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A comparative study on the performance of sago flour in a deep-fat fried coating system

(Kajian perbandingan terhadap prestasi tepung sagu dalam sistem salutan penggorengan minyak terendam)

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Keywords: sago, wheat, fried batter, gelatinization, deep-fat frying

Abstract

This study was done to determine the performance of sago flour compared to wheat flour in a deep-fat fried coating system. Batter from sago and wheat flour was prepared by mixing the flour with water. Chicken breast, as substrate was battered and fried for 0, 6, 18 and 30 seconds. After each frying interval, samples were analysed for frying parameters, moisture and fat content and gelatinization characteristics. Results showed that, sago batter produced lower viscosity, frying parameters and moisture content, while higher in fat content and gelatinization enthalpy as compared to wheat flour. In conclusion, sago flour was found to be unsuitable as the main ingredient in fried batter systems.

Introduction

Batters commonly have their own unique ingredient composition. However, the basic ingredient for batter is flour. Suderman (1983) reported that ingredients play an important role in batter and breading systems. Wheat flour is the most commonly used flour in batter systems (Loewe 1993).

Frying is a process that involves heat and mass transfer. It also involves heating at a very high temperature. Heating with high temperature can cause starch gelatinization, soften the tissue and denature certain enzyme (Baumann and Escher 1995). Gelatinized starch is the major component of fried battered products (Davis 1983). Heating during frying can cause a lot of physical changes in starch granules, and this leads towards the gelatinization process (Blanshard 1987).

According to Arenson (1969) during frying, starch granules will release the amylose fraction, thus providing a layer of barrier. This barrier acts as an obstacle towards oil absorption and moisture loss of the substrate. Suderman and Cunningham (1983) believed that water existence and ample processing time are the key for a complete gelatinization in coating systems.

In Malaysia, apart from wheat flour, rice flour is often used as an ingredient in batter systems. Another type of flour produced locally in Malaysia is sago. Sago is a starch derived from sago palm, *Metroxylon* spp. and is grown in Sarawak. A well-tended farm can produce 175 kg starch/palm, giving a total yield of 25 t/ha (Maamun and Sarasutha 1987). Sago and tapioca starch are the most commercial processed starch in Malaysia (Lee 1987;

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Tunku Mahmud 1994). Almost 3 x 10^5 tonnes sago starch is produced annually in Malaysia.

Research by Ahmad and William (1998) found that sago starch contains 27% of amylose with 30 μm of its particle size. Sago's gelatinization temperature range is similar to corn starch while its hot paste properties are almost the same as potato starch (Ahmad and William 1998). The use of sago flour as batter ingredient is not a common practice among Malaysians. However, sago flour may potentially be used as a batter ingredient either exclusively or partially with other types of flour.

Several researchers have studied the performance of sago starch in food systems. Tsauri and Trisnamurti (1988) and Hazila et al. (2006) studied the performance of sago flour in bread system. While Zaidah et al. (1994) and Mohd Ariff et al. (1992) reported their findings in sago flour utilization in tebaloi, a Sarawak traditional snack. However, studies on the performance of sago starch used in fried batter systems were not available.

Due to the possible potential of sago flour being used as a batter ingredient either exclusively or partially and the lack of published work regarding the use of sago flour in fried products, this study was conducted to determine the performance of coating systems prepared from sago flour and using wheat flour as control.

Materials and methods

Chicken breasts (boneless and skinless), used as substrate in this study, were bought from Dinding Poultry (M) Sdn. Bhd., Setiawan, Perak. The chicken breasts were thawed in a chiller (0–4 °C) for 24 h and subsequently cut into 4 x 7 x 2.5 cm (width x length x thickness). Sago flour was obtained from Nee Seng Ngeng & Sons Sagu Industries Sdn. Bhd., Sarawak, Malaysia. Wheat flour was obtained from Federal Flour Mills Bhd., Pelabuhan Klang, Selangor. Frying oil used was palm olein (VESAWIT, Yee Lee Edible Oils Sdn. Bhd., Perak).

Batter was prepared according to a flour:water ratio of 1:1. Cut chicken breast substrates were dipped in the batter for 30 s, drained for 10 s and deep-fat fried at 180 °C for 0, 6, 18, and 30 s. After frying, the fried batters were separated from the substrate for analysis.

Surface, internal and oil temperature

A K-type thermocouple connected to a digital thermometer Model TES-1303 (TES Electrical Electronic Corp., Taiwan) was inserted below the surface (3–5 mm), at the centre of the substrate, and then deep-fat fried. Another thermocouple was placed in the frying oil. Temperature of the three locations were recorded every 30 s.

Batter viscosity

Batter viscosity was determined at room temperature using a Brookefield rotational viscometer (Model DV-II, Brookefield Engineering Laboratories, Stoughton, MA, USA). A sample of 100 ml batter was used. Measurement was done using a No. 3 spindle at 20 rpm. Viscosity was recorded in centipoises (cP).

Frying parameters

Coating pickup, cooking yield and cooking loss were measured as described by Hsia et al. (1992) (*Table 1*).

Moisture and fat content

After frying, the coating formed by the fried batter was separated from the substrate. Both coating and substrate were analysed separately for moisture and fat content. Moisture content was determined using oven drying method (AOAC 1984). Fat content was determined using soxhlet apparatus with hexane as the solvent (AOAC 1984).

Coating gelatinization

The coating layer from the fried batter was separated and dried using a freeze dryer (Heto Freeze Dryer CD 8, Heto Lab Equipment A/S, Denmark) for 24 h. A total of 2 g dried coating was defatted by soaking in 100 ml of n-hexane for 1 h. This procedure was repeated two times followed by filtration using a filter paper (No.1, Whatman). Samples were then freeze-dried again for 24 h to expel any remaining moisture. The dried and defatted samples were analysed using a differential scanning calorimeter (DSC) (Mettler Toledo Model 822^e, Switzerland) as according to Yaakob et al. (2001). The gelatinization parameters measured were the onset (T_o), peak (T_p) and end (T_e) gelatinization temperature and also normalized enthalpy (ΔH) of gelatinization.

Table 1 Formula of frying parameters

Frying parameters	Formula
Coating pickup	$\frac{b_1 - b_0}{b_0}$ x 100
Cooking yield	$\frac{b_2}{b_0}$ x 100
Cooking loss	$\frac{b_2 - b_1}{b_0}$ x 100

Source: Hsia et al. (1992)

b_0 = Weight of raw chicken breast
b_1 = Weight of battered chicken breast
b_2 = Weight of fried battered chicken breast

Degree of gelatinization was calculated according to the following formula:

$$\text{Degree of starch gelatinization (\%)} = \left[\frac{\Delta Ho - \Delta Ht}{\Delta Ho}\right] \times 100$$

Where:
ΔHt = Starch normalized gelatinization enthalpy at time t
ΔHo = Starch normalized gelatinization enthalpy at 0 s

Statistical analysis
The experiments were repeated three times and all treatments were duplicated. Standard deviations were used to represent the distribution of the data. ANOVA and DUNCAN were used to analyae all the parameters.

Results and discussion
Temperature profile during frying
Figure 1 shows the temperature profiles for the surface and centre of the sample and the oil during frying. During frying, oil temperature was almost stable at 180 °C. Chen and Moreira (1997) has observed that oil temperature did not change when frying was done on one sample at a time. Surface temperature rapidly increased during

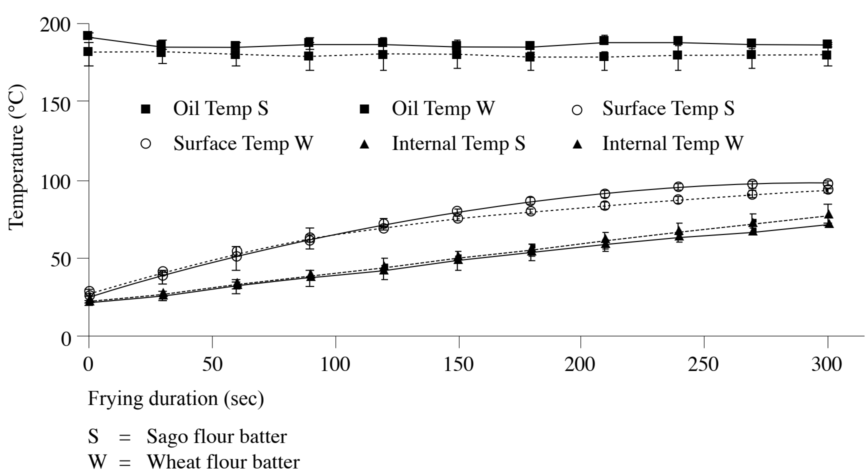

Figure 1. Profile of oil, product internal and surface temperature for sago and wheat flour based batter of chicken breast during deep-fat frying

the early stages of frying due to the heat transfer from the oil to the substrate. Internal temperature also showed a gradual increase during frying but at a lower rate from the surface. The final internal temperature reached 76 °C at the end of frying (300 s). Based on the standard deviations (error bars) of the data, no significant differences were observed during frying between temperature profiles of sago and wheat battered products.

Batter viscosity

The batter slurry from sago was observed to be watery and showing a viscosity of 0.03 x 10^3 cp (*Table 2*). Fasihuddin (1998) reported that sago flour does not mix well with water. Based on the observations during the study, sedimentation of batter would occur if the batter was left without stirring. Suderman (1993) faced a similar problem when using corn flour as batter. It needs continuous mixing to achieve a more uniform viscosity, coating pickup and homogenous sago-based batter.

However, wheat flour batter gave a much higher viscosity reading which was 79 x 10^3 cps. With a flour:water ratio of 1:1, this batter solution from wheat flour gave a dough like batter. Wheat flour needs a higher amount of water compared to sago flour in order to achieve a suitable viscosity to produce an easy to handle batter and uniformly coat the substrate.

Protein content in flour affected the batter viscosity (Lane et al. 1986; Olewnik and Kulp 1990; Sandra 2003). Flour with high protein content needs more amount of water compared to flour with low protein content (Olewnik and Kulp 1990). Protein content in sago flour is significantly lower than in wheat flour (Sandra 2003). Therefore, wheat flour batter has a significantly more viscous reading than sago flour batter if equal amount of water is used. Viscosity adjustment can be made through various ratio of flour:water (Olewnik and Kulp 1990).

Table 2. Viscosity and percentage of coating pickup for sago and wheat flour batter

Batter	Viscosity ($x10^3$ cP)	Coating pickup (%)
Sago flour batter	0.03a ± 0.01	7.0a ± 1.14
Wheat flour batter	79.00b ± 0.14	32.5b ± 1.24

Values are means ± standard deviations (n = 3)
Different letters in the same column indicate significant differences (p <0.05)

Frying parameters

Coating pickup (*Table 2*) refers to the weight increase on coated substrate relative to the weight of the uncoated substrate. Sago flour batter gave an average of 7.00 ± 1.14% of coating pickup compared to wheat flour batter which gave 32.50 ± 1.24%. Sago flour batter produced significantly (p <0.05) lower coating pickup as compared to wheat flour batter. This lower reading of coating pickup may be due to its viscosity. Sago flour batter needs continuous mixing during processing as it tends to settle as sediment in a short time.

The parameter of cooked yield indicates the changes in weight before (after coating) and after frying. The cooked yield of samples battered using sago and wheat flour decreased with increasing frying time (*Figure 2*). At the end of frying, cooked yield for sago and wheat flour batter was 82% and 10% respectively. Cooked yield is

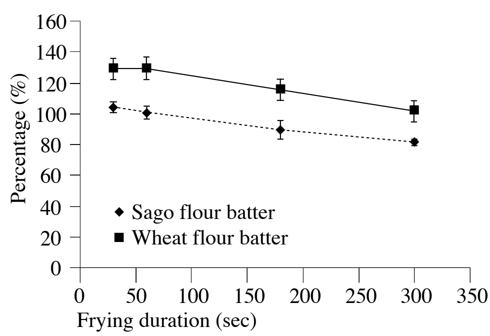

Figure 2. Profile of cooked yield for sago and wheat flour based battered chicken breast during frying

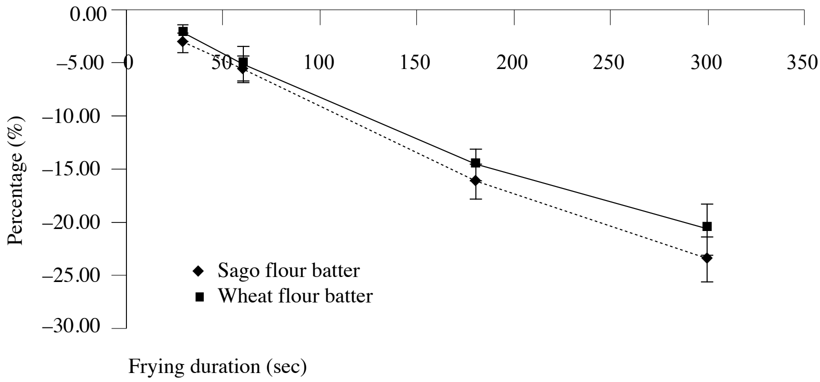

Figure 3. Profile of frying loss for sago and wheat flour based battered chicken breast during frying

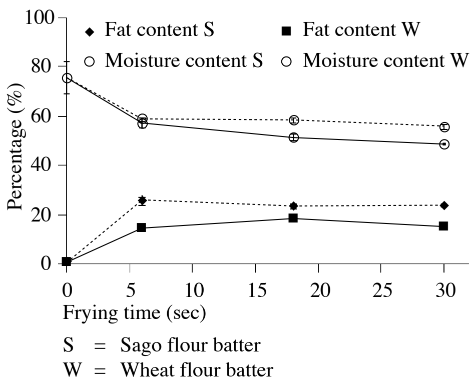

Figure 4. Profile of moisture and fat content of coatings from sago and wheat flour based batter during frying

affected by coating pickup. Sago flour batter had a lower coating pickup than wheat flour batter (*Table 2*), thus the cooked yield was also lower. Yang and Chen (1979) reported that the lower coating pickup percentage was dedicated by the lesser viscosity of the batter.

Frying loss decreased with increasing frying time (*Figure 3*). Frying loss dropped rapidly until the end of frying. At the end of frying process, frying loss for sago flour batter was 23% while wheat flour batter was 21%. The higher frying loss of sago flour batter might be due to its lower coating pickup, resulting in a lower barrier for moisture loss.

Moisture and fat content

Moisture and fat content profile showed an opposite trend during frying (*Figure 4*). During the initial stage of frying, moisture content decreased rapidly while fat content increased rapidly but after frying for 6 s, the moisture and fat content did not show any major changes.

After frying for 6 s, fried sago flour batter gave significantly higher coating moisture and fat content when compared to fried wheat flour batter. At 30 s of frying, the fat content of coatings from sago and wheat flour batter were 23.8% and 15.3% respectively. While moisture content of coatings from sago and wheat flour batter were 55.7% and 48.4% respectively. The lower moisture and higher fat content of coatings from sago flour might be due to the thin layer of coating formed with sago flour.

Coating gelatinization

An opposite trend was observed between gelatinization enthalpy (*ΔH)* and degree of gelatinization of coatings from both sago and wheat starch batter (*Figures 5* and *6*). Gelatinization enthalpy (*ΔH)* decreased rapidly and most of the starch had gelatinized (≈80%) within 6 s of frying, indicating a rapid decline in the amount of ungelatinized starch.

After 6 s of frying, gelatinization enthalpy (*ΔH)* shows further decline but at a slow rate. At 30 s of frying, no

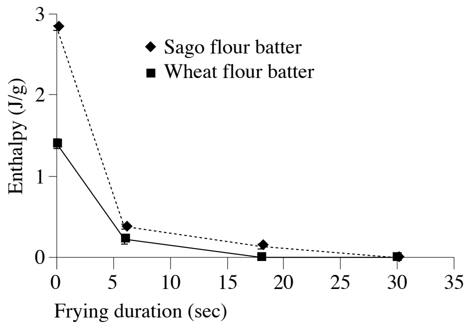

Figure 5. Profile of gelatinization enthalpy of coatings from sago and wheat starch based batter during frying

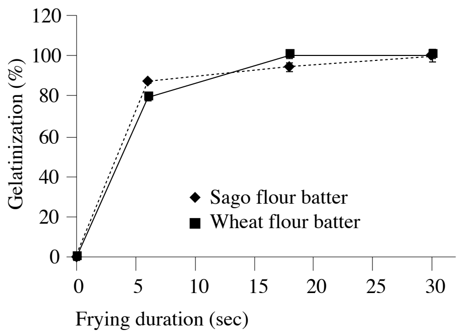

Figure 6. Profile of degree of gelatinization in coatings from sago and wheat starch fried batter during frying

gelatinization enthalpy (*ΔH)* was recorded. This indicated that gelatinization continued to occur after frying for 6 s until 30 s. Sago starch needed more energy to gelatinize when compared to wheat starch. At initial stage of frying, sago starch needed almost 3 J/g to gelatinize while wheat starch needed only about 1.4 J/g to gelatinize which was approximately half of the amount needed by the sago starch.

More enthalpy is required for dense, packed and large starch granule (Cooke and Gidley 1992; Koo et al. 2005). Larger size of starch granule needs more enthalpy to breakdown bonds in the granule (Cooke and Gidley 1992). Granule size of sago starch is larger (30 μm) than wheat starch (10 μm) (Vasanthan and Hoover 1992; Ahmad and Williams 1998). Therefore, higher enthalpy is needed for sago starch to gelatinize compared to wheat starch.

It was observed that coatings from wheat flour batters took 18 s to complete gelatinization during frying. However, coatings from sago starch batters took 30 s of frying time to complete the gelatinization process. Therefore, larger granule size seemed to need higher energy and longer time to complete the gelatinization process during frying.

The gelatinization enthalpy, degree of gelatinization, moisture and fat content were affected during the first 6 s of frying in both wheat and sago batter. The reduced rate of moisture content after 6 s of frying might be related to the near-complete gelatinization from sago (87%) and wheat (80%) flour batters. The gelatinized coating may serve as barrier towards oil and moisture migrations. Higher percentage of sago starch in batter system is needed when compared to wheat starch in order to retard moisture and fat migration during frying.

Conclusion

Performance of sago flour in coating system shows unpromising results. Batter with sago flour absorbs more oil, lower in cooked yield and greater in frying loss when compared to wheat batter. It also had a very low viscosity and percentage of coating pickup. Despite all these, sago flour may be used in batter formulation as a mixture with other flour.

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Abstrak

Kajian ini dilakukan untuk menentukan prestasi tepung sagu berbanding dengan tepung gandum dalam sistem penyalutan bagi produk penggorengan terendam. Salutan daripada tepung sagu dan gandum disediakan dengan mengadun campuran tepung berkenaan bersama air. Daging ayam bahagian dada, digunakan sebagai substrat, dicelup ke dalam cecair penyalut dan digoreng selama 0, 6, 18 dan 30 saat. Selepas setiap interval penggorengan, sampel dianalisis dari segi parameter penggorengan, kandungan lembapan dan lemak, dan juga ciri-ciri penggelatinan. Keputusan menunjukkan cecair penyalut daripada tepung sagu menghasilkan kelikatan, parameter penggorengan dan kandungan lembapan yang rendah, manakala kandungan lemak dan entalpi penggelatinan yang tinggi jika dibandingkan dengan cecair penyalut daripada tepung gandum. Kesimpulannya, tepung sagu didapati tidak sesuai digunakan sebagai ramuan utama dalam sistem penyalutan produk makanan bergoreng.

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