Why Broth is Beautiful--"Essential" Roles for Proline, Glycine and Gelatin

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Several years ago Knox Gelatin introduced a new product named Nutrajoint with great fanfare. This supplement contains gelatin, vitamin C and calcium, and advertisements touted "recent scientific studies" proving that gelatin can contribute to the building of strong cartilage and bones.

In fact, the evidence goes back more than a century, and not only established gelatin's value to cartilage and bones but also to the skin, digestive tract, immune system, heart and muscles.

These early studies, however, have fallen off the radar screen of Knox as well as that of nearly everyone else. So it was not surprising in 1997 when the editors of the *Tufts University Health & Nutrition Letter* advised consumers not to buy Nutrajoint or similar supplements because the idea that gelatin can contribute to the building of strong cartilage and bones "is a theory that has yet to be investigated." As for the theory itself, they sniffed that it "sounds tidy--rather along the lines of 'you are what you eat.'" In conclusion, they stated that even if Nutrajoint worked as claimed, it would be totally unnecessary because "the body can manufacture its own proline and glycine as needed and therefore suffers no shortfall."[1]

The notion that the body can create proline and glycine is, of course, the reason that neither amino is considered "essential." The ability to manufacture them easily and abundantly as needed, however, is probably true only of people enjoying radiant good health.Common sense suggests that the millions of Americans suffering from stiff joints, skin diseases and other collagen, connective tissue and cartilage disorders might be suffering serious shortfalls of proline, glycine and other needed nutrients.

To understand why these nutrients might be so critical to joint health, I consulted several textbooks and learned that hyaline cartilage, the most common type in the human body, derives its strength from a dense, criss-crossing, ropey network of collagenous fibers, and its resilience from the gel-like matrix into which these fibers are embedded.

According to a textbook on bone disorders,[2] proline and glycine play starring roles in the collagenous fibers built from gigantic proteins containing some 1,000 amino acids each. Glycine contributes one-third of the total aminos. Glycine is a tiny amino with a talent for structuring very tightly packed chains. The other aminos that figure prominently are proline and hydroxyproline, an uncommon team with a passion for twisting themselves into tightly wound, left-handed helixes, then switching directions and twisting to the right into a superhelix. These little twisters form tight, tough, rodlike macro molecules, which in turn form thicker rods called fibrils. No wonder cartilage can have such impressive tensile strength.
The remarkable resilience of cartilage comes from its gelatinous matrix. Far from being a jiggling blob of all-natural Jello, this matrix is highly structured with complex

proteins and sugars. Best known are the proteoglycans that wind over, under and around the collagenous fiber network. As the name suggests, these giant molecules are comprised of proteins and sugars. Their primary job is to get and hold water, and they were designed to be very, very thirsty. Accordingly, their elaborate structure includes a central strand of hyaluronic acid on which hang as many as 100 of the biggest proteins found in the body. These in turn, divide into chain gangs known as chondroitin sulfates and keratin sulfates. In electrical terms, these chains carry negative charges and so repel each other. By keeping their distance from each other, they create space for the very water they attract.

Living amidst the proteoglycans are the cartilage cells--chondrocytes--whose jobs are to regulate cartilage metabolism, manufacture the giant proteoglycan molecules and collagenous fibers and build new cartilage as necessary. To do so, the chondrocytes need the right nutrients delivered in the right proportions by the water and synovial fluid that feeds cartilage. Not surprisingly, those nutrient needs include lots of the very aminos that collagen and cartilage are made of: proline and glycine. Although the textbooks don't come right out and say so--and the Tufts editors scorn the very concept--common sense suggests that--cartilage wise, at least--we might very well be "what we eat."

In fact there is solid scientific backing for this common sense observation. Research on proline and glycine is far from a growth industry, but a few good studies exist and serve to clarify the essential nature of these supposedly "inessential" aminos. Most of the researchers believe that both proline and glycine should at the very least be considered "conditionally essential" (along with arginine, cysteine, glutamine, serine, taurine and tyrosine)[3], which means that under most conditions, the body cannot make enough of these compounds and must get them from food. Even more interestingly, this modern research suggests that many of the long-forgotten 19th and early 20th century studies should be looked at anew.

Proline

Evidence is mounting that proline should be classified as an "essential" amino acid. Research shows that plasma levels fall by 20 to 30 percent when individuals in normal health are put on proline-free diets[4] This suggests that the body can produce proline but probably not in sufficient quantities without dietary assistance.

The Tufts editors thought proline deficiency highly unlikely because it is found in virtually all food proteins except lactalbumin, and because few Americans suffer malnutrition from starvation. However, people could still have low proline levels if they consume little protein. This is not only possible but probable in America today, given the popularity of high-carbohydrate, low-protein and low-fat diets. For most of these people the way to bring proline consumption up to par is obvious--add protein to the diet.

Occasionally, however, the problem is not protein intake but the body's inability to metabolize proline into the active form of hydroxyproline. Both acute and a chronic deficiency of vitamin C produce a significant increase in the proline to hydroxyproline ratio in urine,[5] a sign that the conversion is not being made.5 Iron is another needed cofactor and vitamin C is well known to improve iron assimilation.[8, 9, 10, 11] Vitamin C's

function is to maintain the enzyme prolyl hydroxylase in an active form: without this enzyme the proline and lysine in procollagen cannot be hydroxylated.[7]

As one might expect, proline has been recommended as a supplement that might benefit people interested in soft, non-sagging "youthful" skin. Little hard science backs up this idea, but a popular book by Leon Chaitow DO, ND recommends supplementation of 400-1000 mg per day and always along with Vitamin C. Chaitow cites research by Carl Pfeiffer discussed in *Mental and Elemental Nutrients* (Keats, 1975), but not apparently in journals.[12]

A study in the *Journal of Gerontology*, however, begged to differ, concluding that there were "no significant age-related variations in the content of proline, hydroxyproline, lysine and hydroxylysine over the range of 0-93 years of age." What they found was that "changes in cross-links derived from aldehyde may be responsible for the effects of age."[13]

Proline and Vitamin C also team up for other vital functions. Linus Pauling and Matthias Rath have proposed that heart patients with elevated lipoprotein (a) levels take a formula consisting of proline, lysine and vitamin C to help reverse the artery-blocking effects of lipoprotein (a).[14]

Glycine

Glycine might also be considered a "conditionally essential" amino acid.

As the simplest amino acid, it constitutes a basic nitrogen pool for manufacture of other amino acids, and it is used in the synthesis of hemoglobin, creatine, porphyrin, bile salts, glutathione and the nucleotides DNA and RNA. Glycine is involved in glucogenesis (the manufacture of glucose), and low levels may produce hypoglycemic-like symptoms.

Another vital function is detoxification. The human body requires copious amounts of glycine for detoxification after exposure to chemicals, and it conjugates directly with benzoic acid. In that individuals stressed with benzoic acid show inhibition of glutathione synthesis, and glycine is a precursor amino acid for glutathione, some researchers have concluded that glycine might improve the functioning of Phase II hepatic detoxification. "Benzoic acid is used widely in the food industry as a preservative. Under normal circumstances these sources of benzoic acid can be handled with ease at the levels found in the total diet by most normal individuals. However, even these low levels might present a problem to individuals who already have a compromised glycine status in trying to satisfy an increased demand, such as pregnancy or sickle cell disease."[15]

Glycine also helps digestion by enhancing gastric acid secretion. Research published in 1976 established that only proteins stimulate gastric acid secretion, but apparently not all amino acids do so.[16] Glycine is one of those that do, a fact that was known in 1925.[17] The effects of other amino acids and their related peptides on acid secretion has not been determined, but researchers have proposed that "glycine may have application in the design of chemically defined diets for patients with gastrointestinal disorders."[18]

The ability to digest protein obviously plays a vital role in the maintenance of good health. Many popular health writers, including Adelle Davis and Linda Clark, have identified problems caused by widespread hydrochloric acid deficiencies, especially after the age of 40. As Davis put it, "Too little hydrochloric acid impairs protein digestion and vitamin C absorption, allows the B vitamins to be destroyed and prevents minerals from reaching the blood to the extent that anemia can develop and bones crumble." Strong words, but quite possibly backed by the wealth of studies she cites dating from 1939 to 1961.[19]

More recently, Robert Atkins, MD, has taken up the cry. "A lack of stomach acid is commonplace, the result of aging, genetics, use of certain medications and a variety of other factors." Citing 11 studies provided by his chief researcher Robert Crayhon, Dr. Atkins contends that the inability to properly digest protein contributes to asthma, diabetes, food allergies, osteoporosis, iron deficiency anemia, pernicious anemia, candida, rheumatoid arthritis, intestinal infections, psoriasis, vitiligo, hives, eczema, dermatitis, herpetiformis and acne."[20]

Glycine also plays a vital role in wound healing. In a study dating back to 1929, as well as more recent studies, evidence points to "a narrow margin between the metabolic demand for glycine and the rate at which glycine can be formed or made available in the body. A marginal state of glycine availability is probably more common than has been appreciated in the past."[21] In other words, when the body needs glycine for repair, it probably cannot make all it needs, and must obtain additional glycine from the diet.

Researchers at Rutgers University also studied glycine and wound healing. Rats were fed diets with and without supplements of glycine plus arginine or glycine plus ornithine, and the team found that the glycine-plus-arginine combination significantly improved nitrogen retention in both the traumatized and non-traumatized rats. The researchers theorized that glycine and arginine were the most helpful because both "occur in particularly high concentrations in skin and connective tissue and might, therefore, be required in greater amounts for tissue repair." They further speculated that the beneficial effect of arginine-plus-glycine is "related to the creatine synthesis needed for wound healing."[22]

Yet another group of people likely to be short of glycine consists in patients with sickle cell anemia. "In sickle cell disease the ongoing haemolysis creates a demand for glycine of the order of 1-2 gram per day to satisfy the needs of haem synthesis. A normal dietary intake might just provide this amount of glycine, and endogenous synthesis of glycine must be insufficient to satisfy the remaining needs of the body. These people exist in a chronically precarious state with respect to glycine sufficiency."[23]

To meet so many and diverse metabolic demands, glycine must be readily available. The body can make it, obviously, but there are plenty of reasons to think that even normal, healthy people might not be able to make enough. For example, researchers found that the endogenous synthesis of glycine in adult men on low-protein diets failed to satisfy the normal metabolic demand. Studying both glycine and alanine, they found that glycine (but not alanine) synthesis declined when dietary amino acids were removed, especially at the lower intakes. Glycine metabolism (unlike alanine) appears to be "responsive to the amino acid composition of the diet." Although unsure of the exact metabolic and functional significance of this finding,

they concluded that prolonged restriction of dietary nitrogen and/or the supply of glycine and dietary amino acids would probably limit the capacity of tissues to form creatine, prophyrins, purines and glutathione.[24]

Children and pregnant women also need goodly amounts of glycine in the diet. Research indicates that glycine deficiency could limit growth in infants, and stated that the "demands of the growing fetus for glycine are very high, in both absolute terms and relative to other amino acids, two to ten times as great on a molar basis." By optimizing the intake of this amino acid, the outcome of pre-term infants could be improved.[25]

In addition, glycine is the limiting amino acid in children recovering from malnutrition, and it is the limiting amino acid for rapid growth.26 Furthermore, glycine status is an important marker of normal pregnancy. "As pregnancy advances the endogenous production of glycine may be insufficient to satisfy the increasing demands."[27]

Another infant feeding study showed that the sum of free amino acids in plasma increases after feeding and the ratio of glycine to valine falls. The type of meal determines how quickly this happens and how soon before normal levels are restored. Breast feeding as opposed to formula feeding produced faster alteration as well as speedier normalization.[28] This explains why prior to the mid 20th century, doctors recommended the addition of glycine-rich gelatin to the homemade infant formulas that were used when breast feeding was not possible.[29]

Taken together these studies strongly support the idea that if glycine is limited during the early months of life, growth could be limited as well. And once children grow up, the need for glycine does not diminish. As noted above, this little amino acid serves many metabolic functions and is not automatically produced in sufficient quantities by the body.

Gelatin: The Traditional Way to Ensure Adequate Proline and Glycine in the Diet

For many people the simple act of steering clear of low-protein diets and including sufficient protein might do the trick. Protein eaters who still come up short might choose to self medicate by taking proline and glycine supplements, but would be advised to order a custom-blended amino acid formula based on results of an amino acid assay test.

A better solution would be to improve their collagen status by adding gelatin to their diets in the form of gelatin-rich broth used in soups, stews and sauces. This traditional food, which has nearly disappeared from the American table, fits the "you are what you eat" prescription to a T. Manufactured gelatin is also a useful item in that it is nothing less than heat-denatured collagen. However, because manufactured gelatin contains small amounts of MSG, it should be avoided by those who are sensitive to it.

Gelatin is especially rich in proline and hydroxyproline. According to a food industry website, it contains 15.5 and 13.3 grams per 100 grams of pure protein respectively. It also contains 27.2 grams of glycine per 100 grams pure protein. Lysine and

hydroxoylysine needed for collagen synthesis are present in the smaller amounts of 4.4 and 0.8 grams per 100 grams pure protein. Others sources provide somewhat different figures (depending on the ingredients used in gelatin manufacture and the quality of their sources), but they all consistently show high levels of proline, hydroxyproline and glycine.

Gelatin, then, is rich in the proline and glycine components that people need, but weak in methionine, histidine and tyrosine and utterly lacking in tryptophan. Accordingly, textbook writers from the 19th century on have rated gelatin a "poor quality protein." But in spite of its seeming limitations, gelatin was valued for its medicinal benefits for thousands of years and was long considered a panacea for everything from skin and joint disorders to digestive distress to heart ailments.

Gelatin first began to fall out of favor in the 19th century when scientists demonstrated that a diet of bread and gelatin alone could not support life.30 The obvious conclusion--that gelatin is not a replacement for meat or other dietary protein--hardly means that it has no place at all in our diets. On the contrary, a substantial body of evidence exists suggesting that gelatin should have a very big place.

Unfortunately, most of these early studies are hard to locate, having been published in 19th century and early 20th century journals that are not found in most medical libraries. The two most valuable sources are a fascinating 1937 article by Francis Pottenger, MD, on the value of gelatin in digestion, and a copy of an obscure but very valuable 1945 book *Gelatin in Nutrition and Medicine* by N.R. Gotthoffer, Director of Research for Grayslake Gelatin Company, Grayslake, Illinois. In his foreword to this 162-page book, Gotthoffer states that he spent 18 years between 1927 and 1945 studying the scientific literature on gelatin.

Dr. Gotthoffer published his findings several years after Dr. Pottenger announced his theories and research on the value of gelatin in health and digestion with great fanfare in 1937, at the Annual Meeting of the American Therapeutic Society in Atlantic City. "Gelatin may be used in conjunction with almost any diet that the clinician feels is indicated," said Pottenger. "Its colloidal properties aid the digestion of any foods which cause the patient to suffer from ‘sour stomach.’ Even foods to which individuals may be definitely sensitive, as proven by the leucopenic index and elimination diets, frequently may be tolerated with slight discomfort or none at all if gelatin is made part of the diet."[31]

By then, Dr. Gotthoffer had already turned up many earlier studies supporting gelatin’s role in digestion. Early in this century researchers showed that gelatin increases the utilization of the protein in wheat, oats, and barley, though not of corn; that the digestibility of beans is vastly improved with the addition of gelatin; and that gelatin helps the digestion of meat protein.[32] The last appears to confirm the subjective reports of many people who say that meats found in soups and pot roasts--cooked with bones for a long time in a liquid to which a touch of vinegar has been added--are easier to digest than quickly cooked steaks and chops, and why gelatin-rich gravies are at the heart of many culinary traditions.

Confirming recent studies showing that glycine helps infants grow properly, Gotthoffer reports the existence of more than 30 years of research studies showing that gelatin can improve the digestion of milk and milk products. Accordingly,

nutrition textbook writers of the 1920s and 1930s recommended that gelatin be included in infant formulas to help bring cow's milk closer to human milk. Gotthoffer's explanation was that the "curd obtained from the coagulation of woman's milk was softer and more easily digested than that of cow's milk. However, when gelatin was added to cow's milk, a curd of equally desirable characteristics was formed. In addition, gelatin exerted a very important influence on the milk fat. It served not only to emulsify the fat but also, by stabilizing the casein, improved the digestibility and absorption of the fat, which otherwise would be carried down with casein in a lumpy mass." As a result, infants fed gelatin-enriched formulas showed reduced allergic symptoms, vomiting, colic, diarrhea, constipation and respiratory ailments than those on straight cow's milk.[33]

Likewise Gotthoffer found studies showing that convalesing adults who have lost weight because of operations, dysentery, cancer and other illnesses fare better if gelatin is added to their diet. "It is said to be retained by the most sensitive stomach and will nourish when almost nothing else will be tolerated," wrote L. E. Hogan in 1909.[34] One reason gelatin was recommended so highly for malnourished individuals was that it diminishes the amount of complete protein needed by the body.

The "sparing" effects of gelatin on protein were of particular interest to many early researchers. By "sparing protein," they meant that the body is less likely to cannabilize the protein stored in its own muscles, a common occurrence during fasting or during rapid weight loss from illness. Gelatin thus helps keep the body in what today's nutritionists call "nitrogen balance." As Carl Voit, a researcher who spent ten years studying gelatin, wrote in 1872, "By being itself decomposed, it prevented the breakdown of protein in the body and thus exerted its remarkable sparing powers." He found that gelatin alone, however, was not able to build up protein supplies in the body.[35]

Gelatin and Digestion

Voit also found that gelatin improved digestion because of its ability to normalize cases of both hydrochloric acid deficiencies and excesses, and was said to belong in the class of "peptogenic" substances that favor the flow of gastric juices, thus promoting digestion.[36]

Gelatin's traditional reputation as a health restorer has hinged primarily on its ability to soothe the GI tract. "Gelatin lines the mucous membrane of the intestinal tract and guards against further injurious action on the part of the ingesta," wrote Erich Cohn of the Medical Polyclinic of the University of Bonn back in 1905. Cohn recommended gelatin to people with "intestinal catarrh"--an inflammation of the mucus membrane now called irritable bowel syndrome. Interestingly, the type of gelatin used in follow-up experiments done on people with even more serious intestinal diseases was specified as a "concentrated calves foot broth."[37] This form of gelatin would have been rich in cartilage and bone and presumably provide a better amino acid profile than straight collagen.

Today clinical nutritionists see more and more cases of dysbiosis--imbalances of "good" and "bad" bacteria in the intestinal tract. In that the fermentative disturbances that result are linked to allergies to grains and/or excessive

carbohydrate consumption, it is fascinating to find that a researcher named C.A. Herter spoke directly to that point back in 1908:

"The use of gelatin as a foodstuff in bacterial infections of the intestinal tract has never received the attention it deserves. The physician is not infrequently confronted with a dietetic problem which consists in endeavoring to maintain nutrition under conditions where no combination of the ordinary proteins with fats and carbohydrates suffices to maintain a fair state of nutrition. The difficulty which most frequently arises is that every attempt to use carbohydrate food is followed by fermentative disturbances of an acute or subacute nature which delay recovery or even favor an existing infection to the point of threatening life. A great desideratum, therefore, is a food which, while readily undergoing absorption, shall furnish a supply of caloric energy and which at the same time shall be exempt from ordinary fermentative decomposition. Such a food exists in gelatin."[38]

Years later Schwick and Heide found that excess hydroxyproline-containing proteins in serum and urine provides a reliable marker of pathological conditions. They posited that the breakdown of collagen most probably results from an antigenic reaction. "Not so long ago the opinion prevailed that gelatin was not antigenic or immunogenic. However, with the introduction of sensitive immunological methods -- particularly the haemagglutination techniques --antibodies against gelatin could be demonstrated. It was surprising to find antibodies against gelatin in human and animal serum of individuals who had never been injected with gelatin or collagen." Schwick and Heide added that this occurs frequently in cases of rheumatoid arthritis and other degenerative joint diseases. [39]

Though they offered no explanation for this pathological occurrence, many clinical nutritionists report that rheumatoid arthritis and degenerative joint diseases reverse when priority is given to the healing of the GI tract and of "leaky gut" syndrome (in which incompletely broken down proteins cross the mucosal barrier and enter the bloodstream and tissues only to be attacked by the immune system). Because healing protocols generally involve the avoidance of antigenic foods, Schwick and Heide's findings might lead some readers to put gelatin on their already long list of foods to avoid.

However, gelatin is precisely what the turn-of -the-century doctors ordered, not only to heal digestive disorders and the intestinal mucosa but all allergies. Gelatin was even sometimes injected as a plasma or blood substitute.40 More recently, John F. Prudden, MD, DSci discovered that therapeutic doses of cartilage (which always contains copious amounts of proline and glycine) dramatically improved rheumatoid arthritis as well as other degenerative joint conditions and inflammatory bowel diseases.[41]

Additional evidence comes to us recently from a team of Russian researchers. In an article in *Pathophysiology*, they reported that gelatin will protect gastric mucosal integrity, at least in lab rats subjected to ethanol-induced mucosal damages.[42]

Doctors of the past also once knew the value of gelatin in treating celiac disease. In 1924, a researcher named Haas stated that the response of patients to a low-carbohydrate diet in which gelatin "milks" were given at the noon and evening meals was "striking and almost uniformly good results were obtained over a period of about ten years."[43]

Today many people have solved their digestive problems by following the food combining rules popularized in the bestseller *Fit for Life* by Harvey and Marilyn Diamond (Warner, 1985), which was inspired by the work of natural hygiene pioneer Herbert Shelton. Particularly pertinent here is the rule that warns us never to eat protein foods with starches. The reason is that they are supposedly digested on different timetables in the gut, upping the likelihood of indigestion.
Dr. Pottenger, however, found that if gelatin is included as part of the meal, digestive action is distributed throughout the mass of food and digestion of all components proceeds smoothly.[44]

A more recent theory that has helped many people's digestion is laid out in the book Eat Right 4 Your Type by Peter J. D'Adamo (Putnam, 1996). Yet the very grains that Dr. D'Adamo has found to be a problem for people with Type O bloods are easily digested if soaked, then cooked in a gelatin-rich broth. Type A people--who typically lack the abundant secretions of hydrochloric acid (HCl) necessary for easy digestion of meats--find meats far easier to digest if they are served with a gelatin-based gravy, cooked in a gelatin broth or served after drinking a cup of properly made soup and, as we have seen, gelatin may even increase their production of HCl. Finally gelatin can alleviate the allergic reactions and sensitivities that Dr. D'Adamo has related to blood Types B and AB. Thus gelatin not only opens up the dietary possibilities for each blood type but can prove a boon for married couples of different blood types who would obviously prefer to eat the same meals.[45]

Fifty years ago Pottenger pointed out a reason that raw food diets can be so effective in reversing disease and contributing to rejuvenation. "Man's food in the raw state consists largely of hydrophilic (water loving) colloids. The heat of cooking on the other hand . . . precipitates the colloids of our diet. This change in colloidal state alters the hydration capacity of our foods so as to interfere with their ability to absorb digestive juices." Happily for those who prefer their food cooked, Dr. Pottenger went on to explain that this digestive problem could be easily remedied by adding one-half ounce to one ounce of gelatin to a cooked meal of meat, potatoes, vegetables and fruits. [46]

Edgar Cayce--the "Sleeping Prophet" whose extraordinary psychic readings have often anticipated modern medical science by decades--also had good things to say about gelatin and digestion. In his readings he recommended that gelatin be consumed to help the assimilation of vitamins, help the glands function better and to optimize energy and health. Particularly relevant was Cayce's counsel that raw vegetables and salads be eaten with gelatin.[47]

Gelatin and the Liver

Early research has also indicated that gelatin helps the liver. This is plausible in that the liver uses the amino acid glycine for detoxification, and its ability to detoxify is limited by the amount of glycine available. Back in 1935, Reuben Ottenberg, MD wrote in the *Journal of the American Medical Association*: "It has been suggested that the administration of extra amounts of proteins containing an abundance of glycine (such as gelatin) will help the work in the liver. This seems particularly plausible since the recent work of Quick, who has shown that the ability of the liver to perform this protective synthesis is limited by the amount of glycine available."

Ottenberg concluded with the recommendation that patients with jaundice and other liver problems take 5 to l0 grams of gelatin per day either in the form of food or as a powdered medicinal supplement.[48]

Gelatin and Bone Health

Interestingly enough, Gotthoffer didn't find a lot of studies supporting the role of gelatin in joint and bone health, though a 1907 Italian study established that gelatin injections increased the calcium in the circulating blood, which in turn was shown to stimulate bone building.[49]

Recent studies, however, do support such use. A Japanese study reported on protein undernutrition, lowered bone mass and osteoporotic fracture. Mice were fed for ten weeks with a low-protein diet containing either 10 percent casein or a combination of 6 percent casein and 4 percent gelatin. The bone mineral content and bone mineral density of the femur were significantly higher in the group given 6 percent casein plus 4 percent gelatin. The researchers concluded, "these results suggest that gelatin has differential effects on bone mineral density and body weight in protein undernutrition."[50]

A 1999 German study also proved the truth of the saying "*Man ist was man isst*." Their study was inspired by reports of the positive influence of gelatin on degenerative diseases of the musculo-skeletal system and curiosity about the "therapeutic mechanism and the absorption dynamics." Mice fed radioactive gelatin hydrolysate were compared to control mice administered radioactive proline. They found that 95 percent of the gelatin was absorbed within the first 12 hours, and the labeled gelatin found in the tissues was similar to that of labeled proline with one exception--the absorption and accumulation of gelatin in the cartilage was twice as high. This suggested a salutary effect of gelatin on cartilage metabolism that would not occur with the ingestion of proline alone. They concluded, "These results demonstrate intestinal absorption and cartilage tissue accumulation of gelatin hydrolysate and suggest a potential mechanism for previously observed clinical benefits of orally administed gelatin."[51]

In 2000, Dr. Roland W. Moskowitz of Case Reserve University published the results of his review of the literature on collagen hydrolysate in the treatment of osteoporosis and osteoarthritis. He was particularly impressed with clinical studies that suggested that 10 grams of pharmaceutical grade collagen hydrolysate per day were enough to reduce pain in patients with osteoarthrisis of the knee or hip and that gelatin held a significant treatment advantage over the placebo. For bone patients, Moskowitz concluded that studies of the effects of calcitonin (a hormone known to participate in calcium and phosphorus metabolism with and without a collagen-hydrolysate-rich diet showed that calcitonin plus the gelatin inhibited bone collagen breakdown far better than calcitonin alone.[52]

The big question is why so many early studies showing the healing power of gelatin have languished in obscurity. The easy explanation is that after the 1930s, pharmaceutical drugs were widely prescribed for ills that were once healed with gelatin.

A more complete explanation is that many of the results of the early studies could not be replicated. Reading Gotthoffer's compendium, it is evident that one scientist would find that gelatin helps prevent, say, muscular fatigue, the next would find some benefit and a third would see no benefit at all. And so on with anemia, jaundice, ulcers and other ailments. Not being able to repeat and verify results, scientists probably moved on to other substances and apparently never found the key to why gelatin sometimes worked well and sometimes did not.

Why were the studies so variable in their results? The most probable explanation is that the substance described as "gelatin" was not consistent from study to study.

Most commercial gelatins today are brewed exclusively from pigskins or cowhide and so include no cartilage or bones. Years ago, however, some commercial cartilages came from mystery blends of cartilage, bones, skin and other junked animal parts. All these combinations differed in terms of their physical and chemical characteristics and in their physiologic actions. Gotthoffer reported that even glue was sometimes sold as gelatin. Complicating matters further, some of the so-called "gelatin" studies were done with the isolated amino acid glycine.[53]

Given the inconsistencies and hazards of gelatin manufacture, it is no wonder that studies were inconsistent. As for using gelatin today for therapeutic benefits, the highest quality product would come from making gelatin at home using skins, cartilage and bones from organic chicken or meat. As Dr. Pottenger was wont to say: "A big stock pot is the most important gift a bride could receive."[54]

Whatever form of gelatin is used, it should never be cooked or reheated in the microwave. According to a letter published in *The Lancet*, the common practice of microwaving converts l-proline to d-proline. They write, "The conversion of *trans* to *cis* forms could be hazardous because when *cis*-amino acids are incorporated into peptides and proteins instead of their *trans* isomers, this can lead to structural, functional and immunological changes." They further note that "d-proline is neurotoxic and we have reported nephrotoxic and heptatotoxic effects of this compound."[55] In other words, the gelatin in homemade broth confers wonderous benefits, but if you heat it in the microwave, it becomes toxic to the liver, kidneys and nervous system.

Another study suggested that the l-configuration and the proper molecular size are both essential for beneficial effects of l-proline upon memory and for the prevention of depression. [56] There is no reason to think that proline is the only amino subject to this kind of destruction, and it is likely that other aminos would be similarly affected. The studies, however, were done on proline.

Concerned about possible excesses of the amino acids proline and glycine? Humans have shown a high tolerance for both proline and glycine with no ill effects. When people develop problems attributed to an excess of proline, it is the result of a genetic disorder, not the result of food or supplementation. In those few cases excess proline causes renal and central nervous system dysfunction.[57] Glycine excess also can be attributed to a genetic disorder and indicates a very rare genetic metabolism problem that can manifest as severe mental retardation. Although this occurs very rarely, it should be evaluated in any individual who is going to supplement with large doses in pill form.[58]

Not By Gelatin Alone

Historically, gelatin ingestion has caused health problems but nearly all the documented cases occurred when the subjects were fed excessive amounts of gelatin and little else. This occurred quite frequently during the early to mid 19th century when people running hospitals, soup kitchens and poor houses tried to economize by serving gelatin at every meal in the form of bouillon, gelatinous biscuits and other gelatin-based edibles--or inedibles as the case may be. Gelatin bashers have long been fond of quoting one scientific study in which dogs died after a few weeks on a gelatin diet. While it was true that the dogs died, Gotthoffer argued that "no account was taken of the fact that the animals refused to eat the food after a few days."[59]

Remember also that the amino acids in gelatin, like all amino acids, can only be properly utilized when the diet contains sufficient fat-soluble activators--vitamins A and D--found exclusively in animal fats. So don't hesitate to put cream in your broth-based soups and sauces, and include other sources of vitamins A and D in your diet, such as butter, egg yolks and cod liver oil.

These days no one is worried about eating too much gelatin, though a lot of people are worried about eating any gelatin at all. The fear is "Mad Cow" disease. An industry website (it does not reveal its sponsor) states that gelatin today is "hide gelatin," never made from brains, and that processing procedures such as degreasing, acid demineralization, alkaline purification, washing, filtration, ion exchange and sterilization reduce the chance of bovine spongiform encephalopathy to less than zero.[60] Whether this is honest information or a public relations spin, or a little bit of both, is not known, and research into this subject is outside the scope of this paper. In 1992, the FDA took the fear seriously enough to forbid the import of any cow products including gelatin from countries where BSE occurs, but lifted the ban on gelatin in 1997. The main reason was that there have been no cases to date implicating either commercial or homemade gelatin in "Mad Cow" disease or any other neurological disorders.[61]

In favor of gelatin are thousands of years of historical reports and several hundred years of studies, most of which suggest that gelatin-rich broth is the key to turning a quivering blob of ill health into a sturdy specimen of good health. As the South American proverb puts it, "Good broth can resurrect the dead."[62]

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