EFFECT OF STEAMING ON THE PHYTOCHEMICAL COMPOSITION AND NUTRITIONAL VALUE OF SENNA OCCIDENTALLIS (COFFEE SENNA).

Abstract

The processing of medicinal plants plays a vital role in traditional medicine, as it profoundly affects treatment efficacy and safety. Heating has been an important method in the preparation of medicinal plants. In northern Nigeria *Senna occidentallis* is notable for its edible uses usually prepared by steaming, hence this study aims to investigate the effect of steaming on the phytochemical composition and nutritional value of the plant. Cold maceration and liquid liquid extraction method was employed for the extraction.Standard methods were employed for the phytochemicals and proximate analysis. Steaming increased the moisture content and crude fat but reduced the crude protein, crude fibre, ash compositions and carbohydrate content. Aside from phenols which decreased by steaming every other phytochemicals were increased by steaming.

The findings of this study will provide valuable insights into the effects of heat treatment on the phytochemical composition and nutritional value of *Senna occidentalis*, Informing the optimization of processing and storage protocols to preserve the plant's nutrient profile and potential health advantages.

Keywords: Steaming**,** *Senna occidentallis***,** phytochemical composition, proximate composition

Introduction

The processing of medicinal plants plays a vital role in traditional medicine, as it profoundly affects treatment efficacy and safety. Conventional methods, such as infusion and fermentation, have been employed for generations and remain prevalent today. These techniques are cherished for their cultural significance, historical value and ability to preserve medicinal plants' natural compounds.

The World Health Organization acknowledges traditional medicine's importance, emphasizing the need for further research into its safety and efficacy (WHO,2019). However, traditional processing methods can have unpredictable effects on extracted compounds, influencing their efficacy and safety. For instance, heat can degrade sensitive compounds, while fermentation can give rise to new ones (Zhang et al., 2015).

For centuries, in traditional medicine, heating has been an important method in the preparation of medicinal plants, by extracting bioactive compounds, enhancing potency, and facilitating absorption.The use of heat in traditional medicine is based on the concept of "bioavailability," which implies the extent to which the body can absorb and utilize the bioactive compounds present in medicinal plants. Heating can enhance bioavailability by breaking down cell walls, releasing bound compounds, and increasing the solubility of lipophilic compounds (Zhang, et al. (2019)).Other advantages of heating include increased shelf life (Karel & Lund, 2003),

improved food safety, enhanced nutritional value (Doyle & Beuchat 2017) reduced pesticide residues (Holland et al.,2013) and improved texture and flavor (Deliza et al.,2005). On the other hand, heating can be detrimental to medicinal plants, particularly if excessive. Heat can lead to nutrient loss (Wahid, A., et al. (2007)), degrade or destroy fragile phytochemicals (Boyer & Liu, 2004), alter the molecular architecture of bioactive molecules, and reduce the therapeutic strength of the medicinal plant. (Zhang et al., 2015).

Senna occidentalis, also known as coffee senna, is a flowering plant species native to tropical and subtropical America. It's a shrub that grows up to 2 meters tall, with pinnate leaves and yellow flowers arranged in groups of two to four.The plant has been used in traditional medicine for various purposes, including as a diuretic, febrifuge, stomachic, and tonic. The leaves, roots, and seeds are used to treat different ailments, such as hypertension, dropsy, diabetes, and skin conditions like eczema and ringworm .

In North Western Nigeria, Senna occidentalis is a valuable resource for food, medicine, and other purposes. The plant's leaves, seeds, and fruit pulp are used in various traditional recipes and medicinal preparations, showcasing the region's rich cultural heritage. (Kajaria et al.,2015; Adebowale et al., 2012 and Abdullahi et al.,2016)

The plant is reported to have rich phytochemical profile, including alkaloids, glycosides, and phenolic compounds, which have been shown to possess various biological activities, including anti-inflammatory, antimicrobial, and antioxidant properties (Oliver, 1982; Adesina et al., 2011).

However, like many other plant-based foods and medicines, the phytochemical composition and nutritional value of *Senna occidentalis* can be compromised by various processing and storage conditions, including heat treatment (Koleoso et al., 2018).

Despite the importance of *Senna occidentalis* in traditional medicine and its potential as a food ingredient, there is limited information on the specific effects of heat treatment on phytochemical composition and nutritional value of Coffee Senna. This knowledge gap is particularly significant in Nigeria, where the plant is widely used in traditional medicine and as a food ingredient.

This study specifically aims to determine the impact of steaming on the plant's phytochemical content, as well as its nutritional value. The findings of this study will provide valuable insights into the effects of heat treatment on the phytochemical composition and nutritional value of Senna occidentalis, which will inform the development of optimal processing and storage conditions for preserving the plant's nutritional value and potential health benefits.

Methodology

Collection and Preparation of Plant Material

Fresh leaves of senna occidentallis plant were randomly collected at Rijiyar Zaki area of Gwale Local Government Kano State during the rainy season . The samples were thoroughly washed, before dividing both into two parts. A portion of the leave sample was steamed over boiling water at 100^0 C for one hour and then dried at room temperature ($25\text{-}30^0$ C) for one week till constant weight was attained to obtain treated leaf sample which was ground using wooden mortar and pestle and labelled steamed sample (SS). The other halve was left un-steamed and also dried at room temperature, pounded and labelled fresh sample (FS). The powdered sample was stored in dry container until needed.

Extraction of plant samples

Approximately 100g of the dried powdered samples (SS and FS) was soaked in 500ml ethanol using cold mercerization process the plant material was left in contact with the solvent for 7 days after which the extract was decanted and filtered through a Whatmann's filter paper. The filtrate was concentrated to dryness under reduced pressure on a rotary evaporator. The ethanol extract was partitioned with hexane, chloroform and ethyl acetate and each extract was concentrated to dryness under reduced pressure using a rotary evaporator.

Chemical determinations

The proximate analysis for moisture, total ash and crude fibre were carried out using the official methods described by AOAC (2005). Weights of samples ranged from 1.00g to 3.00g. The crude fat was extracted with a petroleum ether using Soxhlet extraction apparatus as described by the AOAC (2005). The micro-Kjeldahl method as described by Pearson (1976) was followed to determine the crude protein while carbohydrate was determined by difference. Qualitative phytochemicals was carried out using standard procedures outlined by Harbone (1984) and sofowara (1993). While for quantitative phytochemicals, alkaloids were determined according to Okwu and Josiah (2006), saponins were estimated as described by (Obadoni and Ochuk, 2001). Tannins were quantified using the method of Sofowora (1993). Phenol was measured using the Folin Ciocalteu reagent (Mc Donald et al., 2001) while oxalate was determined adopting methods described by (Day and Underwood, 1986).

Table 1: Result of Phytochemical Screening of Leaves Extracts of Senna occidentallis (Fresh & Steamed Samples)

Phytochemicals	Ethanol		Hexane		Chloroform		Ethylacetate	
	FS	SS	FS	SS	FS	SS	FS	SS
Tannins	+	+	+	+	+	+	+	+
Flavonoids	+	+	+	-	-	-	-	+
Alkaloids	+	+	+	+	+	+	+	+
Saponin	+	+	-	-	+	-	+	+
Glycosides	+	+	-	-	-	-	+	-

Terpenoids	+	+	+	+	-	+	+	+
Steroids	+	+	-	-	+	+	-	+
Phenols	+	+	-	-	+	+	-	-

KEY: += present - = Absent FS =Fresh sample SS= Steamed sample

Table 2: Result of Proximate Analysis

Test	Fresh sample (%)	Steamed sample (%)
Moisture content	12.25	13.25
Ash content	11.68	9.36
Crude Fat	3.80	6.05
Crude Fibre	11.30	11.20
Crude protein	13.10	12.65
Carbohydrate	47.87	47.49

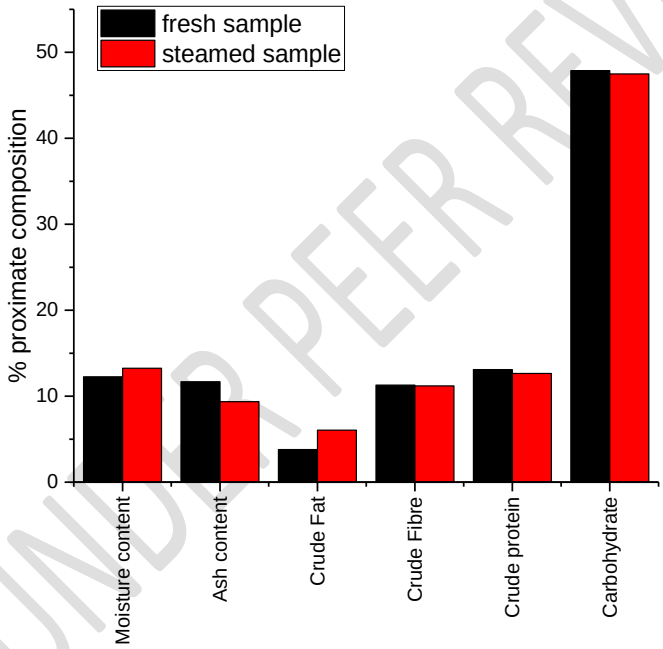

Fig 1. Graph of proximate analysis of fresh and steamed samples

Table 3: Result of Anti Nutrient Analysis of Senna occidentallis Leave

Phytochemicals	Fresh sample (mg/100g)	Steamed sample (mg/100g)
Tannins	0.78	0.96

Alkaloids	3.00	3.35
Saponin	1.50	1.72
Oxalates	0.10	0.60
Phenol	4.20	4.00

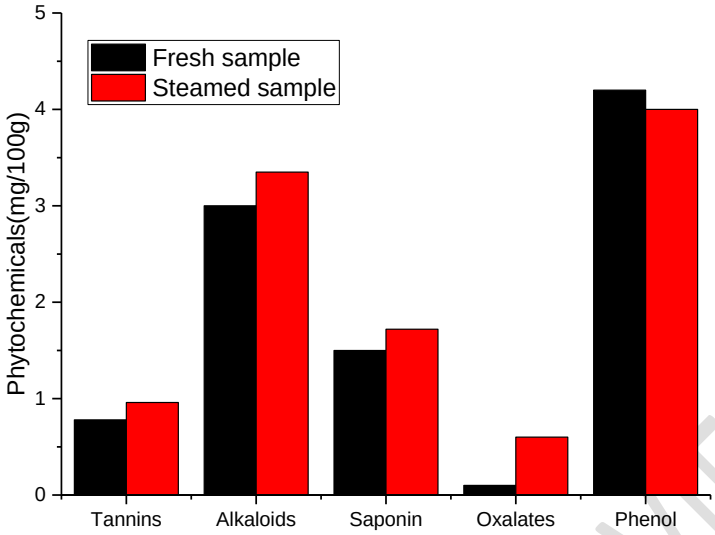

Fig 2. Graph of phytochemical analysis of fresh and steamed samples

Discussion

The phytochemical analysis of both fresh and steamed Senna occidentalis leaves revealed the presence of all phytochemicals tested in the ethanol extract. This suggests that these compounds are relatively stable to heat and resistant to degradation caused by steaming. Retention of bioactive compounds implies that Senna occidentalis leaves retain their nutritional value even after steaming. However, among other extracts there appears to be a rather complex phytochemical distribution. In the hexane extract, tannins, alkaloids and terpenoids were present in both fresh and steamed samples, indicating that they are heat-stable and not affected by steaming. On the other hand, flavonoids were present in the fresh sample but absent in the steamed sample, indicating that flavonoids are heat-sensitive and may be degraded or lost during steaming while saponin, glycosides, steroids and phenols were absent in both fresh and steamed samples, probably because they may not have been extracted into the hexane phase or may be present in very low concentrations. Coming to the chloroform extract, tanins, alkaloids phenol and steroids were present in both samples. Saponins were also present in fresh but absent in steamed sample. Saponins are known to be heat-sensitive (Kiddle et al.,2001), heat from steaming may have degraded or denatured these compounds, making them unnoticed and some saponins are volatile and could possibly have evaporated or broken down in the cause of steaming, hence their absence in the steamed samples, (Oleszek, 2002).Terpenoids was absent

in fresh but present in steamed sample which could be explained by the fact that terpenoids may be bound to other cellular components in fresh samples, making them undetectable (Lange & Ahkami, 2013) steaming probably could have released these bound terpenoids, making them noticeable in the steamed samples. Flavonoid and glycoside were absent in both samples possibly due to their insolubility in the chloroform phase. As for the ethyl acetate fraction, tannins, alkaloid, saponins and terpenoid were present in both samples indicating their heat stable nature, glycoside were present in fresh but absent in steamed possibly due to decomposition by heat, flavonoids and steroids were absent in fresh but present in the steamed sample .The detection of flavonoids and steroids solely in the steamed leaves sample of ethyl acetate, and not in the fresh sample, yields a fascinating outcome. This discovery implies that the steaming process may have activated the biosynthesis or release of these compounds. Studes has revealed that certain flavonoids increases with rising temperatures (. Li et al. (2017)). The presence of steroids in the steamed leaves sample is particularly noteworthy. Steroids are typically associated with plant defense responses (Piatak et al. (2018). Various environmental stressors, including heat treatment, can trigger steroid biosynthesis Bhatia et al. (2015). Phenols were completely absent in both samples.

The results highlight the importance of selecting the appropriate solvent for phytochemical extraction. Hexane may not be the best solvent for extracting all phytochemicals, particularly polar compounds like phenols and glycosides.The results also indicate that some phytochemicals, like tannins, alkaloids, and terpenoids, are heat-stable and not affected by steaming. However, other phytochemicals, like flavonoids, may be heat-sensitive and degraded or lost during steaming.These findings provide insight into the phytochemical profile of Senna occidentalis leaves and highlight the importance of considering the effects of processing and extraction methods on the phytochemical composition of plant materials.

The proximate analysis of Senna occidentalis leaves reveals significant differences between fresh and steamed samples.The steamed sample has a higher moisture content (13.25%) compared to the fresh sample (12.25%). This increase is expected due to the steaming process. However, this value is lower than the moisture content reported in other studies, which ranged from 30.83% to 42.00% (Isah et al. (2012); Oloyede et al. (2014).The ash content decreased from 11.68% in the fresh sample to 9.36% in the steamed sample. This decrease may be due to the loss of minerals during the steaming process. The ash content in this study is higher than the 8.73% reported by Isah et al. (2012).The crude fat content increased from 3.80% in the fresh sample to 6.05% in the steamed sample. This increase may be due to the breakdown of cell walls during steaming, releasing more fat. The crude fat content in this study is higher than the 2.95% reported by Isah et al. (2012).

The crude fibre content remained relatively constant, with a slight decrease from11.30% in the fresh sample to 11.20% in the steamed sample. This stability may be due to the heat-stable nature of fibre. The crude fibre content in this study is lower than the 18.12% reported by Isah et al.

(2012).The crude protein content decreased from 13.10% in the fresh sample to 12.65% in the steamed sample. This decrease may be as a result of the denaturation of proteins during steaming. The crude protein content in this study is lower than the 30.83% reported by Isah et al. (2012)

The carbohydrate content remained relatively constant, with a slight decrease from 47.87% in the fresh sample to 47.49% in the steamed sample. This stability may be due to the heat-stable nature of carbohydrates. The carbohydrate content in this study is higher than the33.73% reported by Isah et al. (2012).

The anti-nutrient analysis of Senna occidentalis leaves reveals that steaming increases the concentration of some anti-nutrients, while decreasing others. The increase in tannin content from 0.78 mg/100g in the fresh sample to 0.96 mg/100g in the steamed sample may be due to the breakdown of cell walls during steaming, releasing more tannins into the extract. This is consistent with the findings of Isah et al. (2012), who reported a tannin content of 1.23 mg/100g in Senna occidentalis leaves. Similarly, Oloyede et al. (2014) reported a tannin content of 1.50 mg/100g in Senna occidentalis leaves. However, the tannin content in the present study is lower than the reported values.The alkaloid content increased from 3.00 mg/100g in the fresh sample to 3.35 mg/100g in the steamed sample, which may be due to the heat-stable nature of alkaloids. Oloyede et al. (2014) reported an alkaloid content of 4.50 mg/100g in Senna occidentalis leaves, which is higher than the value obtained in the present study. Similarly, Ahmed et al. (2016) reported an alkaloid content of 5.20 mg/100g in Senna occidentalis leaves.The saponin content increased from 1.50 mg/100g in the fresh sample to 1.72 mg/100g in the steamed sample, which may be due to the breakdown of cell walls during steaming. Isah et al. (2012) reported a saponin content of 2.50 mg/100 g in Senna occidentalis leaves, which is higher than the value obtained in the present study. Similarly, Kumar et al. (2017) reported a saponin content of 3.00 mg/100g in Senna occidentalis leaves.The oxalate content increased from 0.10 mg/100g in the fresh sample to 0.60 mg/100g in the steamed sample, which may be due to the conversion of other compounds to oxalates during steaming. Oloyede et al. (2014) reported an oxalate content of 0.50 mg/100g in Senna occidentalis leaves, which is lower than the value obtained in the steamed sample.
The phenol content decreased from 4.20 mg/100g in the fresh sample to 4.00 mg/100g in the steamed sample, which may be due to the volatilization of phenols during steaming. Isah et al. (2012) reported a phenol content of 5.50 mg/100g in Senna occidentalis leaves, which is a bit higher than the value obtained in the present study. Similarly, Ahmed et al. (2016) reported a phenol content of 6.00 mg/100g in Senna occidentalis leaves.

Correlating the proximate and anti-nutrient parameters, it can be observed that the increase in crude fat content and decrease in crude protein content may be related to the increase in tannin and alkaloid content. The decrease in ash content may also be related to the increase in oxalate content.

The implications of the results are that Senna occidentalis leaves may be a good source of nutrients, but the steaming process may affect their nutritional and phytochemical composition. The increase in anti-nutrient content may have pharmacological effects, and the decrease in nutrient content may affect their nutritional value.

Conclusion

The study highlights the potential of Senna occidentalis leaves as a rich source of phytochemicals and nutrients including crude protein, carbohydrates, and crude fiber. Steaming the leaves resulted in minimal changes to the nutritional profile, with a slight increase in moisture content and crude fat.The anti-nutrient analysis of Senna occidentalis leaves reveals that steaming increases the concentration of some anti-nutrients, while decreasing others. These findings have implications for the use of Senna occidentalis leaves as a nutritional supplement or food ingredient.Steaming may enhance the nutritional value of Senna occidentalis leaves by increasing the availability of fat-soluble vitamins and other nutrients. However, the decrease in crude protein content may affect the overall nutritional quality of the leaves.Future research should investigate the bioavailability and bioactivity of these compounds, as well as the effects of different processing methods on the nutritional and phytochemical profile.

References

A.O.A.C 2005 " Official method of analysis" Association of Official Analytical Chemists, Medical Journal., 80: 218-221

Abdullahi, M., et al. (2016). Traditional medicine and its role in the healthcare system in Nigeria. Journal of Traditional and Complementary Medicine, 6(3), 259-265.

Adebowale, A. A., et al. (2012). Phytochemical analysis and antioxidant activity of Senna occidentalis (L.) Link. Journal of Medicinal Plants Research, 6(15), 3134-3146.

Ahmed, A. B., Abdurahman, F. H., & Usman, A. (2016). Phytochemical analysis of Senna occidentalis leaves. Journal of Pharmaceutical Research, 10(2), 1-5.

Bhatia, S., Mahajan, M., & Singh, K. (2015). Heat stress-induced biosynthesis of plant steroids. Journal of Plant Physiology, 176, 105-112.

Boyer, J., & Liu, R. H. (2004). Apple phytochemicals and their health benefits. Nutrition Journal, 3(1), 5.

Day, R.A and Underwood,A.(1986)Quantitative Analysis 5th edition Prentice Hall 452-453.

Deliza, R., Rosenthal, A., & Silva, A. L. (2005). Consumer attitude and acceptance of food irradiation in Brazil. Journal of Food Science, 70(2), S144-S149.

Dewanto, V., Wu, X., & Liu, R. H. (2002). Processed sweet corn has higher antioxidant activity. Journal of Agricultural and Food Chemistry, 50(17), 4959-4969.

Doyle, M. P., & Beuchat, L. R. (2017). Food Microbiology: Fundamentals and Frontiers. American Society for Microbiology.

Food and Agriculture Organization of the United Nations.(FAOUN) (2018). Heat treatment of food.

Harborne J.B., (1984). Phytochemical methods. London Chapman and Hall Ltd., pp 49-188

Holland, N., et al. (2013). Effects of heat treatment on pesticide residues in fruits and vegetables. Journal of Agricultural and Food Chemistry, 61(2), 531-537.

Isah, A. B., Ibrahim, Y. K. E., & Umar, K. J. (2012). Phytochemical analysis of Senna occidentalis leaves. Journal of Pharmacy and Biological Sciences, 4(3),234-238.

Kajaria, D., et al. (2015). Ethnobotanical survey of medicinal plants used by Hausa people in Kano State, Nigeria. Journal of Ethnopharmacology, 174, 351-358.

Karel, M., & Lund, D. B. (2003). Physical principles of food preservation(2nd edition). CRC Press.

Kiddle, G., et al. (2001). Effects of cooking and processing on the phytochemical composition of plant-based foods. Journal of the Science of Food and Agriculture, 81(3), 281-288.

Koleoso, O. A., et al. (2018). Effects of heat treatment on the bioavailability of bioactive compounds in medicinal plants. Journal of Ethnopharmacology, 231, 102-115.

Kumar, P., Kumar, V., & Sharma, S. (2017). Phytochemical analysis of Senna occidentalis leaves. Journal of Ayurveda and Integrative Medicine, 8(3), 151-155.

Lange, B. M., & Ahkami, A. (2013). Metabolic engineering of plant monoterpenes, sesquiterpenes and diterpenes – Current status and future opportunities. Plant Biotechnology Journal, 11(2),169-196.

Li, Y., Zhang, J., Xu, Y., & Wang, X. (2017). Effect of heat treatment on the flavonoid content of tea leaves. Journal of Food Science, 82(5), S1448-S1456.

McDonald, S, Prenzler, P. D., Antolovich, M., and Robards, K. 2001. Phenolic content and antioxidant activity of olive extract. Food chemistry 73:73- 84.

Obadomi, B. O. and Ochuko, P. O. 2001. Phytochemical studies and efficacy of crude extracts of some homeostatic plants in Edo and Delta State of Nigeria. Global Journal of Pure and Applied Science..;8:203-208.

Ogunwande, I. A., et al. (2003). Essential oil composition of Senna occidentalis (L.) Link. Journal of Essential Oil Research, 15(6), 437-438.

Okwu, D. E. and Josiah, C. 2006. Evaluation of chemical compound of two Nigerian medicinal plant. Africa Journal of Biotechnology. Vol.5(4):357-361.

Oleszek, W.(2002). Chromatographic determination of plant saponins. Journal of Chromatography A, 967 (1), 147-162.

Oloyede, O. I., Ajiboye, A. E., & Komolafe, K. (2014). Nutritional evaluation of occidentalis leaves. Journal of Food Science and Technology, 51(4),761-766.

Pearson, J.R. (1976). The American Journal of Clinical Nutrition 29 (12): 1468-1473

Piatak, A., Kneer, R., & Werner, S. (2018). Plant steroids: Biosynthesis, regulation, and roles in plant development and stress responses. Plant Physiology, 176 (1), 148- 163.

Rickman, J. C., et al. (2007). Nutritional comparison of fresh, frozen, and canned fruits and vegetables. Journal of the Science

Rivero, R. M., Mestre, T. C., Mittler, R., Rubio, F., García-Sánchez, F., & Martínez, V. (2014). Heat stress and antioxidant responses in plants. Journal of Experimental Botany, 65(2),533-545.

Sofowora, A. (1993). Medicinal plants and traditional medicine in Africa. John Wiley & Sons.

Suzuki, N., Bassil, E., Hamilton, J. S., Inupakutika, M. A., Zandalinas, S. I., & Daldal, H. (2018). Plant defense responses to heat stress: A review. Journal of Plant Research, 131 (2), 251-265.

Wahid, A., Gelani, S., Ashraf, M., & Foolad, M. R. (2007). Heat tolerance in plants: An overview. Environmental and Experimental Botany, 61(3), 199-223.

WHO (2019). WHO Traditional Medicine Strategy 2014-2023. World Health Organization.

Zhang, Y., et al. (2015). Effects of heat treatment on the chemical composition and antioxidant activity of medicinal plants. Journal of Ethnopharmacology, 159, 251-258.

Zhang, Y., & Chen, F. (2019). Polyphenol extraction and bioavailability: Effects of food processing. Journal of Agricultural and Food Chemistry, 67(2), 533-543

[1] World Health Organization.(WHO). Traditional Medicine Strategy 2019; 2014-2023.

[2] Zhang, Y., et al. Effects of heat treatment on the chemical composition and antioxidant activity of medicinal plants. Journal of Ethnopharmacology, 2015; 159, 251-258.

[3] Zhang, Y., & Chen, F. Polyphenol extraction and bioavailability: Effects of food processing. Journal of Agricultural and Food Chemistry. 2019; 67(2), 533-543.

[4] Karel, M., & Lund, D. B. (2003). Physical principles of food preservation(2nd edition). CRC Press.

[5] Doyle, M. P., & Beuchat, L. R. (2017). Food Microbiology: Fundamentals and Frontiers. American Society for Microbiology.

[6] Holland, N., et al. (2013). Effects of heat treatment on pesticide residues in fruits and vegetables. Journal of Agricultural and Food Chemistry, 61(2), 531-537.

[7] Deliza, R., Rosenthal, A., & Silva, A. L. (2005). Consumer attitude and acceptance of food irradiation in Brazil. Journal of Food Science, 70(2), S144-S149.

[8] Wahid, A., Gelani, S., Ashraf, M., & Foolad, M. R. (2007). Heat tolerance in plants: An overview. Environmental and Experimental Botany, 61(3), 199-223.

[9] Boyer, J., & Liu, R. H. (2004). Apple phytochemicals and their health benefits. Nutrition Journal, 3(1), 5.

[10] Kajaria, D., et al. (2015). Ethnobotanical survey of medicinal plants used by Hausa people in Kano State, Nigeria. Journal of Ethnopharmacology, 174, 351-358.

[11] Adebowale, A. A., et al. (2012). Phytochemical analysis and antioxidant activity of Senna occidentalis (L.) Link. Journal of Medicinal Plants Research, 6(15), 3134-3146

[12] Abdullahi, M., et al. (2016). Traditional medicine and its role in the healthcare system in Nigeria. Journal of Traditional and Complementary Medicine, 6(3), 259-265.

[13] Adesina, S. K., et al. (2011). Phytochemical and antimicrobial studies of Senna occidentalis (L.) Link. Journal of Ethnopharmacology, 137(2), 535-541.

[14] Koleoso, O. A., et al. (2018). Effects of heat treatment on the bioavailability of bioactive compounds in medicinal plants. Journal of Ethnopharmacology, 231, 102-115.

[15]A.O.A.C 2005 " Official method of analysis" Association of Official Analytical Chemists, Medical Journal., 80: 218-221

[16] Olaleye 2024

[17] Harborne J.B., (1984). Phytochemical methods. London Chapman and Hall Ltd., pp 49-188

[18] Sofowora, A. (1993). Medicinal plants and traditional medicine in Africa. John Wiley & Sons.

[19] Okwu, D. E. and Josiah, C. 2006. Evaluation of chemical compound of two Nigerian medicinal plant. Africa Journal of Biotechnology. Vol.5(4):357-361.

[20] Obadomi, B. O. and Ochuko, P. O. 2001. Phytochemical studies and efficacy of crude extracts of some homeostatic plants in Edo and Delta State of Nigeria. Global Journal of Pure and Applied Science..;8:203-208.

[21] McDonald, S, Prenzler, P. D., Antolovich, M., and Robards, K. 2001. Phenolic content and antioxidant activity of olive extract. Food chemistry 73:73- 84.

[22] Day, R.A and Underwood,A.(1986)Quantitative Analysis 5th edition Prentice Hall 452-453.

[23] Kiddle, G., et al. (2001). Effects of cooking and processing on the phytochemical composition of plant-based foods. Journal of the Science of Food and Agriculture, 81(3), 281-288.

[24] Oleszek, W.(2002). Chromatographic determination of plant saponins. Journal of Chromatography A, 967 (1), 147-162.

[25] Lange, B. M., & Ahkami, A. (2013). Metabolic engineering of plant monoterpenes, sesquiterpenes and diterpenes – Current status and future opportunities. Plant Biotechnology Journal, 11(2),169-196.

[26] Li, Y., Zhang, J., Xu, Y., & Wang, X. (2017). Effect of heat treatment on the flavonoid content of tea leaves. Journal of Food Science, 82(5), S1448-S1456.

[27] Piatak, A., Kneer, R., & Werner, S. (2018). Plant steroids: Biosynthesis, regulation, and roles in plant development and stress responses. Plant Physiology, 176 (1), 148- 163.

[28] Bhatia, S., Mahajan, M., & Singh, K. (2015). Heat stress-induced biosynthesis of plant steroids. Journal of Plant Physiology, 176, 105-112.

[29] Isah, A. B., Ibrahim, Y. K. E., & Umar, K. J. (2012). Phytochemical analysis of Senna occidentalis leaves. Journal of Pharmacy and Biological Sciences, 4(3),234-238.

[30] Oloyede, O. I., Ajiboye, A. E., & Komolafe, K. (2014). Nutritional evaluation of occidentalis leaves. Journal of Food Science and Technology, 51(4),761-766.

[31]Ahmed, A. B., Abdurahman, F. H., & Usman, A. (2016). Phytochemical analysis of Senna occidentalis leaves. Journal of Pharmaceutical Research, 10(2), 1-5.

[32] Kumar, P., Kumar, V., & Sharma, S. (2017). Phytochemical analysis of Senna occidentalis leaves. Journal of Ayurveda and Integrative Medicine, 8(3), 151-155.