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Evaluation of chemical, morphological, structural and thermal properties of white sorghum starch

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Introduction: Sorghum (*Sorghum bicolor*) is a tropical plant and has the fifth ranking of world cereals production. One of the important aspects of sorghum is drought tolerance and little input need during growth which has made that suitable for cultivation in semiarid regions. Due to the presence of tannin compounds in internal part of sorghum grains and low digestion of cooked protein, sorghum flour consumption is limited. Sorghum grain contains more than 70% starch which is an important tasteless ingredient in food formulas, as the main source of energy and thickening and gelling agent. Extraction of starch from sorghum in regarding to its nutritional problems is a good solution for extension of sorghum uses in food industry. Starch is a semi crystalline structure consisted on linear amylose and branched amylopectin molecules packed in granules. Ratio of these two molecules and their molecular short order and macrostructure and size and shape of granules determine functional properties of starch in the final product. Starch properties is depended on genetic residues so that starches from tubers have distinct differences with cereal starches even obvious differences exists between cereal starches and varieties. In this study we have investigated chemical, morphological, structural and thermal properties of starches four white sorghum line.

Material and methods: White sorghum grains were prepared from local farms with line numbers KDFGS1, KDFGS6, KDFGS9 and KDFGS20. Starches were extracted sorghum lines using alkaline steeping method and further purified using toluene-water-salt solution. Chemical parameters were determined including protein by Kjeldahl digestion method, lipid by soxhlet extractor, ash by burning in furnace, moisture by oven drying and amylose content by iodine binding colorimitry,. Light microscopy coupled with digital camera was used for granules shape and size determination moreover surface properties and morphology of granules was observed using scanning electron microscopy technique. Color of starches were determined with hunterlab colorimeter. To evaluate crystalline structure of sample i.e. type of crystals and degree of crystallinity, starches first were conditioned in desiccator containing saturated aqueous sodium chloride solution at 25°C for a week then X-ray diffraction of sample in diffraction angels from 4-40° was determined. Thermal properties of crystals melting or gelatinization were measured using differential scanning calorimetry of starch in deionized water in temperatures from 20-120°C with heating rate of 10°C/min .From heat flow changes over temperature, temperature of onset, peak and conclusion points of crystalline structure melting and its required enthalpy were calculated. Functional groups of starches were investigated using FTIR technique to observe.

Results & Discussion: Isolated starches had appropriate quality due to low amount of protein (<%0.36), lipid (<%0.11) and ash (<%0.53) and no significant difference was observed within starch samples about impurities, revealed that extraction method effectively separated starch granules from surrounding matrix. Since the apparent amylose contents were between 27.2-30.7%, these starches categorized as normal starches (versus waxy or high amylose starches) and starches from KDFGS6 line had significantly higher amylose content which arose from difference in genetic diversity which caused difference in starch synthetize enzyme led to different synthetizing activity to produce linear and branched alpha glucans. Starches were white with hue angle of 103˚ and 3% color saturation while no differences were observed with LAB color parameters. The color of starches was comparable to values reported for corn starch in literature. Light microscopy images showed that starch granules size distribution were nearly similar but starches from KDFGS9 line had more small granules (diameters lower than 15 µm). The average diameter of starches granules were in the range of 12.07-12.99 µm for different lines which is the smaller than other cereal starches like wheat starch. Scanning electron microscopy revealed that sorghum starches were more spherical or irregular shape and surface pores were also observed. X-ray diffraction analysis showed that starch crystallinity degrees were between 25-31% and all starches exhibited

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A-type diffraction pattern due to strong diffraction at diffraction angles of 15, 17, 18 and 23°, as well as V-type crystal pattern were also observed alongside A type pattern, for some starches. In cereal starches, internal lipids, mostly phospholipids present which can complex with amylose molecules due to hydrophobicity of internal part of amylose helix and aggregation of these complexes can cause diffraction pattern, called V-type crystalline. Crystal melting onset and peak temperatures were 69-70˚C and 73-74˚C respectively and melting enthalpies were between 8-10 J/g. It was observed that starches with lower onset temperature, had higher gelatinization range because of crystal imperfection in that starches. FTIR spectra absorption patterns were similar for all starches with minor differences in absorption values. Also new method of crystallinity calculation based on the absorbance spectra in range of 800-1300 cm-1 were applied on FTIR spectra of starched which not correlation with data had obtained from X-ray diffraction spectra.

Conclusion: Overall conclusion is that starches from white sorghum lines, were slightly different in some properties and for comparison with common industrial native starches, they were similar to normal corn starch according to data published in the literature.

Keywords: DSC, FTIR, SEM, Sorghum, Starch, XRD.