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Effect of process temperature and percentage of rock sugar on the functional group intensity of red ginger extract

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ABSTRACT

Red ginger has various health benefits that can be consumed in various ways, one of which is an instant powder drink, which is practical and extends the shelf life of the product. The processing process involves cooking at high temperatures with the help of sugar as a crystallization agent. This research aims to understand the effects of temperature and sugar concentration on red ginger extract. The variables used are temperatures of 80 and 90°C and rock sugar concentrations of 60% and 100%. Product evaluation was carried out using Fourier Transform Infrared Spectroscopy (FT-IR) to identify product functional groups. The research results showed that there were differences in functional group content between solid and liquid samples, both fresh raw materials and dregs. In the solid sample, seven functional groups were identified: N-H, C-H, C-H bending, C-N, C=C, C-C, and C-O. Meanwhile, in liquid samples, only six groups were identified, namely O-H, C=C, O-H bending, C-N, C-C, and C-O. Overall, this study shows that the functional group content in fresh red ginger is higher than that in red ginger pulp, even though the temperature is lower. However, if the comparison is between the solid and liquid sample conditions for fresh red ginger with fresh red ginger or dregs with dregs, the content at a cooking temperature of 90°C is higher than 80°C. Apart from that, the higher the rock sugar content in the red ginger pulp, the higher the content of functional groups identified in the extract.

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1. INTRODUCTION

Red ginger, which has the scientific name *Zingiber officinale* Rosc. var. Rubrum, is a type of ginger that belongs to the Zingiberaceae family. Red ginger, also known as sunti ginger, has become a superior choice compared to other ginger varieties [1]. This advantage makes it an important ingredient in traditional medicines and cooking spices [2], [3].

The specialty of red ginger lies not only in its distinctive taste and aroma but also in its active compound content [4]. Red ginger contains high amounts of essential oils, around 2.58–3.90%, which gives ginger its distinctive aroma. Apart from that, red ginger also contains 7–10% oleoresin with phenolic compounds such as gingerol, shogaol, zingeron, flavonoids, and resin, which act as strong antioxidants [5]. Because of its unique properties, the general public often uses red ginger as a traditional herbal medicine [6].

Red ginger is often processed traditionally; however, increasing consumer demand has encouraged the development of more modern instant serving methods [7]–[9], both in powder and liquid form [10], but powder products are more popular because they have a long shelf life, product quality is maintained, and they are not easily soiled [11], [12]. The process of making instant ginger drink powder usually involves heating with the help of granulated sugar as a crystallizing agent and sweetness enhancer [13], as is done by [14], [15]. Apart from granulated sugar, brown sugar has also been used to make red ginger extract [16], and crystal sugar or rock sugar can also be used to make red ginger powder [17].

Crystal sugar is the result of processing granulated sugar with the help of heated water [18] with the aim of dissolving it more easily. The material used to form crystal sugar is a liquid sugar solution that is precipitated or crystallized to produce sugar that looks like crystals. The method of forming crystal sugar, which involves adding water in the process, causes the water content in the crystal sugar to be higher than the water content in granulated sugar. Apart from that, researchers [19] said that the antioxidant levels detected were higher if crystal sugar was used compared to granulated sugar. This is the reason that crystal sugar is able to accelerate crystal formation when heated. As a result, the crystallization time will be faster, preventing the antioxidant content from decreasing [19]. However, even though it is categorized as being able to speed up the extraction process, the acid content in red ginger is able to inhibit crystallization because it is able to carry out the hydrolysis process of sucrose into glucose and fructose [18].

The manufacture of red ginger products is closely related to the rate of the extraction process, with the influence of process temperature. Increasing the process temperature will speed up the extraction process. However, temperatures that are too high can damage the processed material and disrupt the crystallization process [20]. So, the existence of these limitations helps this research focus on the influence of differences in sugar content (60, and 100%), the use of crystal sugar types, and variations in the temperature of the evaporation-crystallization process on the identified functional groups (80, and 90°C). The research involving sugar concentration and process temperature has been conducted by researchers [14], [16], using different types of sugar, namely granulated sugar and palm sugar. Therefore, this study aims to investigate and compare the outcomes of these two types of sugar using rock sugar with representations of commercial powdered products and ready-to-drink products. Supporting equipment for product testing is the use of Fourier transform Infrared (FT-IR) spectroscopy on red ginger extract (in phase conditions: solid and liquid). In addition, the reference used to assist this study process will be evaluated by research results [21] using a wavelength range of 400 until 4000 cm^{-1}.

2. RESEARCH METHOD

This research uses evaporator-crystallizer equipment to carry out the evaporation process and continue with the crystallization process [8]. Previously, the red ginger raw materials and supporting materials received initial treatment before entering the dissolution process with distilled water [7]. Red ginger extract will be processed at an operating temperature of 80–90°C while also varying the percentage of rock sugar (60 and 100%) to obtain red ginger powder products. Product size uniformity is also provided to assist the testing process in the laboratory. Testing functional groups for sample products, both solid and liquid, using FT-IR spectroscopy equipment.

3. RESULTS AND DISCUSSIONS

The results of this research have eight groupings to make it easier to identify the effect of temperature and sugar content on the sample functional groups. The achievements are shown in Figures 1 to 4, with variations in the evaporation-crystallization temperature (80, 90°C) and the percentage of rock sugar (60, 100%) in the product form, both solid and ready-to-consume drinks.

The first grouping in Figure 1 (a) shows that the samples that have the lowest transmittance are, respectively, red ginger at 90°C; red ginger at 80°C, which is close to commercial product 1; red ginger at 80°C; and the four other functional groups are highest in red ginger at a temperature of 90°C. Based on Lambert's Law, the transmittance value will be inversely proportional to the absorbance, where the level of the compound in the sample depends on how much absorption is captured [22]. So, from the analysis of the data above, for five of the seven functional groups (N-H, C-H bend, C-N, C-C, and C-O), the highest content is in the red ginger sample with a cooking temperature of 90°C, followed by the red ginger sample at 80°C, which contains the two highest functional groups (C=C and C-H). In the C-O group, this is in line with research results [14] where the absorbance value will increase when the cooking temperature takes place at 90°C.

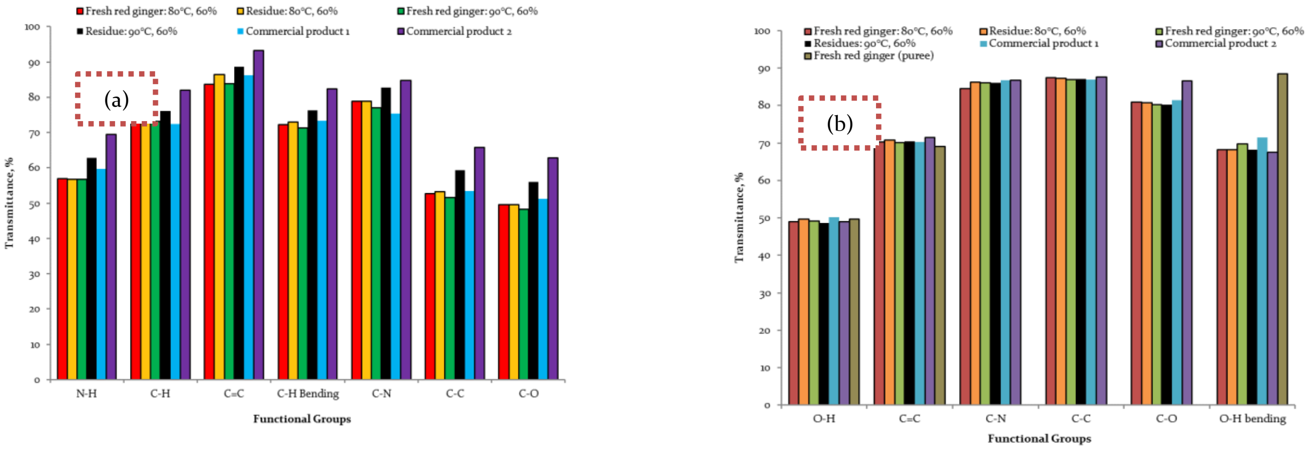

Figure 1. Intensity of product functional groups for 60% sugar content with temperature variations: (a) solid, (b) liquid

From Figure 1 (a), it can be seen that samples of red ginger and pulp with higher cooking temperatures will contain many functional groups with a higher absorption intensity than other samples. This is supported by [23], who says that the functional groups will be higher if the temperature increases due to the breakdown of dextrin, thereby increasing the reducing sugar, which makes the reactive functional groups more numerous.

The second grouping is presented in Figure 1 (b), where the sugar content of 60% shows that the red ginger sample contains more of the highest functional groups. The functional groups are C-N at a temperature of 80°C, then C-C and C-O at a temperature of 90°C. Meanwhile, ginger pulp is only found in the O-H hydroxyl group and the O-H bend at temperatures of 90 and 80°C, respectively. This analysis shows that the functional group content in red ginger will be higher than in red ginger dregs, even though the cooking temperature is lower. The achievement is attributed to the fact that the functional group content in red ginger dregs is not too high, experiencing a decrease of 1.5% [24], and another factor is that there is more water added in the process of making red ginger dregs extract than when making red ginger extract.

The third grouping as indicated in Figure 2 (a), six of the groups were identified as being the highest in the red ginger pulp sample at a cooking temperature of 90°C. These functional groups are N-H, C-H, C-H bend, C-N, C-C, and C-O. Meanwhile, another functional group, namely C=C, is present in the red ginger sample with a processing temperature of 90°C. When the percentage of crystallization agent is 100%, all the highest functional groups are obtained at a cooking temperature of 90°C, and the only difference is the identification of the ginger sample or pulp. The analysis results in Figure 2 (a) show that red ginger pulp contains more functional groups. This achievement is due to the sugar content, which is indicated to influence the amine, hydroxyl, ether, and aliphatic groups. Generally, a higher sugar content in instant drink powder contains more functional groups. This statement is also in accordance with the results of research by researchers [25], where glucose and fructose resulting from hydrolysis during evaporation and crystallization were able to increase the absorbance value. However, both are also able to influence the red ginger content in products that are covered in sugar content [16]. Meanwhile, for products made from red ginger pulp treated at a temperature of 90°C and a content of 100%, the C=C group still had the highest results in the red ginger samples.

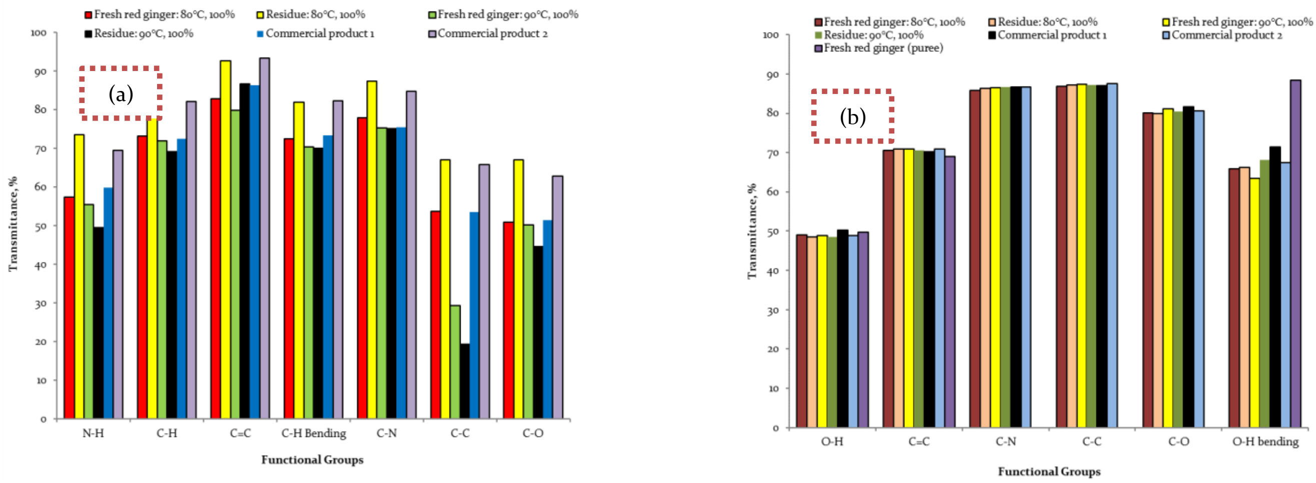

Figure 2. Intensity of product functional groups for 100% sugar content with temperature variations: (a) solid, (b) liquid

Three of the six functional groups in Group 4 are presented in Figure 2 (b). The results showed that the highest functional groups were found in the red ginger pulp samples. Among them, the hydroxyl groups O-H and O-H bend were identified as being the highest at a treatment temperature of 90°C. Meanwhile, at a temperature of 80°C, many ether groups were identified. Then, there are two other functional groups, namely C-N and C-C. Both are common in red ginger with a cooking temperature of 80°C. Finally, pure red ginger without treatment has the highest C=C olefinic group. This achievement shows that the liquid sample with a sugar concentration of 100% is still in line with the results for the solid sample. There are more functional groups in ginger dregs than red ginger. However, in this treatment, the extract with a cooking temperature of 80°C dominated.

Figure 3 (a) shows that commercial product 1 has the two highest functional groups in C-H and C-N. A sample that is close to C-H is red ginger with a sugar content of 60%. Meanwhile, the C-N amine group is in red ginger pulp with a sugar content of 60%. All samples identified as having the highest levels in each functional group were obtained when treated with a sugar content of 60%. Apart from these two functional groups, three other functional groups that 60% red ginger also has are the C=C olefinic group and the C-H bend aliphatic group, as well as the C-C group. This result means that the grouping of red ginger samples has more of the highest functional groups compared to red ginger pulp, which was only detected to contain three of the highest groups (in the form of the N-H amine group and the C-O ether group). Thus, providing a process temperature of 80°C contributed to the fact that the highest functional groups were found in samples with a sugar content of 60% in both red ginger and pulp. This result also states that at this temperature and concentration, it is considered optimal as the ginger flavor remains dominant over the sweetness of the sugar [16].

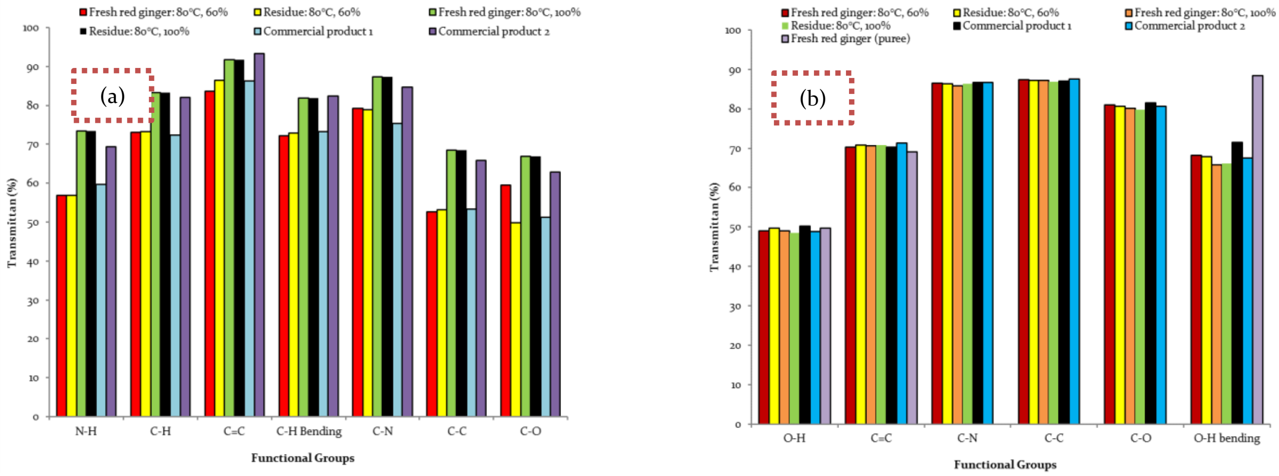

Figure 3. Intensity of product functional groups at 80°C with variations in rock sugar content: (a) solid, (b) liquid

Figure 3 (b) shows that the low transmittance in the O-H, C-C, C-N, C-O, and O-H bend functional groups is owned by the extract sample with 100% crystal sugar content. The indication is that the product has the highest absorption of the five functional groups. Among these groups, C-N and O-H bends were only present in the red ginger samples, while the rest were in the dregs samples. Then, the C=C functional group had the lowest transmittance in the red ginger sample without sugar. Based on the presentation of the results in Figure 3 (b), it can be seen that the highest functional group intensity in pure ginger without sugar is only in the C=C olefinic group. This analysis shows that the red ginger pulp sample will remain higher than the red ginger, which is in line with the fourth grouping. These results state that the evaporation-crystallization process temperature of 80°C for samples with 100% sugar content dominates.

The identification of solid sample grouping at 90°C is presented in Figure 4 (a). The results showed that the six functional groups with the highest intensity were in the red ginger pulp sample. Meanwhile, the highest intensity of the C=C functional group was found in the red ginger sample. The sample with the highest intensity mentioned was found in the 100% sugar content treatment. In other words, the cooking temperature is 90°C for red ginger pulp. This achievement indicates that the higher sugar content provided during the evaporation-crystallization process can increase the intensity of functional groups. This result is in line with the results of the third grouping in Figure 2 (a). The same sugar content in the sample at a temperature of 90°C is able to provide more of the highest functional groups. This process condition also occurs in products made from red ginger pulp (90°C, 100% crystallization agent). The results of this research were also achieved by [26], providing higher sugar levels can increase the inhibition of the crystallization process in red ginger extract samples. The presence of antioxidants (especially phenol as an alpha-amylase inhibitor) is able to reduce reducing sugars and make the dregs sample more dominant at 100% sugar content. High temperatures can also enhance the solubility of phenolic compounds, but an increase in thermal degradation occurs during the extraction process [27], [20].

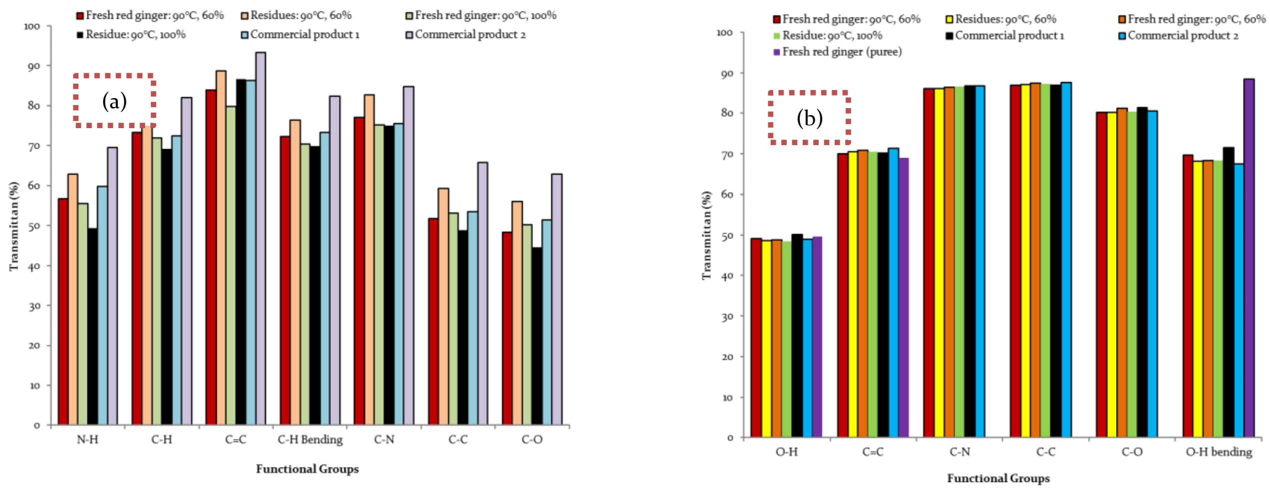

Figure 4. Intensity of product functional groups at 90°C with variations in rock sugar content: (a) solid, (b) liquid

Figure 4 (b) shows the highest absorbance values for three of the six functional groups that have been identified, namely C-N, C-C, and C-O. All three are red ginger samples with a sugar content of 60%. Meanwhile, the highest functional group in red ginger pulp is O-H at 100% sugar content. The highest O-H bend hydroxyl group was in commercial product 2, and the intensity closest to this product was in a sample of red ginger pulp with a rock sugar content of 60%. Figure 4 (b) also shows that in the liquefied red ginger extract, the product with a sugar content of 60% has the highest and most functional group content compared to the product with a crystallization agent content of 100% for the red ginger sample. This achievement is the same as the results of the second grouping in Figure 1 (b). Through the presentation of Figure 1 (b), it is known that the red ginger sample will contain more of the highest functional group intensity, although in this segment the influence of temperature is not very significant. This explanation also supports grouping one in Figure 1 (a), where when the process temperature is 90°C, the functional group content is greater. Unlike granulated sugar and palm sugar [14], [16], rock sugar showed distinct cluster identification. Precisely detected N-H and C-N groups were associated with unique vibrational spectra in each sample. Meanwhile, the results showed that the C=O group remained unidentified due to the absence of peaks in the wavelength range of its spectrum.

4. CONCLUSION

Research on red ginger with variations in the temperature of the evaporation-crystallization process (80, 90°C) and the percentage of new sugar (60, 100%) has been carried out. The results showed that the functional group content in the solid sample was different from the reconstituted solid product (ready for consumption). This achievement leads to further development to maintain product quality after the evaporation-crystallization process is completed. Identification in the solid sample consisted of seven functional groups, namely amine groups N-H and C-N, aliphatic C-H stretch and C-H bend, olefinic groups C=C, ether C-O, and C-C groups. However, in instant drink samples, there were only six functional groups that could be identified, including the hydroxyl groups O-H stretch and O-H bend and the olefinic groups C=C, C-N, C-C, and C-O. The contribution of the roles of the two process variables is clearly presented by whether or not a functional group is identified and how significant its influence is. For a rock sugar content of 60%, red ginger extract contains more functional groups, even though the processing temperature is lower than red ginger dregs. However, at 100% sugar content, red ginger pulp has more functional groups with the highest intensity. In contrast to the percentage of sugar content achieved, temperature variations do not have a significant effect if the products being compared are fresh red ginger and its pulp. However, when juxtaposing the same sugar content for both raw materials, the intensity of functional groups at 90°C is higher than at 80°C.

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