen are still used. Should the efficacy of gelatin be proven in skincare or haircare, it may gain market entry. However, volumes are unlikely to be large due to the wide variety of proteins available to cosmetic formulators.

BSE has been a key driving force in consumption of gelatin for ingestible applications. But it is not the only one. Other forces such as desire for vegetarian/halal/kosher/standards are also important. In the past five years there has been a search across the board to find vegetable sourced ingredients as they are perceived to be healthier.

The debate over BSE tends to be cyclic in Western Europe with issues over beef arising with each new case identified. Recent cases in Japan, have raised concerns over the use of gelatin outside Europe and there is a rumour in the industry that BSE will eventually be identified in North and South America too. This will lead to a scarcity of beef raw material which can be certified as safe as is required under current legislation. In fact, in Western Europe more porcine gelatin is used than bovine, and in food applications pigskin is the main source-therefore in reality there is no risk of BSE being contracted by consumers. But the debate over bovine gelatin has tainted all grades and lead to unfounded concerns over pigskin gelatin. At the moment food manufacturers plan to avoid gelatin where possible.

Currently, in the pharmaceutical industry, even technicians believe in the scientific data to show BSE is contractable from gelatin. There is *A Desire to be Safe*, and so the industry is adopting a policy of *zero-risk*. If there is even the slightest chance of a consumer contacting the human form of mad cow disease from gelatin then it must be eliminated if possible. As the majority of gelatin used in the pharmaceutical industry is derived from beef, these concerns have led to intensive research in Western Europe to identify and develop alternatives to gelatin. To date, few alternatives have been available and therefore it has not been possible to eliminate gelatin.

Vegetarians are more and more accommodated in the marketplace and the *suitable for vegetarians* indicator on the label is appearing on more and more products. Similarly kosher or halal products are provided for avoiding the use of porcine or bovine gelatin respectively. However, this is seen as a stop-gap solution as it leads to the development of different products for different markets. Companies would rather use a raw material with global acceptance, thereby allowing the production of global products and brands which are suitable for all sectors of the population.

There is a tremendous level of research to identify or discover potential materials or blends of hydrocolloids to replace gelatin. These could be of plant origin or synthetic. Synthetic options are of interest in particular to ethical pharmaceutical companies-the non-natural basis would not be considered a problem as many drugs are synthetic. In foods the preference is still for natural products.

Synthetic materials could have another advantage over vegetable-sourced ingredients. They avoid any future concerns over plant-based ingredients which may become a focus if the plant has been genetically modified. GMO foods have been highlighted adversely in the press and the dust has not yet settled on this debate.

There is a belief that more cases of BSE will arise in the coming years and therefore the concerns over BSE will not dissipate for some time. Therefore the industry has invested in the generation of scientific data to prove that the human form of mad cow disease is not contractable from gelatin. In December of last year a new study was published and the results are accepted by scientists as evidence of the lack of risk. The manufacturers now hope that the EU will accept these findings and raise some of the limitations on allowable sources of gelatin for food uses. Gelatin manufacturers hope that this step will allow them to bring closure finally to the mad cow debate as they can then market all grades of gelatin as completely safe.

The gelatin manufacturers plan to launch a new marketing offensive on the food industry, backed up by this new scientific data in which there is absolute trust. In the past gelatin manufacturers have aimed marketing and assurances on safety at the food manufacturers level but this time the consumers will be included. Media coverage and press advertising is planned, focusing on the positive aspects of gelatin such as:

- A natural foodstuff rather than an additive
- Allows for the production of low-calory foods
- Source of amino acids, healthy foodstuff
- Helps build strong healthy bones, nails etc
- Good for osteoporosis and arthritis

DGF Stoess is leading this marketing angle and the company has had research completed to show the benefits of gelatin in treating arthritis and osteoporosis. There is belief that gelatin holds much potential as a functional food and will benefit from the current focus on identification and development of new products in this fast-growing market.

Across the industry there is continued research to find new sources of gelatin which might be viewed more favorably. There is much interest across the market in gelatin from fish and poultry. Fish gelatin is already available on the market. Poultry skin and bones are also expected to yield gelatin in the near future. Currently, these are niche products. Poultry gelatin is limited to date by the low yields. Poultry bones are soft and extraction of pure gelatin is difficult. Should a process be established which led to higher yields from poultry, the market would find these grades very interesting.

A potential problem with fish gelatin is in new labeling requirements. In September 2001, the European Commission adopted a proposal to amend the existing EU framework on food labeling (Directive 2000/13/EC) in order to ensure mandatory labeling of certain allergenic substances and to provide more information to the consumer on all ingredients contained in food by abolishing the so called “25% rule” for compound ingredients.

- Current EU food labeling rules require all food ingredients to be listed with the exception of compound ingredients (ingredients composed of several ingredients), which constitute less than 25% of the product. In its proposal, the Commission seeks to abolish this exemption (with exceptions)

?? In addition, current EU food labeling rules do not require the labeling of allergenic substances. Under this proposal for an amendment to the directive, labeling of certain allergens listed under Annex IIIa would be mandatory. This list includes **fish and fish products**

Currently, gelatin is indicated on the label of food products but the source of gelatin is not included. Should this amendment go through, fish as the source of gelatin would have to be indicated. The amendment guidelines indicate gelatin would be included in the list of ingredients, rather than specifically indicated as a potential allergen.

In the **food** industry, the attitude to fish or fish products varies depending on the sector being investigated. Certainly, in fish products fish gelatin would be very acceptable. A key factor in the attitude in other sectors is related to the labeling requirement. If the gelatin source must be indicated, there is considerably more importance attached to the source of gelatin and the consumer acceptance of the source.

In low fat spreads, fish was regarded as acceptable but it would not allow for the production of vegetarian products.

In desserts there is an expectation of a negative attitude to fish products due to the taste and odor from fish which does not suit creamed desserts.

In ready meals the attitude varied –overall fish is regarded as 'healthy' but the vegetarian label requirement would not be met for non-meat based products.

The source of the fish would be important. Recently, there have been reports in the press on the unhealthy state of fish, particularly salmon, bred in fish farms. Fish farming methods have become intense, leading to the development of various fish diseases and unnatural states of health. This has led to fears and concerns over the value of looking to the fish industry as a favorable health option to red meat.

Food processors appreciate the distance between gelatin from fish and the actual fish in terms of purity. Providing the fish gelatin is taste-free and odor-free, fish gelatin would be regarded as a very acceptable alternative to current grades, especially if it offered advantages in functionality. However, if the fish source must appear on the label then the consumer perception will play an important part in their decision on use of fish gelatin. This attitude of consumers will vary by food sector.

In the **pharmaceutical** industry, the opinion on fish gelatin varied widely. Some companies saw gelatin from fish as an attractive alternative as fish is perceived to be 'healthy'. For the production of capsules, pharmaceutical and nutritional supplement houses were concerned that fish would not offer the marketing advantage of vegetarian status. On the positive side, other than vegetarianism, fish gelatin would allow for the production of capsules which could be sold to all markets globally, including the Middle East.

Considerable volumes of gelatin are used in capsules production. This may lead to concerns over the availability of sufficient quantities on a continuous basis.

In **photographic** applications, there are concerns over the source of fish gelatin due to the importance of purity. Photographic consumers must know exactly what is present in the gelatin grade. Bovine animals tend to have a very constant diet which is controlled. There are fears that as the fish diet is dependent on surrounding waters which are subject to current influences, pollution and contamination-chemical or other, the fish could pick-up undesirable components which may be difficult to remove and could prove detrimental to the photographic film or paper. However, if the purity of the grades can be proven

these fears can be allayed. In fact, as some grades of fish gelatin are deionized, they have even lower conductivity than current grades used.

Fish gelatin has been available on the market for many years but to date, the market for gelatin from fish still has remained niche market. Volumes currently consumed are estimated at 1,000 to 1,500 tonnes on a global basis. This compares to a total gelatin market of 250,000 tonnes world-wide. Despite concerns over BSE, consumption of gelatin has grown over the past ten years with growth for porcine and bovine gelatin estimated currently at about 2% per annum. Hoffmann-La Roche is believed to be the largest single consumer of fish gelatin in the world. The company is believed to account for some 30% of the global consumption. The rest of the market is very dispersed.

Fish gelatin has not been able to penetrate the market for the following reasons:

- **Availability:** Large volume consumers are unwilling to commit to fish gelatin unless there is a guarantee of availability of fish gelatin in the required amounts.
- **Price:** Fish gelatin is currently priced in Europe at €12-18/kg, which is three to four times the price of other gelatins. This prohibits its inclusion in many products.
- **The melting point of cold water fish grades:** The low melting point of these grades excludes them from use as a gelling agent in solid, room temperature foods.
- **Odor or off-flavour:** Fish gelatin should be completely neutral in taste even when formulated. Not all producers have succeeded in purifying the gelatin to achieve this.
- **Lack of commitment:** Other than Norland, none of the producers of fish gelatin appear committed to supply of fish gelatin. The main business of the leading gelatin suppliers are bovine or porcine grades. Fish gelatin is added to the range to meet the requirements of customers who will not accept bovine or porcine gelatin. These fish gelatin producers do not appear to wish to attract too much attention to fish gelatin as doing so might raise concerns over other grades.

To enter the market successfully and to gain a significant tonnage, i.e. in the order of some thousands of tonnes, a supplier must address the above factors and limitations.

The greatest volume potential in the short-term is likely to be in the food industry. The pharmaceutical industry, especially in nutritional supplements, also holds potential. The photographic market is more specialized and will be more of a ‘make or break’ nature due to the small number of potential customers.

There will always be some sectors of the food market which will strongly resist fish gelatin as some marketing departments feel fish has a negative image for some products. But across the market there is potential providing:

- Availability can be guaranteed by assurance of supply of raw materials
- The gelatin can be used in liquids and solids across the market. Should the melting point of cold water fish gelatin be modifiable to above room temperature, at least in the high 20s, the potential is greatly expanded.
- Pricing is favorable: The food or pharmaceutical markets can accept a premium of perhaps up to 25% but a higher premium will preclude interest from many food products.

If the melting point of fish gelatin is limited to 10 °C then the potential market will probably be small and primarily

- Aimed at new applications such as health drinks, and
- Frozen or refrigerated goods.

The potential for a given supplier is likely to be only of the order of hundreds of tonnes rather than thousands of tonnes.

But if the melting point can be raised and the other issues with availability and price are addressed, the potential market is far greater. Grades of fish gelatin with higher melting points are already available on the market but are supplied by players which have a stronger desire to prove the safety of beef gelatin and drive the market back towards bovine sources.

In the food and pharmaceutical markets, in applications in which gelatin can not be replaced by other agents, the vegetarian issue can not be solved by fish gelatin but fish as a source is acceptable to the portion of the vegetarian market that avoids red meat and poultry but consumes fish. Fish gelatin, provided it is kosher, is suitable for the Muslim and Jewish populations and so allows for the development of products which can be sold in the Middle East.

The question of labeling as an allergen is not yet answerable as the EU has not yet adopted this directive. Also it is not clear if the label will apply to gelatin from fish or to more directly derived products such as fish oils. Should fish gelatin fall into this Annex, it will be a negative factor but not a show-stopper. With or without a labeling requirement, heavy and active promotion will be necessary to raise the awareness of gelatin sources and the potential to avoid gelatin derived from pigs or cows. The bovine gelatin suppliers are expected to go directly to the press with their next round of marketing, expounding the safety of bovine gelatin, following the completion of the investigations last year. There is also expected to be a focus on the use of gelatin as a protein source for heath benefits for the body and also in haircare products. These offensives by current bovine gelatin suppliers are expected to create an atmosphere of awareness and a greater acceptance of gelatin in general. Once the acceptance of gelatin use is established the source becomes another issue. Whilst fish gelatin is not expected to become as widely used as bovine or porcine grades, it could capture some 5% to 10% market share over time. In Western Europe alone, this would mean a market potential in the order of 5,000 to 10,000 tonnes.