

Simultaneous Heat and Mass Transfer in *Kek Lapis Sarawak* Baking

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Abstract— *Kek Lapis Sarawak* is a specialty of Sarawak. Nowadays, energy becomes a global issue and there is call to minimize energy consumption for a better tomorrow. In cake industry, the use of oven in baking process contributes to the major energy consumption. This research aims to optimize the baking process for an efficient energy consumption. Therefore, it is very important to investigate the relationship between baking temperature, time and cake quality so that the baking process can be optimized. *Kek Lapis Sarawak* baking process has been modelled and simulate using finite element method (FEM). Then, results from the model was validated with experiment. As a result, similar model of the *Kek Lapis Sarawak* baking process has been developed. The finding shows interdependent relationship between porosity, thermal conductivity and moisture content where higher porosity that can lead to poor thermal conductivity.

Keywords— *Kek Lapis Sarawak*, *FEM Simulation*, *Baking Process*, *Thermal Conductivity*.

I. INTRODUCTION

Kek Lapis Sarawak is a special cake from Sarawak with unique cake's pattern and flavor that seizes the world attention [1]. Conventional process of making *Kek Lapis Sarawak* is very tedious and repetitive. Basically, the process consists of five main sequential methods namely depositing, baking, cooling and pressing [2]. Flow process of making *Kek Lapis Sarawak* is shown in Fig 1. Currently, the conventional process mostly used Liquid Petroleum Gas (LPG) for baking. As the industry started to move towards automation there is need to replace the conventional oven with electrical oven for more accurate control of the process.

Electrical oven used higher energy consumption. In the meantime, energy is a global issue and there is demand to minimize energy consumption in every single activity. In the cake industry, the use of oven for baking process is the major energy consumption. The effectiveness of oven usage relies on oven design factors and baking process [3]. Optimization of the oven operating condition is able to contribute significant reduction in energy consumption. Consequently, improve the production cost.

Baking is a complicated process that involves with changing of the physical, biochemical and chemical properties

of the product, throughout the process [3]. Thermal energy during baking is transmitted to the surface of the product by radiation from the oven wall's and by convection from the hot air inside the baking chamber [4-5]. Furthermore, heat transfer from conduction is occurred through internal flux within the product from surface to the center [6]. Defining the baking process in mathematics and phenomenological aspects is crucial as both are correlated with the uniform heating process and with the non-uniform heating process, chemical, physical properties and structural changes of the thermo-physical properties of the system [7].

Transformation taking place during baking when water particles from batter evaporate to the baking chamber that occurs with the increased of batter's volume due to expansion of gas from leavening while pressure of the stream is produced as chain reaction of heat transfer. Thermo-setting of the gluten products leads to the gas expansion, depending on the rheological properties of the batter, fat melting and the amount of starch gelatinization. After all, the crust formation slows down the mass transfer due to browning development [3-15].

Porosity is related to the moisture content of the bread during baking, as porosity increases the moisture content of the bread will decrease [16]. Consequently, the relation between the thermal conductivity with moisture content is directly proportionate to each other [17]. It is stated the values of the thermal conductivity for ground chuck were higher than values for ground beef because ground chuck had a slightly higher moisture content [18]. Moreover, from observation it showed that the water content of meat affects the thermal conductivity because it was the main constituent with higher values than the solid components.

Recently, computer simulation is expected to play a major role in modelling the baking process and proven as one of the most beneficial tools to assist individuals to understand the processes and to forecast phenomenon [19]. Simulation can be distinct as the process designates the real phenomenon without carrying out the experiments. Simulation intent to recognize, control and forecast specific real process [10]. Improvement of the computer's simulation performance with the existence of high processor speeds and RAM, enable integration of