ISSN 0975-6299 Vol.1/Issue-4/Oct-Dec.2010

International Journal of Pharma and Bio Sciences

DEXTRAN - THE POLYSACCHARIDE WITH VERSATILE USES

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ABSTRACT

Dextran is the collective term given to a group of bacterial polyglucan composed of chains of D – glucose units connected by alpha – (1 -6) linkages. These polysaccharides are synthesized by a number of bacterial species. The synthesis occurs extracellularly and are catalyzed by a species-specific enzyme, dextransucrase. Dextran is produced at the industrial level by the fermentation of sucrose rich media. Yield of the product depends on various factors like temperature, pH and nitrogen source. Dextran is commercially available and it is used as drugs, especially as blood plasma volume expander. It has found industrial application in food, pharmaceutical and chemical industries as adjuvant, emulsifier, carrier and stabilizer. In food industry dextran is currently used as thickener for jam and ice-cream. It prevents crystallization of sugar, improves moisture retention and maintains flavor and appearance of various food items.

KEY WORDS

Dextran, *Leuconostoc mesenteroides*, food industry, sucrose, dextransucrase ,Dextran sulphate.

INTRODUCTION

Dextran is a complex, branched polysaccharide made of many glucose molecules composed of chains of varying length (from 10 to 150 kilodaltons).The native dextran straight chain consists of alpha – 1,6 glycosidic linkages between glucose molecules; while branches begin from alpha-1,4 linkage (alpha-1,2 and alpha-1,3 linkages as well)(fig.1).

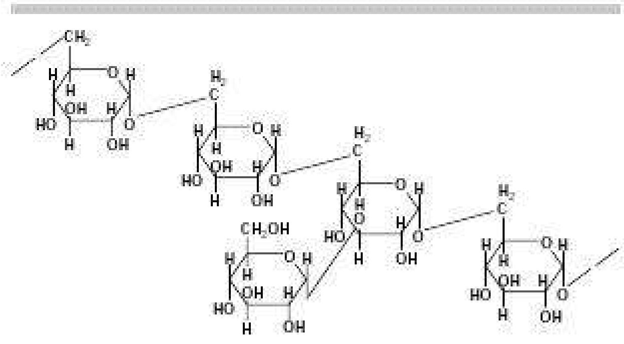

Fig 1. Structure of fragment of Native Dextran molecule.

The polyglucans are synthesized from sucrose by many species of the genera Leuconostoc, Lactobacillus and Streptococcus. Hucker and Pederson(1930) was the first who reported the production of dextran from sucrose by strains of Leuconostoc species. Jeans *et al* (1954) reported the formation of dextran from different strains of bacteria that were primarily Leuconostoc strains. Species of bacteria from other genera have been also found to produce dextran. Soluble and insoluble dextran are produced and molecular weights range from 1.5 x 104 to 2 x 107 and higher.

The microorganisms used for the production of dextran (*Leuconostoc mesenteroides, Saccharomyces cerevisiae, Lactobacillus plantarum, Lactobacillus sanfrancisco*) are currently used in food processing without any restriction(U.S.Food and Drug Administration ,Code for Food Regulations).

Dextran due to its numerous industrial applications it is being produced commercially using the strains of *Leuconostoc mesenteroides* NRRLB – 512F (Shah Ali UL Qadar *et al* 2006).

Using pure components for the fermentation medium in dextran production imposes high costs on the industry, So the economic production of dextran using local and cheap sources of carbohydrates and nitrogen are investigated. Different concentration of molasses and wheat bran extract are used.

Derivatives of Dextran

Dextran sulphate is a low molecular weight derivative of dextran .Its high purity and quality recommend it for many applications in health care sector and molecular biology. It is a polyanion which is freely soluble in water and it forms clear solutions. It is also readily degradable by ecological systems. Dextran sulphate is prepared by sulphating dextran followed by careful purification.

Application of Dextran and its Derivatives

Dextran are used in the manufacture of blood plasma extenders, heparin substitutes for anticoagulant therapy, cosmetics and other products(Leathers *et al* 1995; Sutherland 1996; Alsop 1983; Kim and Day 1994).Another use of dextran is the manufacture of sephadex gel beads which are widely used for industrial and laboratory protein separations(Sutherland 1996).

Medical Uses

Antithrombotic effect: These agents are used to decrease vascular thrombosis. The antithrombotic effect of dextran is mediated by its binding of erythrocytes, platelets and vascular endothelium, increasing their electronegativity and thus reducing erythrocytes aggregation and platelet adhesiveness. Dextran also reduce the VIII-Ag Von Willebrand factor, thereby decreasing platelet function. Clots formed after administration of dextran are more easily lysed due to an altered thrombus structure. By inhibiting alpha – 2 antiplasmin, dextran serves as a plasminogen activator and therefore possesses thrombolytic features.

Apart from these features larger dextrans, which do not pass out of the vessels are potent osmotic agents, and thus have been used to treat hypovolemia. The hemodilution caused by volume expansion with dextran use improves blood flow, thus further improving patency of microanastomoses and reducing thrombosis.

Usage in intravenous fluids: It is used in some eye drops as a lubricant and in certain intravenous fluids to solubilize other factors. Dextran in intravenous solution provides an osmotically neutral fluid that once in the body is digested by cells into glucose and free water. It is occasionally used to replace lost blood in emergency situations, where replacement blood is not available, but must be used with caution as it does not provide necessary electrolytes and can cause hyponatremia or other electrolyte disturbances.

Anticoagulant activity: Chemically prepared sulphuric esters of polysaccharides are known to have anticoagulant action. One of these is the dextran sulphate. The anticoagulant expressed in units/mg appears to be independent of the molecular weight but depends on a certain minimum number of sulphate groups per glucose units.

Clinical grade Dextran are available as Dextran 1,Dextran 40,Dextran 60 and Dextran 70.Solutions of Dextran 40,Dextran 60 and Dextran 70 for injections are commonly used in clinical practice for replacement of blood loss, plasma substitution, thrombosis prophylaxis, volume expansion rheological improvement.

Administariton of Dextran 1 prior to injection of Dextran 40,Dextran 60 and Dextran 70 is known to reduce the adverse reactions significantly. Clinical grade dextran is the safest plasma substitute in clinical use.

Clinical grade dextran are used for different purposes example cryopresevation and solutions for storing organs for transplantation and as carriers in vaccines.

Iron Dextran : Dextran is an important starting material for Iron dextran synthesis. The iron dextran solution for injection is applied for treatment of human and veterinary anemic deficiency.

In Food Industry

Bakery Products: The incorporation of dextran in bakery products improves softness, crum texture and loaf volume. The addition of 2% native dextran increases the water absorption of Lee flour dough by about 12%.William *et al* (1959) reported that displayed unique effects on dough mixing properties.

Confectionery: Dextrans have also been used as additives in products such as candies and ice creams. It has been used as a stabilizer for confectionery where its presence prevents crystallization, improves moisture retention, increases viscosity and maintain flavor .Its use is also proposed in soft drinks, flavor extract, milk beverages and icing compositions.

Ice cream: As edible substances dextrans are bland odorless, tasteless and nontoxic, and are considered to have many advantages over other ice cream stabilizers. Tests performed on ice cream mixes containing 2-4% dextran indicated that it conferred beneficial properties on viscosity.

The suitability of dextran as an ingredient for stabilizing frozen dairy products have been investigated (McCurdy *et al* 1994).The viscosity of dextran solutions (MW <500 000) has been found to display Newtonian behaviour, i.e the viscosity is independent of shear rate. The viscosity of dextran solutions (0-2%) is unaffected by co-solvents, salts or changes in the pH. Dextran solutions do not form gels typical of many other bacterial polysaccharides.

Frozen and Dried foods:

The favourable properties of dextran for stabilizing vacuum, air dried ,and freeze-dried or frozen foods enable the use of dextran in fish products, meat, vegetables and cheese protection of surfaces with a film of dextran could protect food from oxidation and other chemical changes and also help to preserve texture and flavour. The increasing demand for fast food and table reading dishes in frozen or dried state creates an opportunity for the use of dextran as a food preservative, as well as a texture, flavour and smell enhancer.

In Photographic Industry :

Highly purified Dextran fraction are widely used in the photographic industry, where the dextran biopolymers have been shown improve the quality of silver emulsion of photographs.

In the field of Cosmetics :

Dextran and Dextran derivatives have some beneficial applications to the cosmetics as a moisturizer and a thickener, especially Cationic Dextran (CDC) makes complex salts with anionic or amphoteric surfactants, which moderately adsorb to hair and skin to form films having moisturizing effects. CDC is a useful conditioning agents for hair care and skin care products.
Dextran sulfate has the following properties which makes it more favorable for its usage in cosmetics.

- Anti-ageing
- Anti-wrinkle effects
- Smooth fresh ; non-sticky feeling
- Good moisture retention
- Increased lipase activity giving weight-reducing effects and supple skin.
- Anti – inflammatory and anti- allergic
- Treating rough, chapped skin

Anti- inflammatory effects of Dextran sulfates have been demonstrated in various studies (Patrushev and Shekhtman 1973; Giri *et al* 1975 ; Giroud and Timsit 1973; Kocha *et al* 1969 : Von Przerwa and Arnold 1975). Dextran sulfate has beeen found to reduce lymphoblast extravasation in skin sites inflamed (Bellavia *et al.,*1987). The osmotic
retention of water by Dextran sulfate present in tissue will contribute to the well being and mechanical properties of the tissue concerned.

Waste Water Management:

Native Dextran finds a wide range of application in waste water management. Dextran offers many useful features like stable alkali and acids at room temperature. It binds metal ions at alkaline pH and is Biodegradable. The usage of it is also economical. It is used extensively in the waste water treatment during the flocculation process.

Laboratory Uses:

- Dextran is used in some size exclusion chromatography matrices eg: sephadex It is used to make micro carriers for cell culture.
- Dextran preferentially binds to early endosomes fluorescently labeled dextran can be used to visualize these endosome under a fluorescent microscope.
- Dextran has been used in immobilization in biosensors. It can also be used as a stabilizing coating to protect metal nano particles from .
oxidation and improve biocompatibility
- Dextran coupled with a fluorescent molecule (such as FITC) can be used to create concentration gradients of diffusible molecules for imaging and allow subsequent characterization of gradient slope.
- It can also be used as a stabilizing coating to potent metal nano particles from oxidation and improves biocompatibility.
- Dextran is also been used in immobilization in biosensors.
- And in bead form it is used to aid in biosensors applications.

CONCLUSION

From the facts outlined above it appears that Dextran the branched polysaccharide supposedly has many health benefits. Apart from which it contributes to many more applications in technical and pharmaceutical industries too. It has been recognized the necessity to encourage the industrial production of dextran using cheaper substrates considering the economic strategies.

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