Process Development of Producing High Isoflavone Soybean Milk Powder by Using Fluidized Bed Drying

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Abstract

Soymilk is becoming more and more popular because consumers become more health conscious and seek out alternatives to dairy products. Basically, soymilk is a water extract of soybeans, closely resembling dairy milk in appearance and composition. It contains high amounts of protein, iron, unsaturated fatty acids, and niacin, but low amounts of fat, carbohydrates, and calcium as compared with cow's milk and human milk. Soymilk is also touted as a healthy food because it is cholesterol and lactose free and contains phytochemicals. It is recommended for those who are allergic to milk protein or have lactose intolerance and those who have special health or religious diet requirements. Furthermore, there is a real interest that soymilk in dried product. A dry powder product is highly desirable since it not only possesses long shelf-life, but also requires relatively low transportation cost and storage capacity and the product can be distributed over a wide area. Thus, a process for producing a dried soymilk powder that is soluble and without loss of nutritive value is highly desirable.

A new develop technology for producing powder materials from suspension, namely fluidized bed drying of inert particle. The drying of pastes and suspensions in fluidized bed of inert partcles is a lower cost alternative to the spray drying, with the same level of product quality. Fluidized bed drying is much smaller volume and floor area than in a competitive spray dryer. This translates into lower investment and operating costs and possibly lowers power consumption. A high drying efficiency results from the large contact area and from the large temperature difference between the inlet and outlet air. The flexibility in the fluid flow regimes, the control of particle agglomeration, drying efficiency, film removal from particle surfaces and powder production should be enhanced in drying of suspensions in fluidized beds of inert particles.

The objective of this research is to study in depth, how the process changes liquid feeds into powder can occur in the fluidized bed dryer of inert particles. Then several specific purposes can be described as follows: (i) determine the drying curve, (ii) study effect of inlet air temperature and inlet air velocity on thermal efficiency, material hold-up, and the residual moisture content, (iii) study the characteristics of powder product includes the proximate analysis (moisture, ash, protein, and carbohydrates), particle size distribution, morphology (appearance, size, and shape), density (bulk, tapped, and particle), porosity, wettability, and dispersibility, and (iv) simulation work for studying the effect of inlet air temperature and inlet air velocity on thermal efficiency.

All the research activities will give five outputs fundamentally scientific and industrially application as contributions, such as: (i) data of type of inert particles,

inlet air velocity, inlet air temperature, mass of feed, concentration of feed, and static bed height as operating parameter for commercially process design, (ii) prototype of fluidized bed dryer including piping, sensors and control system for producing soybean milk powder, (iii) data of drying kinetics for scaling up into industrial dryer scale design, (iv) one international publication within title "Performance Characteristics of Fluidized Bed Drying of Inert Particles for Producing Soybean Milk Powder" will be submitted in Drying Technology Journal, (v) one draft of proposed patent.

The experimental works was conducted in the Food Process Engineering Laboratory, and the Separation Laboratory, Chemical Engineering Department, Diponegoro University from May-October 2009. The fluidized bed drying apparatus was made and has a cylindrical fluidization zone with an inner diameter of 90 mm and a length of 335 mm, made of glass. Air is sucked by a blower by unit from the environment, and heated by electric heater with controllable power up to 3kW allowing air temperatures up to 80 °C. At the dryer inlet, the inlet air to be attained at superficial air velocities up to 15 m/s. The velocity was measured by Anemometer AM-4200. Then the flow rate of air is controlled by valve in which there is bypass line. A porous distributor plate made of zinc and nylon is placed below the fluidisation section. The homogeneously distributed air contacts the inert particles in the fluidized bed. The inert particles were loaded 300 gr is made of plastic spheres with the mean diameter dp = 4 mm. The pulps 50 gr with 20% (wb) of initial moisture content were fed in the bed region from upper side. Dry powder separated from inert particles by attrition iis carried out of the drying chamber with the exhaust air, and separated in between product and air in the cyclone, and finally is collected in a continer. Normally, the processing time is around 30 minutes. For moisture content determination, a 3–5 g sample of soymilk powder was dried in the air convective oven at 98–100°C until it attained a constant mass. In this work, the inlet air temperature was varied between 50-70°C, while air drying velocity is 5.48-6.12 m/s.

For the simulation works, the fluidized bed drying simulator based on two phase model was developed. This program was written in MS Excel by means of Visual Basic. In this simulator, the user can adjust (i) the operation mode (discontinuous, or continuous), (2) the operating conditions of drying air (e.g. temperature, humidity, flowrate, and pressure), (3) the apparatus (i.e. diameter of bed, hold up type, length of bed, number of vessel), (4) the solids (i.e. diameter, density, initial moisture content, total mass, or mass flowrate for continuous mode), (5) indirect heating systems (i.e. with or without), (5) calculation method (i.e. desired residual moisture content, time step of integration).

From the experimental results show that (i) it is technically feasible to obtain quality powder from soymilk dried on the surface of inert particles in the classical fluidized bed drying, (ii) the evaporation process is very fast, occurring in the first two minutes of the drying experiment, (iii) increasing of the inlet air temperature will decrease the thermal efficiency, while increasing of the inlet air velocity will increase the thermal efficiency, (iv) the material hold-up will decreases by increasing of the inlet air temperature or inlet air velocity, (v) the

powder moisture content decreases with an increase in outlet air temperature, and (vi) the dried soymilk powders had low cohesiveness and good flowability. For simulation results give similar trend regarding on the influence of inlet air temperature and inlet air velocity on thermal efficiency.