

THE UTILIZATION OF WHEAT HULL ASH FOR THE PRODUCTION OF BARIUM AND CALCIUM SILICATES

P. TERZIOĞLU^{†*}, S. YÜCEL[‡] and D. ÖZÇİMEN[‡]

[†]Muğla Sıtkı Koçman University, Chemistry Department, Kötekli, 48000, Muğla, Turkey.

*pinarterzioglu@mu.edu.tr, pinarterzioglu86@gmail.com

[‡]Yıldız Technical University, Bioengineering Department, Esenler, 34210, Istanbul, Turkey.

Abstract—Wheat is the world's second most produced grain because of its high consumption rate, easy growth, multipurpose use and important role in the human diet. Every year, abundant amounts of wheat hull are obtained after shell process of the wheat as a waste material. Wheat hull, a by-product of the food industry, has low economic value. The utilization of wheat hull ash in various areas of industry can contribute to both financial and waste management strategies. In the present study, wheat hull ash that contains a high proportion of silica (43.22%), was utilized for barium and calcium silicate production. The wheat hull ash based barium and calcium silicate had a BET surface area of 30 and 54 m²/g, respectively. There has been no research on barium and calcium silicate production from wheat hull. So, this study will present originality on this area.

Keywords—Agricultural waste; barium silicate; calcium silicate; silica; wheat hull ash.

I. INTRODUCTION

Today, silica “a chemical combination of silicon and oxygen” has been widely used in pharmaceutical products, ceramics, electronics, polymer material industries, oil refining and detergents, rubber and photoelectric material industries, such as thixotropic agents, thermal insulators, composite fillers and chromatograph column packing (Proctor *et al.*, 1975; Liou, 2004; Zhang *et al.*, 2010). Ultra-fine silica powders can be applied in many technological fields because of their small particle diameter and high surface area (Pijarn *et al.*, 2010). Silicate is made up of silicon, oxygen, and other elements such as aluminum, magnesium, sodium, etc. Sodium silicate, the precursor for silica production is currently manufactured by smelting quartz sand with sodium carbonate at 1300°C (Brinker and Scherer, 1990; Iler, 1979). Although silica and silicates can be produced from different inorganic resources, wheat hull ash is also a source of silicate because it contains high amounts of silica (Terzioglu and Yucel, 2012; Zhang and Khatib, 2008). Therefore, wheat hull ash can be presented as a new renewable silica source and sodium silicate can be produced easily and economically by using wheat hull ash.

Wheat is the world's second most produced and consumed grain. The global wheat production and consumption values are presented in Table 1. Wheat “the raw material of various products such as flour, bread

Table 1. The global production and consumption values of wheat (million tone) (Boyacıoğlu, 2009).

	2006	2007	2008	2009
Production	621	598	609	674
Consumption	625	611	614	647

Table 2. The chemical composition of wheat hull (dry base, %) (Hoseney, 1994).

Material	Ash (%)	Protein (%)	Lipid (%)	Cellulosic material (%)
Wheat hull	2	6	0.5	20

etc.” is also produced in Turkey with high amounts. In 2009, 20 million 600 thousand tons of wheat were produced in Turkey (Boyacıoğlu, 2009; Akbaşı *et al.*, 2010).

Wheat hull is a natural fiber which can be defined as a polymeric compound containing cellulose, hemicelluloses, lignin, protein, starch, lipid and ash (Bledzki *et al.*, 2010). Wheat hull constitutes almost 5% of the total grain which consists of approximately 6% protein, 2% ash, 20% cellulose and 0.5% fat and non-starch polysaccharides (Hoseney, 1994). The results are presented in Table 2 (Hoseney, 1994).

Wheat hull ash is usually obtained by burning wheat hull (the rest of the wheat crust after husking) in air atmosphere. Ash contains mainly K, P, Mg, Cl, Ca, Na, Si and small amounts of Zn, Ni, Mn, Cu, Co, F, Se, Br, I, B and Al. The amounts of these inorganic elements vary depending on environmental conditions, largely on the type of soil, rainfall condition and the type and amount of used fertilizer (Hoseney, 1994). In a study, Zhang and Khatib (2008) investigated the chemical composition and physical properties of wheat hull ash obtained by burning at 450-500°C for production of construction material. It was found that wheat hull ash contains 53.94% SiO₂, 13.23% Al₂O₃, 4.40% CaO, 4.10% Fe₂O₃, and 1.58% MgO (Zhang and Khatib, 2008).

Wheat hull ash is called “waste product of food industry” and it causes environmental pollution because it taken to land fill areas. Wheat hull can be also evaluated to produce biofuels such as biochar and bio-oil (Bledzki *et al.*, 2010; Motojima *et al.*, 1995). Moreover, it was used to produce the fibers of Si₃N₄ by Motojima *et al.* (1995). Wheat hull ash is also used as concrete additive in the construction industry (Mani *et al.*, 2004). The utilization of wheat hull ash in various areas of industry will contribute to both economic and also waste management strategies. Different silica-based materials such as barium silicate and calcium silicate can also be produced from wheat hull ash. Barium silicates are spe-