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COMPARISON OF VISCOELASTIC PROPERTIES OF CHESTNUT AND ACORN STARCH BY MEANS OF MECHANICAL MODELS WITH AN IN-BUILT SPRINGPOT

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ABSTRACT:
The effect of concentration on viscoelastic properties of chestnut and acorn starch is discussed in the paper. The starch structure was assessed using a rheological fractional standard linear solid model FSLSM in contrary to very simple power-law model usually used in many published papers concerning determination of rheological properties of starch. Rheological parameters of this model were determined and their changes for different concentrations of the two tested types of starch were discussed. The values of the rheological parameter of FSLSM model give a useful of information concerning the elastic properties of materials such as total elasticity of networks, network oscillations, gel stiffness, structure of cross-linking and relaxation time of the materials. The proposed method for the interpretation of rheological measurements of the two types of starch allows for a comprehensive estimation of the analyzed biomaterial structure. The fractional rheological models can be very useful to control the biomaterial structure the needs of the final to meet envisaged product which is particularly significant from the point of view of materials engineering.

KEY WORDS:
fractional standard linear solid model, chestnut and acorn starch, viscoelastic behavior

1 INTRODUCTION

Polysaccharides, including starch, are the biopolymers which due to their physicochemical properties are commonly used in many industrial applications. However, primarily, they find the widest applications in the food processing industry. It is estimated that annually in the world about 60 million tons of starch is extracted from various types of cereals, tubers and root crops, at which about 60% is used in food related applications (e.g. bread, sauces, soups, syrups, ice cream, snacks, meat products, baby food, drinks, and fat substitutes), while the remaining 40% is applied in the production of medicines and in the manufacturing of packaging materials [1]. In food industry starch of various botanical origins has been used for years, e.g. starch obtained from potatoes, corn, wheat, oat, rye, rice, or tapioca, which differs in the shape and size of grains or the content of amylose and amylopectin. The extremely wide applicability is a reason for searching for the new sources of starch, hence studies on starch obtained from kiwifruit (Actinidia deliciosa) [2], banana (Musa paradisiaca) [3], pea (Pisum sativum) [4, 5], but also acorn (Quercus ilex L.) [6–11] and sweet chestnut (Castanea sativa Mill.), etc. can be found in the literature [12–20].

An interesting source of starch is sweet chestnut (Castanea sativa) which should not be confused with the common horse chestnut (Aesculus hippocastanus). Sweet chestnuts contain up to 70% starch, 17% sugar (saccharose), 6% protein and 2% fat. A high content of starch in the chestnut makes it attractive for use in food. Similarly, another interesting source of starch are acorns, i.e. apparent fruits of oak trees (Quercus) composed of a nut and a cupule. Oak seeds, i.e. acorns contain starch and other carbohydrates amounting to 37% and 7%, respectively. They also contain 8.1% protein and 31.4% fat as well as about 7% tannins.

Due to the growing interest in both chestnut and acorns starch, the authors of the present paper have undertaken to analyze the mechanical state of structure of pure paste obtained from chestnut and acorn starch, using the results obtained by Kim and Yoo and Moreira [9, 18] and to explain the effect of the concentration of these two types of starch on the rheological properties

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model. Simpler, power-law rheological models (Equations 1 and 2) used in earlier studies have limited utility to obtain such complete information on the structure of starch pastes.

4 CONCLUSIONS

Analysis of the data obtained using the Zener fractional rheological model allowed us to infer that chestnut and acorn starch pastes are behave like viscoelastic quasi-solid gels. The parameters of the Zener fractional rheological model show that acorn starch has much stronger elastic properties which increases with concentration. Additionally, high values of structure cross-linking power G_N^o indicate a possibility of slowing down the physical ageing of this biomaterial in time. Chestnut starch has also elastic properties but much weaker than the acorn starch. It is also probable that this starch can be unstable in time, its values of G_N^o are much lower than that for the acorn starch. Nevertheless the chestnut starch at a relatively lower overall elasticity and cross-linking power, as compared to the acorn starch, is characterized by high factor of network oscillations k which can be the evidence of its stability and resistance to mechanical action. At the same time it shows that chestnut starch form gels harder than the acorn starch which forms softer and more elastic gels.

It is also worth mentioning that chestnut starch has granules with diameter smaller than the granules of acorn starch, the mean diameter of chestnut starch granules is ca. 13.0 μm at amylose content of ca. 21.5% [16], while mean diameter of the acorn starch granules is about 17.5 μm at amylose content of ca. 31.5% [11]. A higher content of amylose (by 10%) and bigger diameters of granules (by ca. 4 μm) in the acorn starch probably contribute directly to the formation of macromolecular gel with properties determined by a bigger amount of amylose which was released from bigger granules of this starch forming a network composed of combined large numbers of amylose molecules and destroyed starch granules which occurred between its structures. However, it should be emphasized here that the choice between chestnut and acorn starch as a material of the biopolymer matrix depends on the required properties and destination of the formed product.

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