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Effect of various pretreatment and temperature on chemical properties of sweet potato flour

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Abstract
In this study, sweet potato slices were pretreated with various pretreatments such as 0.1% w/v potassium metabisulfite (KMS), 1% w/v calcium chloride ($CaCl_2$), and blanching at 80 °C for 5 min. These pretreated slices were dried in a mechanical tray dryer at 50, 55, 60, and 65 °C at a constant drying air velocity of 2 m/s in the drying chamber. The dried samples were ground into the flour and subjected to various chemical analyses such as protein, starch, total sugar, total soluble solids, ash, fiber, and colour. According to results obtained, protein and starch content were found to decrease with an increase in drying temperatures. At 60 °C, the total sugar content was found to be highest for $CaCl_2$ pretreated samples. Total soluble solids (TSS) were found to increase with drying temperature and to be highest for $CaCl_2$ pretreated samples at 65°C. Ash content was found to be highest for $CaCl_2$ pretreated samples and decreases with drying temperature. The $CaCl_2$ pretreated sample was found to be best in terms of studied characteristics and can be used as an ingredient in food formulations.

Keywords: Pretreatments, tray drying, protein, total sugar, total soluble solids, ash

1. Introduction

Sweet potato (*Ipomoea batatas*) is the oldest fiber crop grown almost throughout the world. Around 105 million tonnes of sweet potato are produced annually worldwide, making it the world's fifth most important crop (Zhang *et al*., 2000) [21]. In India, the total production of sweet potato was 16.39 million tonnes in a 1.34 million ha area, while Rajasthan state produced around 10910 MT of sweet potatoes on an area of 1100 ha in the years 2016-17 (Anonymous, 2017) [4]. The sweet potato root is rich in numerous useful and health-beneficial components and is thus the chief product for processing. It consists of an average of 70% vitamins, organic acids (e.g. folic acid and pantothenic acid), and other components (on a dry matter basis) (Sablani & Mujumdar, 2006) [18]. Sweet potatoes are unique with a balanced biochemical and functional composition suitable for food use, feed use, and industrial applications.

Processing improves the root's usability as a food or an industrial raw material, and it addresses market fluctuations and off-season availability. Its highly perishable nature, which limit its utilisation and increases post-harvest losses. The conversion of this root crop into flour and other industrial products like starch can reduce losses after harvest. Unit operations like drying and milling may be beneficial for the quality of flour and starches from this root crop (Nagar *et al*., 2021) [12]. It can also be used to enhance food products' colour, flavour, natural sweetness and supplement nutrients. In product development, the final quality of a product is highly dependent on the quality of the raw ingredients used.

Pretreatment is an important step before processing of food materials. It has been studied that pretreatment can not only accelerate the drying rate but also improve the quality of dehydrated products by expelling intercellular air from the tissues, softening the texture and destroying the enzymes and microorganisms (Jayaraman & Gupta, 2006) [10]. Many reports are available on the effects of different pretreatments on various fruits, vegetables, and other dried foods (Alvarez *et al*., 1995) [3]. Many studies have been focused on sweet potato flour and the development of new food products using sweet potato flour rather than on efficient methods to produce the flour. Some researchers have reported different chemical and functional characteristics of sweet potato flour processed from various cultivars and under diverse conditions (Van Hal, 2000) [20].

There is a need to understand the effect of interactions among the independent variables such as on the chemical properties of sweet potato flour and also optimize the suitable pretreatment and drying conditions that produce the best quality of sweet potato flour that can be incorporated in various food formulations.

2. Material and Methods

2.1 Preparation of the Sample

The sweet potato (procured from local market of Udaipur) slice samples were prepared by sorting (based on size), washing under running water, peeling manually using a stainless steel knife and slicing with the help of an adjustable stainless steel slicer. The samples were cut into slices of around 6 (±0.1) mm in thickness.

2.2 Pretreatments

Based on the pre-trails, sweet potato slices were pretreated as follows:

- Without any pretreatment (control)
- 1% w/v KMS (1 gm KMS in 1-liter water) for 30 min
- 1% w/v Cacl2 (10 gm Cacl2 1-liter water) for 1 min
- Blanching (80 °C for 5 min)

2.1.1 Pretreatment process

In the case of chemical pretreatment, raw slices were immersed in the above provided chemical solution, which was prepared by adding chemicals with water in desired concentration in a beaker for the soaking duration at room temperature. The ratio of sweet potato slices to the pretreatment solution was kept at 1:5. After the soaking time interval, samples were immediately removed and blotted gently using tissue paper. Then slices were weighed again. After the pretreatment, the sweet potato slices were dried in a mechanical tray dryer at four different air temperatures: 50, 55, 60 and 65 ºC. After drying, sweet potato slices are grounded into fine powder and passed through a 100 mesh screen. These samples are kept in airtight containers for further quality analysis.

2.2 Quality Evaluation

2.2.1 Protein content

The crude protein content of the obtained flour samples was estimated according to the Micro Kjeldahl method (AOAC, 1990) [5].

2.2.2 Starch content

The starch content of sweet potato flour was determined by the Anthrone reagent method as provided by Sadasivam & Manickam (1996) [19].

2.2.3. Total sugar content

The total sugar content of sweet potato flour was determined using a method suggested by Ranganna (2000) [16].

2.2.4 Total soluble solids

The total soluble solid (TSS) of sweet potato flour samples was determined with the help of a digital refractometer (0-53° Brix), which gave the reading directly in degree brix.

2.2.5 Ash content

5g of sample was weighed into a crucible, which was heated at a low flame till all the material was completely charred and cooled. Then it was kept in a muffle furnace at 600 ^{0}C for 5 hours. It was again cooled in desiccators, weighed, and repeated until two consecutive weights were constant. The percent ash was calculated by knowing the difference between the initial and final weight (AOAC, 2005) [6].

2.2.6 Fiber content

The fibre content of sweet potato flour was determined using the method suggested by AOAC (2005) [6].

3. Result and Discussion

The results obtained from the experimental combinations are presented in the following subsections.

3.1 Effect of different pretreatment and air temperatures on protein content of sweet potato flour

The perusal of data presented relates to the effect of pretreatment and drying temperature on protein content of sweet potato flour, which has been shown in Figure 1.

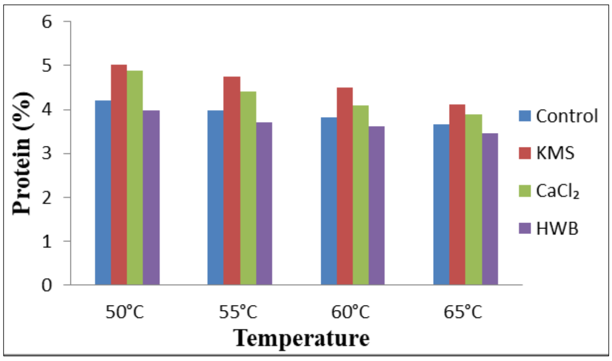

Fig 1: Effect of process variable on protein content (%) of sweet potato flour

In the case of individual effects of pretreatments, the maximum protein content was found for KMS pretreated slices and a minimum for hot water blanching pretreated sweet potato flour. The protein content in KMS pretreated sweet potato flour was found to be 4.59 per cent, while in the case of controlled, $CaCl_2$ and hot water blanching pretreated flour, it was found to be 3.91, 4.32, and 3.68 per cent, respectively. These results are in good agreement with Olatunde *et al.* (2016) [14]. They reported that hot water blanching pretreated flour has lower protein content than a sample pretreated with $CaCl_2$.

While taking the individual effect of drying temperature into account, it was found that as the temperature was increased from 50 °C to 65 °C, the protein content decreased from 4.52 to 3.77 per cent. This is probably due to the denaturation of proteins at higher temperatures. These results were in good agreement with Pendre *et al.* (2012) [15]. They studied the effect of drying temperature and slice sizes on the quality of dried okra.

In terms of the interaction between pretreatment and drying temperature, the maximum protein content was 5.01 percent for KMS pretreated sweet potato flour at 50 °C and a minimum of 3.45 percent for hot water blanching pretreated sweet potato flour at 65 °C. These findings are consistent with those of Van Hal, (2000) [20] who found that the protein content of sweet potato flour ranged from 1.0 to 8.5 percent.

3.2 Effect of pretreatments on starch content of sweet potato flour

The perusal of data presented pertaining to the effect of pretreatment and drying temperature on starch content of sweet potato flour has been presented in Figure 2.

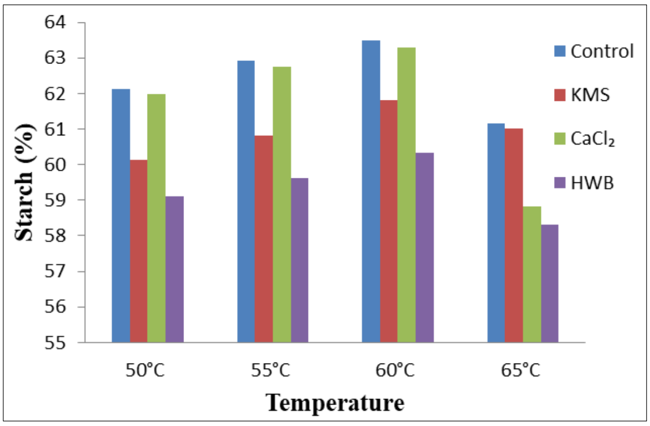

Fig 2: Effect of process variable on starch content (%) of sweet potato flour

As concerns the individual effects of pretreatments, the maximum starch content was found in controlled samples, while the minimum was obtained from hot water blanching pretreated sweet potato flour. The starch content in controlled sweet potato flour was found to be 62.42 percent, while in the case of KMS, $CaCl_2$ and hot water blanching pretreated flour, they were found to be 60.94, 61.70, and 59.34 percent, respectively. The minimum starch content of the flour prepared using hot water blanching treatment, might be attributed to the leaching out of the starch granules into the blanching water due to plasmolysis. These results were in good agreement with Olatunde *et al*. (2016) [14]. They reported significant variations in starch content values from 55.76 to 83.65%, which may be due to blanching and sulphitation.

When the temperature was increased from 50 °C to 60 °C, the starch content increased from 60.83 to 62.23 percent, and at 65 °C, the starch content was 59.82 percent, which was lower than at 50 °C.may be due to starch gelatinization. These results were in good agreement with Ruttarattanamongkol *et al*. (2016) [17]. They reported that sweet potato starch gelatinized in the range of 60 to 88 °C. Drying temperature is positively correlated with amylose content, resistant starch, and viscoamylographic properties. The sweet potato flour dried at 60 ºC was found to be better and obtained the highest starch content of 62.23 per cent.

The maximum starch content was 63.48 per cent in the case of a controlled sweet potato flour sample at 60 °C and a minimum of 58.31 per cent was obtained by blanching pretreated sweet potato flour at 65 °C.

3.3 Effect of pretreatments on total sugar content of sweet potato flour

The effect of various pretreatments and drying temperatures on the total sugar content of sweet potato flour has been presented in Figure 3.

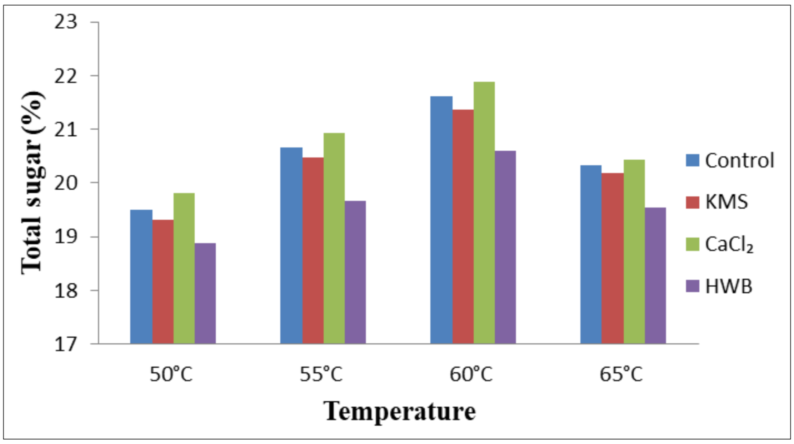

Fig 3: Effect of process variable on total sugar (%) of sweet potato flour

The individual effect of pretreatments showed that the maximum total sugar content was found in the $CaCl_2$ pretreated sample, while the minimum was obtained from hot water blanching pretreated sweet potato flour. The total sugar content in $CaCl_2$ pretreated sweet potato flour was obtained at 20.76 per cent, and in the case of KMS, hot water blanching pretreated and controlled samples were found to be 20.33, 19.67, and 20.52 per cent, respectively. The reduction in total sugar content of the prepared flour by the hot water blanching treatment may be due to higher leaching losses of reducing sugars. These results were in good agreement with Ahmed *et al*. (2010) [1]. They reported that total sugar was slightly higher in $CaCl_2$ pretreated samples than in blanching and control samples. This minor increase was found to be due to the Complexation of sugars by calcium. Samples treated with $CaCl_2$ showed slightly higher total sugar content compared to the control and $NaHSO_3$-treated samples.

The individual effect of drying temperature showed that as the temperature increased from 50 °C to 60 °C, the total sugar increased from 19.37 to 21.36 per cent. This is probably due to hydrolysis of the disaccharide. At a drying temperature of 65°C, total sugar content was found to be 20.12 per cent, which was lower than at 60 °C. These results were in good agreement with Ahmed *et al*. (2010) [1]. The individual effect of temperature concluded that the sweet potato flour dried at 60 ºC was found to be better and had the highest total sugar content of 21.36 per cent.

The interaction between pretreatment and drying temperature was reported. The maximum total sugar content was found to be 21.88 per cent for $CaCl_2$ pretreated sweet potato flour at 60 °C, while the minimum was 18.88 per cent using hot water blanching pretreated sweet potato flour at 50 °C.

3.4 Effect of pretreatments on total soluble solids (TSS) of sweet potato flour

The effect of pretreatment and drying temperatures on total soluble solids (TSS) of sweet potato flour has been shown in Figure 4.

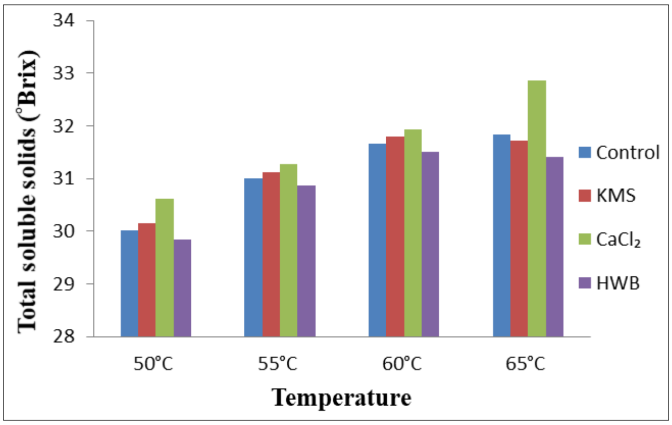

Fig 4: Effect of process variable on Total soluble solids (˚Brix) of sweet potato flour

The individual effect of pretreatments for the total soluble solids was found to be maximum for $CaCl_2$ pretreated and minimum for hot water blanching pretreated sweet potato flour. The total soluble solids in $CaCl_2$ pretreated sweet potato flour was found to be 31.67 ˚Brix KMS, while hot water blanching pretreated and controlled sample flour were found to be 31.19, 30.90 and 31.13 °Brix respectively. The minimum total soluble solid content of the flour prepared by hot water blanching pretreatment may be related to the leaching out of the dissolved solids into the blanching water from the tissues during blanching. These results were in good agreement with Aina *et al*. (2009) [2]. They reported that it had no effect on the TSS content of dehydrated onion rings, cauliflower, and okra slices that were pre-treated with KMS and citric acid before dehydration.

In the case of individual effects of drying temperatures, as the drying temperature increased from 50 to 65 °C, the total soluble solids increased from 30.16 to 32.20 °Brix. However, the results indicate that temperature affects the total soluble solids of the sweet potato flour produced in such a way that as the temperature increased, the total soluble solids also increased; this was in accordance with the report of Ashebir *et al*. (2009) [7], which indicated that the value of total soluble solids of tomato significantly increased after drying at 55, 65, and 75 °C. It is clear that with respect to the individual effect of temperature, the sweet potato flour dried at 65 ºC was found to be better and the highest total soluble solids were recorded at 31.95 °Brix.

The interaction between pretreatment and drying temperature, the maximum total soluble solids was 32.86 ˚Brix for $CaCl_2$ pretreated sweet potato flour at 65 °C and minimum was 29.85 ˚Brix for hot water blanched sweet potato flour at 50 °C.

3.5 Effect of pretreatments on ash content of sweet potato flour

The effect of different pretreatments on the ash content of sweet potato flour has been shown in Figure 5.

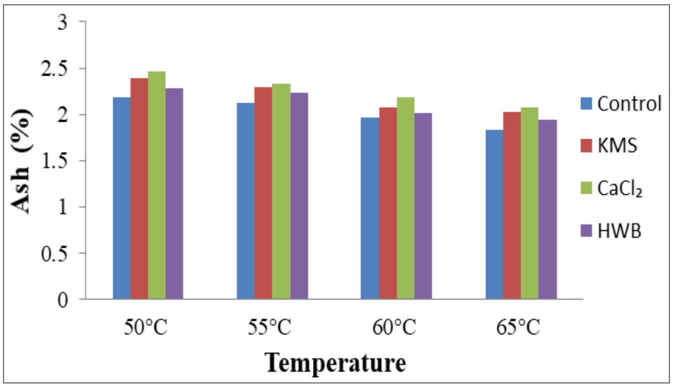

Fig 5: Effect of process variable on ash content (%) of sweet potato flour

In terms of individual pretreatment effects, the average ash content was found to be highest for CaCl2 pretreated sweet potato flour and lowest for controlled sweet potato flour. The average ash content in $CaCl_2$ pretreated sweet potato flour was found to be 2.26 per cent, and in the case of KMS, hot water blanching pretreated and controlled sample flour were found to be 2.19, 2.11, and 2.02 per cent, respectively. As expected, ash content was slightly increased in $CaCl_2$ samples compared to KMS, hot water blanching, and controlled samples. This may be due to the addition of calcium in the pretreatment step. These results were in good agreement with Ndangui *et al*. (2014) [13]. They reported that ash content was slightly increased in $CaCl_2$ samples compared to blanching and controlled samples, likely owing to the addition of calcium in the pretreatment step.

The individual effect of drying temperatures was reported to be such that as the temperature increased from 50 °C to 65 °C, the ash content decreased from 2.33 to 1.97 per cent, However, the results indicated that temperature affects the ash content of the sweet potato flour produced in such a way that as the temperature increased, the ash content decreased; similar results were reported by Blanco-Metzler *et al*. (2004) [8] for roots and tuber crops. The individual effect of temperature concluded that the sweet potato flour dried at 65 ºC was found to be better and found to have the lowest ash content of 1.97 per cent.

The interaction effects of pretreatment and drying temperature found to be maximum ash content was 2.46 per cent for $CaCl_2$ pretreated sweet potato flour at 50°C and minimum was 1.83 per cent for controlled sweet potato flour at 65 °C.

3.6 Effect of pretreatments on fiber content of sweet potato flour

The perusal of data presented pertaining to the effect of pretreatment and drying temperature on fiber content of sweet potato flour has been shown in Figure 6.

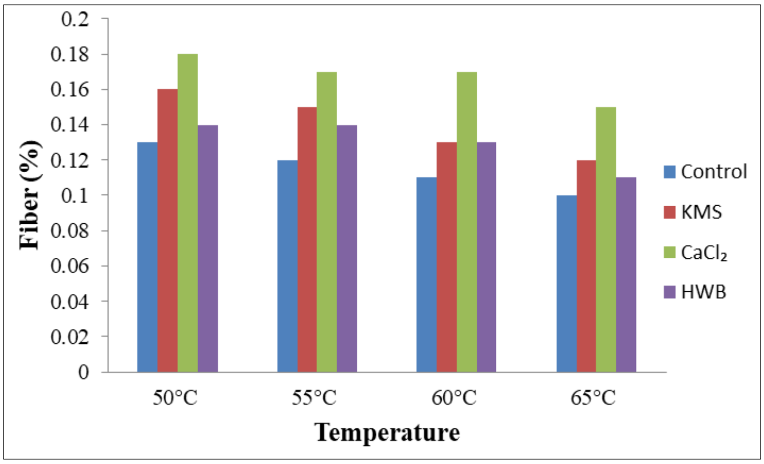

Fig 6: Effect of process variable on fiber content (%) of sweet potato flour

The individual effect of pretreatments reported that the average fiber content was maximum for $CaCl_2$ pretreated and minimum for controlled sweet potato flour. The average fiber content in $CaCl_2$ pretreated sweet potato flour was found to be 0.16 per cent, while for KMS, hot water blanching pretreated and controlled sample flour were found to be 0.14, 0.13, and 0.11 per cent, respectively. These results were in good agreement with Olatunde *et al*. (2016) [14].

Individual drying temperature effects were discovered, with the fibre content increasing from 0.10 to 0.18 percent as the temperature increased from 50 °C to 65° similar results were reported by Fana Haile *et al*. (2015) [9]. It may be the influence of drying temperature on selected properties of flour produced from orange-fleshed sweet potato tubers.

The interaction between pretreatment and drying temperature showed that the maximum fiber content was 0.18 per cent for $CaCl_2$ pretreated sweet potato flour at 50 °C and minimum was 0.10 per cent for controlled sweet potato flour at 65 °C.

3.7 Effect of pretreatments on Colour of sweet potato flour

Colour is often used as an indicator of quality and freshness for food products. Hence, it becomes important for food processors to be able to evaluate and grade the products based on their colour. The colour values were measured using a Hunter lab. The colorimeter was relative to the absolute value of a perfect reflecting diffuser as measured under the same geometric conditions (ASTM methods). The measurements were taken at room temperature (30.5 °C) and with a relative humidity of 25%. The data presented pertaining to the effect of different pretreatment and drying temperatures on the colour of sweet potato flour has been represented in Figure 7.

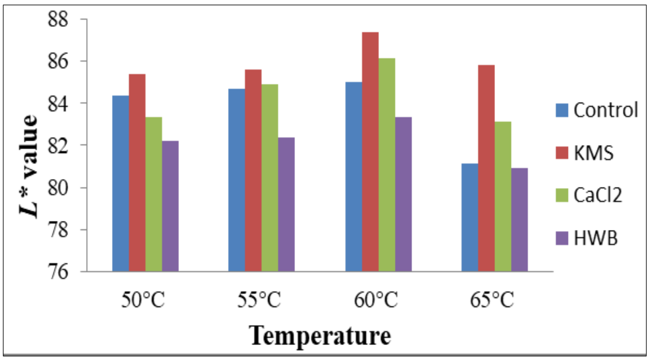

Fig 7: Effect of process variable on *L** value of sweet potato flour

3.8 L^* value

*L** value represents the lightness index of the product, and the values of sweet potato flour at various experimental conditions ranged from 80.94 to 87.38. The individual effect of pretreatments, the average L^* value was found to be maximum for KMS pretreated and minimum for hot water blanching pretreated sweet potato flour. The average L^* value in KMS pretreated sweet potato flour was found to be 86.03 while for controlled, $CaCl_2$ and hot water blanching treated flour was found to be 83.80, 84.38 and 82.20 respectively. The individual effect of pretreatments reported that the sweet potato flour pretreated with KMS was found to be better and recorded the highest L^* value of 86.03. These results were in good agreement with Ahmed *et al*. (2010) [1]. They reported the effect of pre-treatments on the sensory qualities of sweet potato flour and found that the higher L^* value may be due to sulphitation treatment. They reported that sulphite is a good colour preservative and it retards both enzymatic and non-enzymatic reactions.

The individual effect of drying temperatures was found to be that as the temperature increased from 60 ºC to 65 ºC, the L^* value of colour was found to be decreased, which may be due to elevated temperature. The colour value L^* also decreased with a decrease in drying temperature from 60 to 50°C. It might be due to the longer exposure of hot air during drying. Similar results were reported by Van Hal (2000) [20] for onion slices. It is clear, with respect to the individual effect of temperature, that the sweet potato slices dried at 60 ºC were found to be better and recorded the highest colour L^*value of 85.47. Similar results were quoted in the case of the convective drying of osmotic dehydrated apple (Kowalski & Mierzwa, 2013) [11].

The interaction effect of pretreatment and drying temperature was reported. The maximum *L** value was found at 87.38 for KMS pretreated sweet potato flour at 60°C and the minimum was 80.94 for hot water blanching pretreated sweet potato flour at 65 °C.

From the above treatments it was reported that sweet potato slices pretreated with $CaCl_2$ was found to be best than other pretreatments such as KMS and hot water blanching, in terms of chemicals characteristics such as protein, starch, fiber, ash, TSS and sugar content.

4. Conclusions

This study may be concluded with the following highlights:

the maximum protein content was found for KMS pretreated samples and decreased with an increase in drying temperature. At 60 °C, starch content and $CaCl_2$ pretreatment samples were found to be at their highest. Total soluble solids (TSS) were found to increase with drying temperature and to be highest in $CaCl_2$ pretreated samples at 65 °C. Ash content was found to be highest in $CaCl_2$ pretreated samples and decreased as drying temperature increased. Fiber content ranged between 0.10 and 0.18 percent. The maximum L^* value was recorded (87.38) for KMS pretreated at 60 °C and the minimum was (80.94) for KMS pretreated at 65 °C. In terms of the above characteristics, the $CaCl_2$ pretreated sample was found to be the best among other treatments.

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