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Short Communication

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Chitin Nanofibrils: Turning Fishery's Waste into Goods

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Introduction

According to the last FAO report, fisheries and aquaculture remain important sources of food and nutrition for a global population expected to reach 9.7 billion by 2050 [1]. With a global production if 167.2 million tons/year (MT), the capture fishery represented 93.4 MT compared to an increased aquaculture generating 73.8 MT in 2014. It is interesting to underline that world pro capita fish supply reached 20kg in 2014, representing one of the most-traded food commodities worldwide, thus playing an important role in providing food nutrition and employment to current and future generations. This is the positive aspect of the future food problem. The negative ones is represented from the discarded fish that is estimated to represent between 10 and 20% of the global marine fisheries catches [2]. The relative discarded organic materials causing hypoxia and anoxia of the seabed, exert a high biochemical oxygen demand (Fig.1). Thus they affect not only the food security but also the socioeconomic sustainability. Fish discards, in fact, can have direct and collateral effects on ecosystem food web processes and structure, increasing level of this materials in ecosystems and landfill where they are considered hazardous for their high perishability and high polluting effect when disposed off-shore. In addition FAO estimates that, each year, one-third of all food produced for human consumption in the world (~1.3 billion tons) is lost or wasted representing 45% of all fruit, 35% of fish and seafood, 30% of cereals, 20% of dairy products and 20% of meat (Fig.2) [3]. Thus the necessity to ameliorate the food chain from production to distribution and consumption, trying to change consumer behaviours, policies and regulations. Another must of our society should be the plain use of food and industrial by-products to make goods and energy with the goal to produce zero waste [4]. The major utilization of the underutilized chitin as by-product of the fishery' processing go in this direction [5].

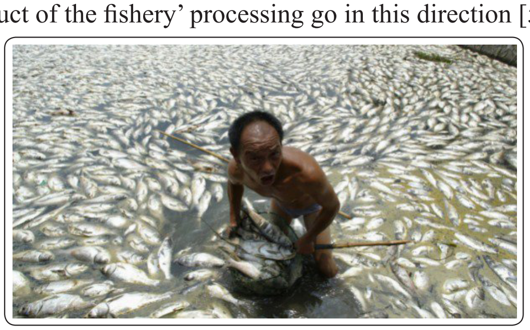

Figure 1: The fish discarded material into the sea

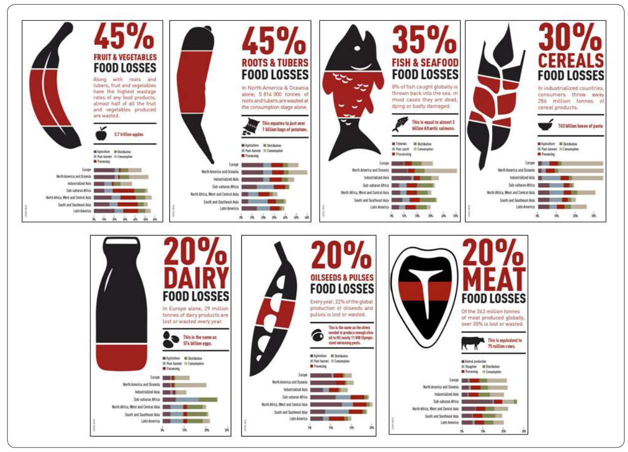

Figure 2: Food waste By courtesy of FAO

Chitin Nanofibrils

Chitin is the second most abundant renewable carbon source in nature after cellulose with a production of over 1 trillion tons per year [6]. It is an N-acetyl-D-Glucosamine biopolymer which, found in the exoskeleton of crustaceans and insect as building material (Fig 3), is also an important and fundamental component of the cell wall of bacteria and fungi [7].

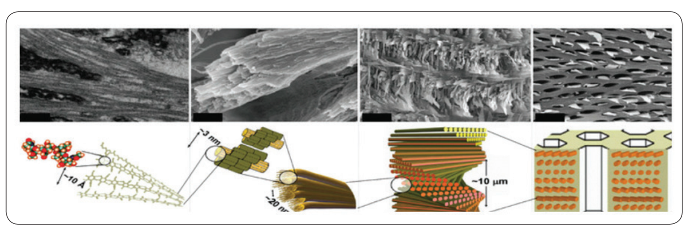

Figure 3: Chitin as building material of crustaceans

As a structural polysaccharide chitin has mechanical strength and other interesting properties, making it a suitable alternative, for example, to many plastic compounds or to be used for medical applications. Because of its linear structure joined to form a crystalline molecule, it presents the same carbohydrate backbone of hyaluronic acid (Fig.4). On the one hand, the chitin-derived chitosan is a deacetylated polymer with one amino group and two hydroxyl groups in the repeating glycosidic residues. On the other hand, cellulose without nitrogen content, possesses different chemical reactivity and water solubility. However, chitin and chitosan are important bioactive molecules to be used as multifunctional bio-based alternative materials in a variety of applications. Thus, due to the positive charges covering their crystalline structures, they can complex many important biological molecules, allowing for adsorption.

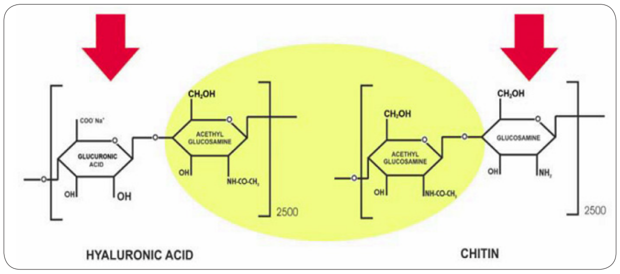

Figure 4: Chitin and hyaluronic acid have the same molecular backbone.

In any way, since the biodegradation of chitin is very low in crustacean shell waste, its accumulation as discard material from crustaceans processing has become an important industrial problem. In fact, it has been estimated that 6/8 million tons waste are produced globally per year and more than 10 giga tons of this sugar-like polymer are synthesized and degraded in the biosphere each year [8,9].

Because of its easy biodegradability to cell useful compounds by "chitinase and human chitotriosidase enzymes", chitin has interesting antimicrobial activity and interesting capacity to accelerate wound healing [10]. However, it is interesting to underline that chitin effectiveness seems to be directly connected to its crystallinity and dimension. Its fragments, in fact, has shown to exert a size-dependent effect on macrophage activity: the intermediate size chitin (40-70 µm) triggers inflammation, its small size fragment (<40 µm) has shown an anti-inflammatory function activating interleukin-10 (IL-10) (Fig.5), while large chitin polymers are biologically inert. For this probable reasons chitin nanofibril (CN), obtained by our group as nanocrystal of a lower dimension of 240x7x5 nm, has shown interesting antimicrobial and cicatrizing effectiveness, when electrospun in nanocomposites for advanced non-woven medications [11-14].

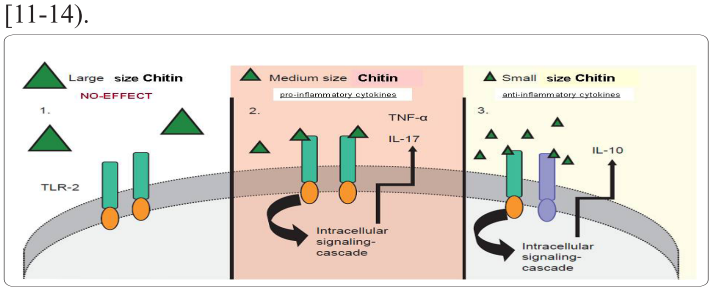

Figure 5: The anti-inflammatory activity of chitin depends on its dimension size

CN complexed, for example, with lignin has been used as filler of natural and synthetic biopolymers to make nanocomposites. These nanocomposites have shown interesting versatile and mechanical properties useful to produce, among others, innovative packaging for extending food shelf life and improving its quality , or to make advanced medications (Fig.6), able to accelerate the cicatrizing process or to produce innovative cosmetic products , all characterized for their biodegradability, compatibility and skin-friendly activity [15-21].

Figure 6: Cicatrizing activity of chitin nanofibrils on burned skin

Finally it is interesting to underline that CN, chitosan and other oligosaccharides of low molecular weight and dimensions are shown to act as plant elicitors having also the ability to induce its defence systems against pests and pathogens [22].

Conclusive remarks

Today, there is a pressing need for innovative and natural materials able to support more efficient technologies and serve different fields from advanced medications, to sanitary products, cosmetics and food packaging. All these raw materials have to be 100% biodegradable, environmental-friendly, skin friendly and possibly obtained from agricultural and food waste by sustainable technologies at a low consume of energy and water.

At this purpose nanotechnology and nano-biotechnology are opening a spectrum of new unsuspected opportunities for its ability to manipulate the material at level of molecule and atoms. The possibility to design biopolymer compounds with a micro/nano organization, architecture and fabrication techniques able to mimic the structures present in nature, will open a new era to make innovative and self-repairing materials of great interest especially in the electronic, agricultural, medical, and cosmetic fields.

Among various materials oligosaccharides as chitin nano fibrils and nano chitosan could represent, in my opinion, the more interesting biopolymers of the next future because made of biocompatible material, easily biodegradable and obtainable in great quantity from waste material at low cost (Fig.7).

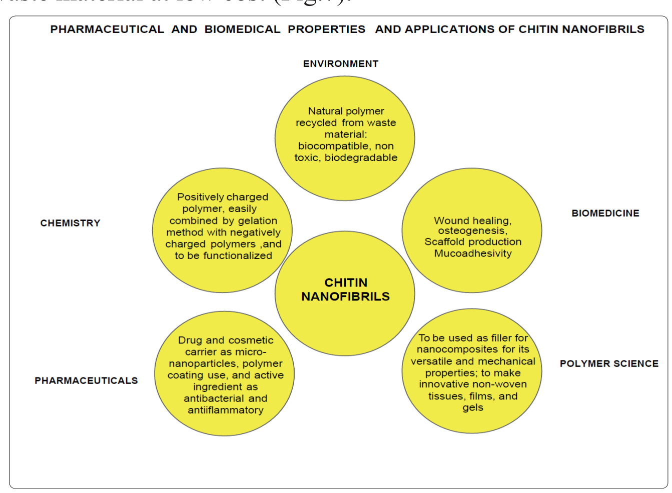

Figure 7: Versatile use of chitin nanofibrils: pharmaceutical and biomedical properties and applications

Acknowledgments

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