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Effect of Hot Water, Steam and Microwave Blanching on *Colocasia esculenta* Leaves

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Abstract

Blanching, a pre-processing procedure, is usually carried out to inhibit enzymatic and other reactions which contribute to loss of quality prior to processing of green leafy vegetables. In this work the effect of hot water, steam and microwave blanching on peroxidase inactivation, colour changes, ascorbate degradation and changes in phenolic content of *C. esculenta* leaves was studied. Hot water and steam blanching were carried out in boiling water and steam, respectively, for 10, 20, 30, 60 and 120 s while microwave blanching was carried out for 5, 10, 15, 20 and 30 s. Peroxidase inactivation was faster in microwave blanched leaves. A 90% inactivation of peroxidase was achieved within 15 s of microwave blanching compared to 120 s and 30 s of hot water and steam blanching, respectively. The highest change in colour (ΔE) and chroma was observed after 20 s of microwave and steam blanching, respectively, although the changes were not significant. All the different blanching techniques resulted in ascorbate degradation, although higher losses were observed with hot water blanching compared to steam and microwave blanching.

Keywords: ascorbate; Blanching; *C. esculenta* leaves; Peroxidase activity.

Effet du blanchiment à l'eau chaude, à la vapeur et au micro-ondes sur les feuilles de Colocasia esculenta

Résumé

Le blanchiment, une procédure de prétraitement, est généralement effectué pour inhiber les réactions enzymatiques et autres qui contribuent à la perte de qualité avant la transformation des légumes à feuilles vertes. Dans ce travail, l'effet de l'eau chaude, de la vapeur et du blanchiment par micro-ondes sur l'inactivation de la peroxydase, les changements de couleur, la dégradation de l'ascorbate et les modifications de la teneur en phénol des feuilles de C. esculenta a été étudié. L'eau chaude et le blanchiment à la vapeur ont été effectués dans de l'eau bouillante et de la vapeur, respectivement, pendant 10, 20, 30, 60 et 120 s tandis que le blanchiment au micro-ondes a été effectué pendant 5, 10, 15, 20 et 30 s. L'inactivation de la peroxydase était plus rapide dans les feuilles blanchies au micro-ondes. Une inactivation de 90% de la peroxydase a été obtenue dans les 15 s de blanchiment par micro-ondes contre 120 s et 30 s d'eau chaude et de blanchiment à la vapeur, respectivement. Le changement le plus élevé de couleur (Δ E) et de chrominance a été observé après 20 s de blanchiment au micro-ondes et à la vapeur, respectivement, bien que les changements n'aient pas été significatifs. Toutes les différentes techniques de blanchiment ont entraîné une dégradation de l'ascorbate, bien que des pertes plus élevées aient été observées avec le blanchiment à l'eau chaude par rapport au blanchiment à la vapeur et au micro-ondes.

Introduction

Green leafy vegetables are an important source of essential nutrients for many Africans, where the daily diet is dominated by starchy foods. These vegetables serve as cheap source of vitamins and essential amino acids (Amagloh and Nyarko, 2012). In Ghana, among the most commonly consumed green leafy vegetables are *Colocasia esculenta* leaves, commonly called *kontomire*. This leaf is also widely consumed in other West Africa countries for the preparation of soups and stews. *Colocasia esculenta* is an economically important leaf (Cortbaoui, 2015; Okmen *et al*., 2009), with its cultivation and sale serving as a source of income for farmers and vendors. The leaf is high in polyphenols, vitamins and minerals, which provide a wide variety of health benefits including valuable antioxidant, anti-inflammatory, and anti-cancer properties (Boulekbache-Makhlouf *et al*., 2013; Cortbaoui, 2015). Despite these benefits, the leaf perishes a few days after harvest, leading to considerable loss of quality and economic value.

Food processing technologies are, therefore, needed to inhibit or slowdown the de-greening of the leaf. Converting the leaf into shelf stable products such as powders and purees can be used to enhance storage life and improve economic value. However, long waiting times prior to processing can still lead to the de-greening of the leaves. Therefore, blanching, a thermal pre-processing method, can be employed to slow down or even inhibit the de-greening of the leaves before processing.

While blanching can slow down de-greening, prolonged exposure to heat and water medium could also lead to the loss of important nutrients and other quality parameters of the leaves (Brewer and Begum 2003; Lin and Brewer 2005; Miglio *et al.,* 2008; Severini *et al*., 2016). In this regard, it is important to compare the effect of different blanching techniques on the quality and nutritional content of *C. esculenta* leaves. The most commonly employed blanching technique is hot water blanching. Other available blanching techniques include steam and microwave blanching. In this study, the objective was to compare the effect of hot water, steam and microwave blanching on peroxidase inactivation, colour, ascorbate and phenolic content of *C. esculenta* leaves.

Materials and Methods

Sampling collection and blanching

Fresh leaves of *C. esculenta* were harvested from the School of Biological Science Garden and authenticated by the Herbarium of the

Department of Conservation Biology and Entomology of the University of Cape Coast, Ghana. The leaves were washed with distilled water, air-dried, cut into pieces of 4 cm^2 average surface area and blanched as follows. For hot water blanching, 15 pieces of cut leaves were placed in a wire mesh bucket (surface dimension of 1 0 cm by 8 cm) and blanched in boiling water for 10, 20, 30, 60 and 120 s. Steam blanching was done with another 15 pieces of cut leaves placed on the wire mesh bucket and blanched in steam produced from boiling water for 10, 20, 30, 60 and 120 s. Microwave blanching was carried out with 20 pieces of cut leaves placed on a tissue paper (dimension of 15 cm by 15 cm) and blanched using a microwave oven (K30CSS14, Kenwood) for 5, 10, 15, 20 and 30 s. Blanching durations of more than 30 s were not employed due to the fact this caused significant shrinking and hardening of the leaves. Each blanching treatment was replicated four times.

Colour measurement

The colour of the leaves was determined using a colour meter (CS-10, CHN Spec, China). Prior to the colour analysis, water was drained off from both hot-water and steam blanched leaves. The loss of colour (ΔE), Chroma and Hue angle were calculated from the measured L*, a* and b* values.

Residual peroxidase activity determination

The method employed by Bania and Mahanta, (2012) was used in the determination of peroxidase activity. Homogenized leaves were put in sodium phosphate buffer (pH 7.4) and centrifuged. O-dianisidine solution was added after which hydrogen peroxide was added. The absorbance was measured at 430 nm and the residual peroxidase activity estimated.

Determination of ascorbate and phenolic content

The ascorbate content of the leaves was determined by the 2,4-dinitropheny-lhydrazine assay as described by Dadzie *et. al*., (2019), while the phenolic content of the leaves was determined by the Folin-Ciocalteu reagent-based assay as described by Ampofo-Asiama *et al*., (2020).

Statistical analysis

Analysis of variance (ANOVA) was performed to determine differences between the three blanching conditions at a significance level of 0.05 using SPSS (IBM, SPSS Statistics 20).

Results and discussion

Peroxidase inactivation

The ability of the different blanching methods to inactivate peroxidase is shown in Figure 1. Blanching for 10 s resulted in reduction of peroxidase activity of about 60, 26 and 15%,

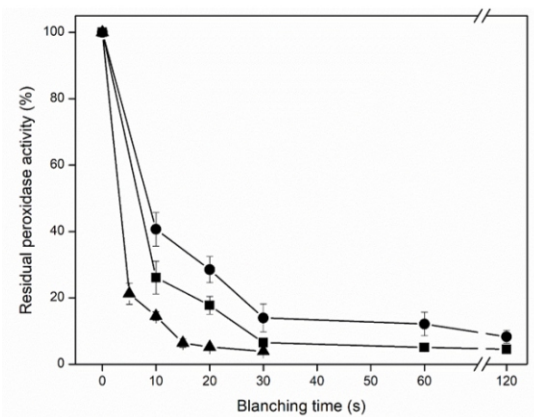

Figure 1: Residual peroxidase activity following hot water (●), steam (■) and microwave (▲) blanching of *C. esculenta* leaves. The activity of peroxidase measured after blanching is expressed as a percentage of the peroxidase activity in the unblanched leaves.

respectively, for hot water, steam and microwave blanching. A 90% reduction in peroxidase activity was observed after about 2 min of hot water blanching. Similar reductions in peroxidase activity were observed after about 30 and 15 s of steam and hot water blanching, respectively (Figure 1).

For non-pasteurised vegetables, a 90% inactivation of an indicator enzyme such as peroxidase is recommended (Bahceci *et al*., 2005). The findings of this work showed that this recommendation can be achieved within a much shorter duration when microwave blanching is employed. Similar to the observation of this study, hot water blanching required the longest duration to achieve 90% peroxidase inactivation in broccoli leaves (Severini *et al*., 2016). Wang *et al*., (2020) also reported longer blanching times to achieve 90% peroxidase inactivation in *T. sinensis* when using hot water blanching, although similar durations were required when using steam or microwave blanching.

Changes in colour

Table 1 shows the effect of the different blanching methods on colour changes (ΔE), Hue angle and chroma. The initial L*a*b* colour values of the leaves were 39.46, -15.81 and 17.76, respectively, with Hue angle and chroma of 23.8 and 131.7, respectively. Both hot water and steam blanching resulted in an increased greenness of the leaves during the initial stages of blanching, similar to the observation of Severini *et al.,* (2016). Several studies have reported an increase in lightness (L-value) during the initial stages of blanching (Brewer and Begum 2003; Lin and Brewer 2005; Miglio *et al*., 2008; Severini *et al*., 2016). A similar observation was made in the hot water and steam blanched leaves, even though these increases were not significantly different compared to the unblanched leaves.

The highest colour change (ΔE) was observed after 20 s for all the blanching conditions (Table 1). While changes in Hue angle and chroma were observed upon blanching, these were not significantly different compared to the unblanched leaves. With the exception of microwave blanching for 10 s, the hue angle for all the treatments decreased (Table 1). This is contrary to the observation of Severini *et al*., (2016), and Brewer and Begum (2003), who observed an increase in Hue angle upon microwave blanching. An increase in hue angle shows divergence from the green colour, thus, it is possible that the treatments employed in this study helped enhance the

Table 1: Effect of hot water, steam and microwave blanching on the colour properties of *C. esculenta* leaves

Blanching method and time (s)	ΔE	chroma	Hue angle
Hot water			
10	2.50	28.92	132.30
20	4.42	30.56	130.69
30	5.89	21.35	132.27
60	2.23	27.88	132.44
120	3.44	29.43	131.97
Steam			
10	3.22	29.64	129.03
20	6.79	33.14	128.48
30	0.60	27.03	129.74
60	2.36	26.45	130.64
120	2.98	23.71	130.99
Microwave			
5	6.85	21.02	132.67
10	5.77	21.32	136.09
15	7.41	31.52	132.55
20	9.13	33.10	130.52
30	4.51	29.44	130.92

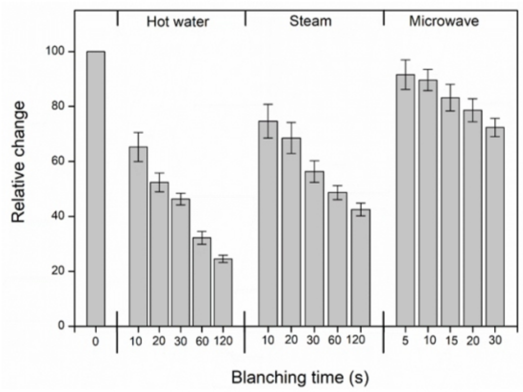

Figure 2: Effect of hot water, steam and microwave blanching on ascorbate level in *C. esculenta* leaves. The ascorbate level remaining after blanching has been expressed as a percentage of the unblanched leaves (time 0 s).

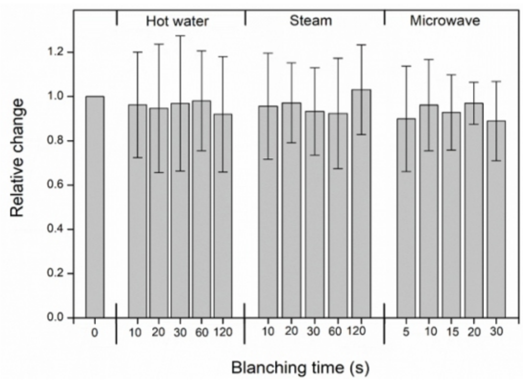

Figure 3: Effect of hot water, steam and microwave blanching on the phenolic content of *C. esculenta*. The phenolic content of the blanched leaves has been expressed relative to the unblanched leaves (time 0 s).

green colour of the leaves.

Ascorbate degradation and changes in phenolic content

Figure 2 shows the retention of ascorbate under the different blanching conditions. The highest retention of ascorbate after 10 s was observed in the microwaved leaves while hot water blanching resulted in the highest ascorbate loss. In broccoli, higher losses in ascorbate were observed upon hot water blanching compared to steam and microwave blanching, probably due to leaching of nutrients during hot water blanching (Arroqui *et al*., 2001; Severini *et al*., 2016). The loss of ascorbate following microwave blanching is opposite that reported in other leaves where an increase was observed (Oerlemans *et al*., 2006; Severini *et al*., 2016; Verkerk and Dekker 2004), although other studies have reported decreased ascorbate levels (Drake *et al*., 1981; Brewer and Begum 2003). Generally, an increase in the duration of blanching resulted in higher ascorbate loss, irrespective of the blanching method.

The relative changes in phenolic content of the leaves are shown in Figure 3. The phenolic content of the unblanched leaves was 298.7 mgGAE/100 g. Contrasting reports on the effect of blanching on phenolic content have been reported. While decreases in phenolic content have been observed in some studies (Stewart *et al*., 2000; Turkmen *et al*., 2005; Wang *et al*., 2020), others have reported no significant changes in phenolic content upon blanching (Severini *et al.,* 2016). In this study, no discernible trend in phenolic content was observed under the different blanching conditions. These observations may be due to the high degree of variability in the leaf samples as well as differences in the types of phenolic compounds that may be present in these samples (Podsedek *et al*., 2006).

Conclusions

Hot water, steam and microwave blanching can be employed as a pre-processing step during the processing of *C. esculenta* leaves without significantly affecting colour and phenolic content. However, all three blanching methods resulted in reductions in ascorbate levels, with highest losses observed in the hot water blanched leaves. Using peroxidase as an indicator enzyme, the leaves of *C. esculenta*, can be successfully blanched within 15, 30 and 120 s when using microwave, steam and hot water blanching, respectively.

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