Chapter 1- Introduction

The background of the study, introduction to organogels, organogelators and the objectives of the thesis were presented in chapter one. Many sensory attributes (e.g., spreadability, mouth-feel, snap, and texture) of fats and oil based foods such as margarine and chocolate depend on the fat crystal network, which is comprised mainly of high-melting fats. Thus far, high-melting fats containing trans fatty acid and saturated fatty acid moieties have been employed. However, the intake of high levels of trans and saturated fats contribute to global epidemics related to metabolic syndrome and cardiovascular disease. These negative health implications can be reversed by altering intake and replacing unhealthy fats with healthier alternatives. Organogels (or oleogels) were introduced as alternative oil-structuring materials that have physical, chemical, and organoleptic properties similar to those of conventional high-melting fats; they are also cost-effective and food-grade and avoid negative health effects.

Organogels are viscoelastic materials comprised of organic gelators and liquid oils and are semi-solid systems in which the liquid oil phase is immobilized by a three-dimensional network composed of self-assembled, inter-twinned gelator fibers. Recently, different types of organogels have been employed in cosmetics, deodorant, and hair-care materials. Such organogels are also significant for food materials, because they may reveal softness, easy handling, sharp melting, spreadability, easy film formation, water-barrier properties, etc.

In this study, we introduce plant waxes as potential edible gelators for organogelation with special attention on rice bran wax (RBX). RBX is highly available, cost-effective, natural gelator obtained as a byproduct in rice bran oil extraction process. The main purpose of the study
was to understand the physical properties of plant wax-vegetable oil organogels using various physicochemical techniques.

Chapter 2- Materials and Methods

This chapter briefly described the materials and different methods used in this research work. Various physical analyses techniques were applied to understand the physical and kinetic properties of plant waxes and plant wax organogels.

Chapter 3- Physical properties of rice bran wax in bulk and organogels

Thermal behavior, crystal structure, and crystal morphology of rice bran wax (RBX) in bulk and oil-wax mixtures were presented and described in this chapter, and compare them with those of carnauba wax (CRX) and candellila wax (CLX). The RBX has high melting temperature with quite large enthalpy of melting compared with CLX and CRX. RBX crystals crystalize in O₁ subcell packing with a long spacing value of 6.9nm. Thin long needle-shaped crystals were observed in the mixtures of RBX and liquid oils; and finely dispersed in liquid oils. The mixture of RBX and olive oil at a concentration ratio of 1.99 wt.% formed organogel, whereas the lowest concentration necessary for CRX to form organogel in olive oil was 4 wt.% and that for CLX was 2 wt.%. The gel structure was formed soon after RBX crystallized, whereas a time delay was observed between the organogel formation and wax crystallization of CRX and CLX. These results demonstrate RBX’s good organogel-forming properties, mostly because of its fine dispersion of long needle like crystals in liquid oil phases.

Chapter 4 - Crystallization kinetics of organogels prepared by rice bran wax and vegetable oils

The kinetics of crystallization and the viscous properties of RBX organogels prepared using different RBX concentrations in salad oil, olive oil, and camellia oil were described in this chapter. The liquid oil type had no significant effect on the thermal properties of RBX. However, the viscosity and the texture of the organogels differed with liquid oil type, temperature, and RBX concentration. Drastic viscosity changes observed in accordance with the onset of crystallization in DSC thermographs. RBX in the olive oil and camellia oil mixtures had higher viscosity than RBX in the salad oil mixture, which correlates with the hardness. Synchrotron radiation X-ray diffraction (SR-XRD) study revealed that the RBX formed crystals with a long spacing of 7.3±1nm and short spacings of 0.41±1 nm and 0.37±1nm. The intensity of the long-spacing pattern was remarkably weaker than that of the short-spacing patterns, which demonstrated strong anisotropy in the crystal growth of RBX crystal particles.
Chapter 5 - Whipping ability of plant wax-vegetable oil mixtures

The whipping or air incorporation ability of the organogels made of plant wax-vegetable oil was described in this chapter. The results revealed that plant wax-vegetable oil organogels have a considerable potential to form whipped oil without any additives. The type of vegetable oil used is not affecting the whipping qualities of the whipped oil. However the type of plant wax used has significant influence in whipped oil formation. Especially RBX has high potential in air bubble formation over CLX. The air bubble forming ability and shape retaining of the whipped oil increased with the RBX concentration. The minimum concentration of RBX required to achieve optimal characteristics of whipped oil is 10% on weight basis with 90% of vegetable oil. Rapid cooling conditions are required to get the optimum qualities of whipped oil. The plant wax-vegetable oil whipped oils are stable over a certain period of time.

Chapter 6 - Synchrotron Radiation Microbeam X-ray Diffraction Study of Gelator Crystals in RBX-vegetable Oil Organogels

The microstructure of RBX crystals in RBX-salad oil organogels observed with a synchrotron radiation small-angle X-ray diffraction (SR-μ-SAXD) technique was described in this chapter. The lamella planes of RBX crystals were parallel to the long-axis of the crystal. The degree of orientation of the lamellar planes of RBX crystals was remarkably higher. These results demonstrate the unique and extreme crystal growth anisotropy of RBX crystals that lead to needle shape morphology.

Chapter 7 - General Discussion

This chapter presents the discussion of the study, representing the different sections of this thesis. Organogels were introduced as alternative oil-structuring materials that have physical, chemical, and organoleptic properties similar to those of conventional high-melting fats; they are also cost-effective and food-grade and avoid negative health effects. From the present study, it has been shown that RBX has high potential as a high-melting lipid material revealing organogel forming and oil-whipping properties due to its unique properties of crystal morphology and network formation. Finally, this chapter presents suggestions for the future studies.