UNIVERSITI PUTRA MALAYSIA

PREPARATION AND CHARACTERIZATION OF STEAMED BUNS INCORPORATED WITH CROSS-LINKED RESISTANT STARCH TYPE-4

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By

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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November 2017

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Steamed buns were prepared from different percentages (5%, 10%, and 15%) of three types of cross-linked (CL) starches as wheat flour substitution. The objectives of the research were to study effects of three types of CL starches at different levels (5%, 10%, and 15%) on physicochemical properties and sensory acceptance of steamed buns. The storage study was also conducted to determine the shelf life of the fortified steamed buns at refrigeration temperature (±4°C) for 15 days. The study was carried out to evaluate the potential of RS as a dietary fibre in a conventional steamed bun and its potential for health benefits in food application without affecting the appearances of the steamed buns produced. Three types of CL starches which were cross-linked potato starch (CLPS), cross-linked corn starch (CLCS) and cross-linked tapioca starch (CLTS) were produced by cross-linking with a combination of 12% sodium trimetaphosphate and sodium tripolyphosphate (99:1) for 3 h at 45 °C under pH 11.5. Cross-linking process demonstrated significant increase of RS and TDF content in the three different types of CL starches (CLPS, CLCS and CLTS) more than 70% compared to their native starches. For pasting properties, the viscosity of the CL starches displayed a significant decrease as CL starches resist swelling much greater than their natives starches. In contrast, CL starches had higher transition temperatures but lower enthalpy values of gelatinization as compared to their native starches for the thermal properties. The gelatinization enthalpy of the CLCS was 13.03 J/g which was lower than CLPS and CLTS (15.27 J/g and 16.21 J/g, respectively). The cooked steamed buns were characterized by physicochemical and sensory properties. The volumes were positively correlated with the protein content, indicating lower gluten formation in fortified steamed buns. Fortification of CL starches in steamed buns had minimized the distribution of air cells in the buns, lowered the volume of

expansion by making them slightly denser. The CL starch-enriched steamed buns had high TDF and RS content (up to 3.8% and 3.05% respectively), improved textural properties and similar sensory acceptance as the control. The addition of 5%, 10% and 15% substitution of CL starch showed no statistically significant on the moisture content of steamed buns but was observed to increase slightly around 0.27-0.7% from the positive control (PF) for CL potato starch enriched steamed buns. Among all the starches, CL corn and CL potato starches had a better overall effect on the physicochemical and textural properties, as well as the sensory acceptance of the steamed buns. For the microbial storage study, the a_w and pH of the fortified steamed buns showed no significant changes. The steamed bun samples kept for 15 days still had total plate count lower than 4.00 log CFU/g which implied that they were safe to consume. Formation of molds only been detected in some samples on day 13 and day 15. The results indicated that CL starches, particularly CLCS and CLPS have potential to improve the nutritional properties of steamed buns with less detrimental sensorial and textural effects as compared to whole wheat flour.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENYEDIAAN DAN ANALISA SIFAT-SIFAT ROTI PAU DENGAN PENAMBAHAN KANJI RINTANG HABA HADAM JENIS-4

Oleh

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Kuih pau disediakan dari tiga jenis kanji rintang haba untuk menggantikan tepung gandum dalam peratusan yang berbeza (5%, 10% dan 15%). Objektif kajian ini adalah untuk menyediakan tiga jenis kanji rintang haba dan mengkaji kesan kanji rintang haba tersebut dalam jumlah peratusan yang berbeza ke atas kesan fizikokimia dan penilaian penerimaan deria roti pau. Kaedah penyimpanan turut dikaji untuk melihat jangka hayat bagi roti pau tersebut. Kajian ini dijalankan untuk mengenalpasti potensi kanji rintang haba untuk penambahbaikan dari segi kesihatan dalam penghasilan makanan tanpa mengubah ciri fizikal pau yang terhasil. Tiga jenis kanji rintang haba iaitu kanji rintang haba kentang, kanji rintang haba jagung dan kanji rintang haba ubi kayu telah dihasilkan dengan kombinasi 12% natrium trimetafosfat dan natrium tripolifosfat (99:1) selama 3 jam pada 45 °C dalam pH 11.5. Proses perintangan haba telah menunjukkan peningkatan jumlah RS dan TDF dalam tiga jenis kanji rintang haba (kanji rintang haba kentang, kanji rintang haba jagung dan kanji rintang haba ubi kayu) melebihi 70% berbanding kanji asal. Untuk keupayaan kepekatan, kelikatan kanji rintang haba telah memaparkan penurunan kerana kanji rintang haba lebih menolak proses gumpalan berbanding kanji asal. Selain itu, kanji rintang haba juga menunjukkan suhu transisi yang lebih tinggi tetapi rendah nilai entalpi jika dibandingkan dengan kanji asal dalam keupayaan termal haba. Nilai entalpi bagi kanji rintang haba jagung adalah 13.03 J/g iaitu lebih rendah daripada kanji rintang haba kentang dan kanji rintang haba ubi kayu (masing-masing dengan 15.27 J/g dan 16.21 J/g). Roti pau yang telah dimasak disifatkan oleh ciri-ciri fizikokimia dan penilaian penerimaan deria. Kadar pengembangan roti pau dikaitkan dengan kandungan protein, menunjukkan pembentukan gluten yang rendah dalam roti

pau kanji rintang haba. Penambahan kanji rintang haba telah mengurangkan ruang-ruang udara di dalam roti pau malah melemahkan kadar pengembangan roti pau dengan menjadikan ia lebih padat. Kanji rintang haba yang diperkayakan dalam roti pau mempunyai kandungan TDF dan RS yang tinggi (masing-masing dengan 3.8% dan 3.05%) serta tekstur roti dan penerimaan penilaian deria yang baik. Penambahan 5%, 10% dan 15% kanji rintang haba ke dalam formulasi roti pau telah menambahbaik dari aspek kelembapan dalam lingkungan 0.27-0.7% daripada roti pau kawalan positif terutamanya bagi pau kanji rintang haba kentang. Di antara semua kanji, kanji rintang haba jagung dan kanji rintang haba kentang mempunyai kesan keseluruhan (sifat-sifat fizikokimia dan tekstur, serta penerimaan penilaian deria) yang lebih baik kepada roti pau. Untuk kajian penyimpanan mikrobiologi, a_w dan pH bagi roti pau yang ditambah baik menunjukkan tiada perubahan ketara. Kesemua sampel roti pau yang disimpan selama 15 hari di dalam suhu penyejukan (±4 °C) masih menunjukkan jumlah kiraan plat lebih rendah daripada 4.00 log CFU/g yang menggambarkan sampel roti pau masih selamat untuk dimakan. Pembentukan kulat hanya dapat dikesan di beberapa sampel roti pau pada hari ke 13 dan hari ke 15. Kesemua hasil menunjukkan bahawa kanji rintang haba, khususnya kanji rintang haba jagung dan kanji rintang haba kentang mempunyai potensi untuk memperbaiki sifat pemakanan roti pau dengan mengurangkan pengubahan tentang penerimaan penilaian deria dan kesan tekstur jika dibandingkan dengan tepung gandum bijian sempurna.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
CL	Cross-linked
CLPS	Cross-linked potato starch
CLCS	Cross-linked corn starch
CLTS	Cross-linked tapioca starch
CS	Corn starch
DSC	Differential scanning colorimeter
EtOH	Ethanol
g	Gram
H_2O	Water
HCl	Hydrochloric acid
HNO_3	Nitric acid
KOH	Potassium hydroxide
MeOH	Methanol
$NaNO_2$	Sodium nitrate
NaOH	Sodium hydroxide
Na_2SO_4	Sodium sulphate
NH_4NO_3	Ammonium nitrate
P	Phosphorus
PF	*Pau* flour
PFCLPS	*Pau* flour mixed cross-linked potato starch
PFCLCS	*Pau* flour mixed cross-linked corn starch
PFCLTS	*Pau* flour mixed cross-linked tapioca starch
PS	Potato starch
RS	Resistant starch
RVA	Rapid Visco Analyzer
SEM	Scanning Electron Microscopy
STMP	Sodium trimetaphosphate
STPP	Sodium tripolyphosphate
TDF	Total dietary fibre
TS	Tapioca starch
U	Enzyme unit
v/v	Volume per volume
w/w	Weight per weight
WWF	Whole wheat flour
mg	Miligram
µL	Microlitre
µM	Micromolar
°C	Degree Celcius
%	Percentage
min	Minute
h	Hour
pH	Potential of Hydroxide

CHAPTER 1

INTRODUCTION

According to the World Health Organisation (WHO) Non-Communicable Disease Country Profile in 2011, Malaysians are the most obese amongst citizens of South-East Asian countries leading by 44.2 % (Alwan A., 2011). The numbers are alarming as Malaysians that have body mass index (BMI) of over 25 are considered as overweight or obese. Malaysia is now facing an upward rush of non-communicable diseases such as diabetes and cardiovascular diseases (Kiew and Chong, 2013). Malaysians enjoys roti canai, nasi lemak, capati and traditional kuih as their staple food that contain high carbohydrates, sugar, and oil but low in fibre intake. Malaysia Reference Nutrient Intake (2005) recommended 20-30 g of dietary fibre per day for all age groups, but still Malaysians cannot achieve this. Therefore, it is crucial to incorporate more dietary fibre into Malaysians daily diet.

Dietary fibre is known to positively influence the functioning of digestive tract, microbial flora and blood cholesterol level. Being included in the fibre group, resistant starch (RS) displays hypoglycaemic effect that is similar to the health benefit of fibre. RS also has low water holding capacity, fine texture, white colour and tasteless, as opposed to other conventional fibre (Fuentes-Zaragoza et al., 2010). Resistant starch (RS) has received attention for both its potential health benefits and functional properties. Another positive advantage is its lower impact on the sensory properties of food compared with traditional sources of fibre, as whole grains, fruits or bran (Fuentes et al., 2010).

RS is categorized into five types, RS1, RS2, RS3, RS4, and RS5. RS1 is the physically inaccessible starch normally found in whole grains; RS2 consists of ungelatinized resistant granules, and RS3 is retrograded or recrystallized starch. RS4 is chemically modified starch with additional chemical bonds formed (Sajilata et al., 2006) and RS5 is amylose-lipid complex (Brown et al., 2006).

Enrichment of famous Malaysian foods with resistant starch is a good way to ensure Malaysian community consumes high fibre food for prevention and management of overweight problems. As being a well-known delicacy in Malaysia among all races, steamed bun or pau is selected to be enriched with resistant starch. In Malaysia, steamed bun is usually eaten for breakfast or tea time. The popularity of steamed bun is due to the fact that the cooking process does not involve cooking oil and other means of introducing ‘fats’ into the food. It is perceived as a healthy food because it is cooked by steaming method. Basically, steamed bun is made from soft wheat flour, water, yeast, and vegetable shortening and originated from northern China where the supply of wheat is high because of wheat growing areas (Rubenthaler et al., 1990). Beside wheat flour, there is an attempt to produce steamed bun using whole wheat flour that has gained much attention among health-conscious consumers but it showed poor appearances of the bun such as darker in colour and crumbly texture.

Health-conscious people always find new ways to improve health. The awareness has become a trend due to the aging process of the population and limitations of modern medicine. Doubts surrounding lifestyle and diet along with the growing interest in functional foods and neutraceuticals also have contributed to this trend. Researches on functional foods in the past decades were focusing on vitamin fortification. Later, the focus has changed to enrich food with dietary fibre (Foschia et al., 2013). However, usage of traditional fibre, for example, whole wheat flour and bran in a steamed bun may cause undesirable changes in the physical properties of the product such as harder texture, darker colour, have distinct fibre taste and gives out a very low specific volume (Seyer and Gélinasy 2009). These changes will negatively affect the overall acceptability of consumers. Hence, fortification of steamed bun with RS is a good option because RS has a fine texture, white in colour and tasteless. The appearance of steamed bun would be more appealing to consumers with the benefits of additional fibre.

The study was carried out to evaluate the potential of RS as a dietary fibre in a conventional steamed bun and its potential for health benefits in food application. The selection of RS4 was based on factor that RS4 is more convenient to be produce by chemical modification using cross-linking agents with almost accurate amount of RS compare to RS3. In contrast, production of RS3 requires longer process (cooking and refrigeration) and the amount of RS produced is inconsistent. RS4 were produced by cross-linking three types of starches (potato, corn, and tapioca) with a combination of 12% sodium trimetaphosphate and sodium tripolyphosphate for 3 h at 45°C under alkaline condition. The proximate composition, amylose content, RS content, total dietary fibre (TDF) content, phosphorus content, pasting properties and thermal properties of cross-linked (CL) starches were determined. Steamed buns were incorporated with 5, 10, and 15% RS4 and the physicochemical, textural, and sensory acceptances of steamed buns were evaluated.

The objectives of the study were divided into three parts:

I. To prepare and characterize the chemical, pasting and thermal properties of three types CL starches.
II. To evaluate the effect of CL starch at different percentages on the physicochemical properties of steamed buns fortified with CL starch.
III. To determine the sensory attributes acceptability and storage study of steamed buns fortified with CL starch.

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