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Dissimilarity Analysis of Wheat Dough of Different Final Thermal Processing Techniques Based on the Chemical Composition and Starch Hydrolysis

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Abstract. Due to technical availability, different thermal processing techniques has been adopted to finalise the preparation of wheat-based dough in Indonesia. This study aimed to compare dough that have been prepared using different final thermal process namely baking, frying, and steaming. Chemical composition and starch hydrolysis of the dough were used as the basis of the comparison. The chemical composition comprising solid, protein, and lipid were analysed by mean of gravimetry, Kjeldahl, and solvent extraction methods respectively. Subsequently, dough was subjected to hydrolysis in a mixture of alpha-amylase and glucoamylase for 60 min at 37 °C at an optimum pH and enzymes ratio. At the end of reaction, glucose release was assayed by mean of glucose oxidase to indicate the degree of hydrolysis. Pattern recognition analysis was then conducted by mean of principal component analysis (PCA) on the chemical composition and the starch hydrolysis to observe the dissimilarity and similarity among the products. As results, the first and the second principal components were able to explain 88% of variances determining the dissimilarities of the three products. Briefly, fried product was found to be associated with solid, lipid, and starch hydrolysis and is distinct compared to the other products. Furthermore, baked product was found to be associated with protein. Thus, dough prepared under baking, steaming, and frying as final processes do have dissimilarities in chemical composition and starch hydrolysis.

INTRODUCTION

Wheat-based doughs are not Indonesian authentic as the plant does not grow in the country. However, wheat-based doughs have gained popularity in the community. Food is product of living style and socio culture and so are the preparation and type of processing. In Indonesia, wheat-based doughs are available in products made by different type of processing such as baking, steaming, and frying. While baking is well known as an authentic processing of bread, steaming and frying are considered as of Asian authentic.

Bread is a product of wheat flour processing. The unique property of wheat flour is the presence of gluten [1]. Gluten and starch in wheat flour form network matrix that are elastic and expandable during dough preparation [1, 2]. Enzymatic hydrolysis of starch is an important nutritional property of starch [3, 4]. Enzymatic hydrolysis indicates the digestibility of starch [5]. Enzymatic hydrolysis of starch is influenced by the microstructure of starch [6, 7]. As a semicrystalline granular structure, starch microstructure is influenced by processing. Major status of granular phases namely semicrystalline, gel, and retrograded transform at different level during processing that depend on the type and intensity of thermal processing [8, 9]. The enzymatic hydrolysis of starch is also influenced by the presence of

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other substances such as protein [10, 11, 12], lipid [12, 13], and another micronutrient such as polyphenol [14, 15, 16].

In this study, commercial wheat products that have been undergone different final processing namely baking, frying, and steaming were investigated for their starch hydrolysis and chemical composition. The dissimilarity of the three types of products were then analysed.

Product characterisation and comparison is an important step in product design and development. Products comparison have been mostly conducted based on univariate data, such based on protein, lipid, starch, sensory etc by mean of analysis of variance (ANOVA). Such approach frequently faces difficulties when come into conclusion and decision-making. Therefore, the current study used a multivariate data analysis approach called principal component analysis (PCA) to integrate the quality attributes of dough under the study to lead to a conclusive interpretation regarding their dissimilarity.

MATERIAL AND METHODS

Samples Selection and Analysis of their Chemical Composition

Wheat-based dough undergone different thermal processing namely baking, frying, and steaming were collected from one of the most popular bread manufacturers in the city of Semarang. Subsequently, the chemical composition of the products namely solid, protein and lipid were analysed by mean of gravimetry, Kjeldahl, and organic solvent using Soxhlet respectively. The analysis of chemical composition was conducted in triplicate.

Experiment and Analysis of Starch Hydrolysis

A hundred milligram of sample was transferred into a beaker glass containing 10 mL of a mixture of alpha-amylase (Novozyme, Denmark) and glucoamylase (Novozyme, Denmark) in a predetermined optimum ratio. The mixture was then shaken on an orbital shaker (KJ-201BS, China) for 60 min at 37 °C in an incubator at a predetermined optimum pH condition. Subsequently, glucose release in the mixture was assayed by mean of glucose oxidase (Allmedicus, Korea) to observe the degree of starch hydrolysis. The experiment of starch hydrolysis was conducted in triplicate.

Data Analysis

The data of chemical composition and the starch hydrolysis of the dough products were then subjected to pattern recognition analysis by mean of Principal Component Analysis (PCA) to determine the similarity and dissimilarity of products. The PCA analysis was conducted using Chemoface software v1.64 (Lavras, Brazil) [17]. Briefly, the data were input into the software with corresponding variables and samples. Subsequently, autoscaling was conducted as a data pre-processing prior principal component analysis.

RESULT AND DISCUSSION

The descriptive statistics of solid content, protein content, lipid content and starch hydrolysis of three type of products namely baked, steamed, and fried are presented in Table 1.

TABLE 1. Chemical composition and starch hydrolysis of wheat-based breads undergone different type of final thermal processing.

Type of products	Solid (%)	Protein (%)	Lipid (%)	Starch hydrolysis (mg/dL)
Baked product	62.81 ± 0.30	7.45 ± 0.38	8.03 ± 0.08	4700.00 ± 2250.19
Steamed product	63.34 ± 0.14	5.85 ± 0.15	2.06 ± 0.13	2133.33 ± 1383.63
Fried product	79.76 ± 0.21	6.96 ± 0.15	20.94 ± 0.35	8266.67 ± 1841.50

The data are presented in mean ± standard error (n=3)

In the current study, fried product is apparently high in solid and distinctly high in lipid and poses a high starch hydrolysis. On the other hand, steamed product seams to contain lipid at a low level and poses a low starch hydrolysis. Furthermore, the protein of the three types of products seems to be similar. As discussed earlier, it is rather difficult

to conclude the similarity and dissimilarity of products when comparison is conducted based on individual attribute. There, PCA has been conducted on all the measured attributes of the three types of bread.

Figure 1 presents a biplot showing the sample plots and variable plots of principal components analysis as conducted. It is shown that the first and the second principal components (PCs) were able to explain high number of variance (88%) responsible to the similarity and dissimilarity of baked, steamed, and fried products. Along with the PC1, 67.36% of variance has been explained while on the PC2, 21.81% of variance has been explained.

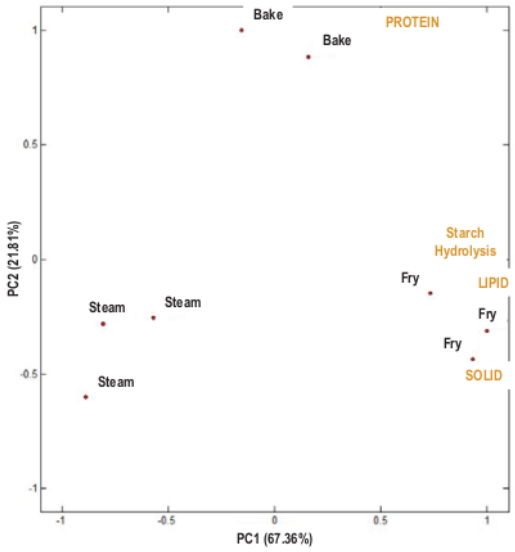

FIGURE 1. Biplot of principal component analysis showing the similarity and dissimilarity of baked, steamed, and fried products based on solid content, protein content, lipid content and starch hydrolysis. Bake: baked products, steam: steam products, fry: fried products.

The samples plots clustered per thermal treatment indicating the similarity among the same thermal treatment and dissimilarity among other thermal treatments. In relation to the PCs, steamed and fried products plots distributed along the PC1 at -1 and 1 scales respectively indicating both the product types are distinctly different and the difference has been successfully explained (67.36% variance explained). Regarding PC1, baked products plots positioned in the middle of steam and fry plots indicating the properties of baked products are between steamed and fried products. Regarding PC2, baked products plot on the top value (close to 1) while both steamed and fried products plots distributed at similar position along the PC2.

Apart from the sample plots, biplot shows variable plots namely solid, protein, lipid, and starch hydrolysis that influenced the grouping and separation of sample plots. As the four variables are quality attributes of the three types of breads, the grouping and separation of products are influenced by their attributes. It is seen that the variables plot differently along PCs. Solid, lipid, and starch hydrolysis plot along PC1 (values close to 1) indicating that solid, lipid and starch hydrolysis explain 67.36% variance of the similarity and dissimilarity of the three types of bread products. On the other hand, protein plots along PC2 and explains 21.81% of variance. Thus, protein content influenced the similarity and dissimilarity of the three types of products less than that influenced by solid, lipid, and starch hydrolysis.

The distribution of samples plots and variable plots along the PCs explains their relationship. Thus, fried product is attributed with high in solid, lipid, and starch hydrolysis and oppositely the steamed product. Another product, the baked is attributed with high in protein while both the steamed and fried products are comparable in term of protein.

Starch hydrolysis that is high in fried product is quite surprising. This finding agrees with a study that show an increase in starch digestibility of potato after frying [18]. However, other study shows decrease in digestion rate of wheat starch after frying [19]. Fried product is associated with lipid (Fig 1). The lipid represents the oil content coming from the frying oil. Therefore, it is suggested that the presence of oil in the fried product did not hinder the starch hydrolysis in a way of preventing enzyme-substrate contact. Furthermore, it requires further study whether the microstructure of starch of the fried product is responsible for the high starch hydrolysis. Fried product is also

associated with solid because of a low moisture content. Indeed, frying that occur above boiling point of water resulted in a low moisture content.

Baked product is associated with protein (Fig. 1). It probably indicates that the wheat flour used in preparing baked product is high in protein. As understood, baked product undergo proofing to expand the dough and increase the volume by mean of fermentation by yeast. Prior proofing, mixing is important to create starch-protein network [20] that is responsible for elastic properties of dough during proofing. To make sure that starch-protein network is well improved, protein content of wheat is topmost important. In term of starch hydrolysis, baked product is associated with a medium starch hydrolysis. It is unsure if the level of starch hydrolysis of the baked product that is not as high as fried product is influenced by the protein content. Nevertheless, previous study showed that the presence of protein reduced the starch digestibility [10, 11, 12].

Figure 1 shows that steamed products clustered separately indicating their difference compared to the other products. Furthermore, Figure 1 suggested that steamed products had low levels of solid, protein, lipid. These finding is somehow as expected. Surprisingly, steamed product is associated with low starch hydrolysis. It is unknown whether microstructure of starch of is responsible for this low starch hydrolysis.

The finding of this study suggest that the steamed products are potentially more beneficially healthy than other products because fried product is high in lipid and starch hydrolysis. For baked product, despite it is low in lipid and starch hydrolysis, high protein that might come from gluten might lead to gluten intolerance [21, 22] for some consumers. Moreover, wheat product is not an authentic crop of the country thus the community of the country might have no digestive system that naturally ready for the gluten.

CONCLUSION

PCA successfully explained the dissimilarities of baked, steamed, and fried products of wheat dough based on starch hydrolysis, solid content, protein content, and lipid content. Further study needs to be conducted to investigate the fraction of starch digestibility. Furthermore, consumer preference of the products is also important to investigate for a possible connection with the health impact of the consumption upon the three types of products.

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