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Assessment of Fatty Acid Profile in Herbal Teas Consumed in North West Nigeria and Their Potential Health Implications

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ABSTRACT
Herbal teas and related beverages have achieved significant internal recognition due to their rich Natural bioactive compounds that are known to exhibit diverse biological effects, including antioxidant and anticarcinogenic properties. However, the lipidomics profiles of herbal teas remain largely unexplored. The aim of this study was to comprehensively characterize and compare the fatty acid composition of ten popular herbal teas (GM, LM, EMR, STR, PNP, O&G, GH, CSH, EG, TM) Using Gas Chromatography–Mass Spectrometry (GC–MS) Distinct molecular species of lipids were identified, dominated by long-chain saturated and unsaturated fatty acids. Significant quantities of hexadecanoic acid (palmitic acid, 16:0) and octadecanoic acid (stearic acid, 18:0) were consistently detected across the samples. Several biologically active unsaturated fatty acids were also identified, including 9,12-octadecadienoic acid (linoleic acid, 18:2, n-6) and essential omega-6 fatty acid and 9-octadecenoic acid (oleic acid, 18:1, n-9), known for their cardio protective properties. Interestingly, trace amounts of short-chain and odd-chain saturated fatty acids, such as dodecanoic acid (lauric acid, 12:0) and pentadecanoic acid (15:0), were also detected, potentially serving as authenticity markers for herbal teas. Although these lipids occur in small quantities per serving, their presence suggests that herbal teas may provide a previously unaccounted spectrum of bioactive lipid compounds. Overall, this study provides novel insights into the lipidomics diversity and potential bioactive lipid components of herbal teas, offering a foundation for further research into their nutritional value, authenticity, and health-promoting properties.

Keywords:
Fatty acid, Lipidomics, Bioactive lipid, Palmitic acid, Anticarcinogenic.

INTRODUCTION

Tea is the most consumed non-alcoholic beverage worldwide after water, valued for its unique flavor, pleasant taste, and numerous perceived health benefits, including antioxidant, antimicrobial, immune-stimulatory, and antimutagenic properties, as well as its potential to reduce cardiovascular diseases and cholesterol levels (Gomeset al., 2019).

Tea leaves are also rich in essential mineral elements such as cobalt (Co), manganese (Mn), iron (Fe), zinc (Zn), magnesium (Mg), calcium (Ca), sodium (ND), and potassium (K). These minerals play crucial roles in the growth and development of tea plants and are involved in various physiological and metabolic processes. Moreover, they contribute to the nutritioNDl value of tea, as minerals are present in all body tissues, including those associated with fatty acid metabolism**.**

The beneficial effects of tea consumption on weight maNDgement**,** reduction of type 2 diabetes risk, and cardiovascular health have been widely reported (Wolfram, 2007; Huxley et al., 2009; Phung et al., 2010). According to Wolfram (2007), the intake of five to six cups of green tea per day was associated with improvements in cardiovascular and metabolic health, as well as a lower risk of type 2 diabetes.

Lipidomics, a rapidly advancing aNDlytical technique, is widely used to characterize lipid molecules in foods. In previous studies, we have successfully applied lipidomics to identify diverse lipid species, including furan fatty acids, N-acyl lysophosphatidyl ethanolamine (LPE), and acyl sterol glycosides**,** as well as to comprehensively profile the lipid composition in salmon, shellfish, seaweed, and beans (Gowda et al., 2024).

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The aroma diversity among tea varieties largely depends on the type and concentration of fatty acids, as well as factors such as leaf maturity, harvest time, and storage conditions (Guo et al., 2021). Fatty acids are recognized as key aroma precursors in tea, and their content tends to increase with leaf maturation (Mahanta et al., 2010).

Recent lipidomics studies have identified over 340 lipid species in herbal teas, including novel short-chain fatty acid esters (SFAHFAs), which are associated with gut health benefits. For instance, omega-6 fatty acids were found to be abundant in acacia, rose, and yarrow teas**,** while omega-3 fatty acids were predomiNDnt in mint, green tea, and lavender teas (NDth et al., 2024). Fatty acids with 14–20 carbon atoms and polyunsaturated fatty acids (PUFAs) containing more than 20 carbon atoms, such as docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), also contribute to the unique biochemical and sensory characteristic of tea.

Significance of the study

This study provides a detailed characterization of the fatty acid composition of ten widely consumed herbal teas, uncovering a diverse array of lipid species that have been largely unexplored. Both long-chain saturated and unsaturated fatty acids were identified, including bioactive compounds such as linoleic acid (18:2, n-6) and oleic acid (18:1, n-9), which are associated with cardioprotective and other health-promoting effects. In addition, trace levels of short-chain and odd-chain saturated fatty acids, including lauric acid (12:0) and pentadecanoic acid (15:0), were detected, suggesting their potential use as markers for product authenticity. Although these lipids occur in small quantities per serving, their presence highlights an additional nutritional and functional dimension of herbal teas. The findings expand current understanding of the bioactive components of these beverages beyond their well-known polyphenols. Furthermore, this study establishes a baseline dataset that can guide future research on the nutritional value, health-promoting properties, and authenticity of herbal teas. Collectively, the results emphasize the importance of considering lipid components in evaluating the overall functional potential of herbal teas

MATERIALS AND METHODS

SAMPLE COLLECTIONS

The analysis of fatty acids in tea and their infusions was performed using ten herbal tea brands purchased from distributors' retail markets across the Northwest region of Nigeria between 2024 and 2025. Samples were collected from three states: KatsiND (n = 3), Zamfara (n = 3), and Kano (n = 4), each obtained from three different retail shops.All tea samples were stored in their origiNDl sealed packaging at room temperature (25 ± 2 °C) for no longer than one month prior to analysis and within their manufacturer's expiration dates

The study included ten types of herbal teas: MG (Mango), TM (Turmeric), O&G (Orange & Garlic), STR (Strawberry), PNP (Pineapple), LM (Lemon Mix), EG (Ginger & Honey), EMR (Emerald), CSH (Cashew), and GH (Green Herb), each represented by one sample (n = 1 per type). These fruit–herbal teas consisted of ingredients such as strawberry, mango, turmeric, cashew, pineapple, ginger and honey, orange and garlic, and lemon herbs.

SAMPLE PREPARATION

The ten commercially purchased tea samples were removed from their packaging, and the contents of each tea bag were carefully transferred to ensure a representative composite sample.

Each sample was ground into a fine, homogeneous powder using a blender and liquid nitrogen to prevent thermal degradation of lipids. The powdered samples were stored in airtight glass containers until further analysis.

A 1.0g portion of each homogenized tea powder was weighed into a pre-tared glass vial. Samples were lyophilized (freeze-dried) for 24h to remove residual moisture. Lyophilization is critical to ensure efficient solvent penetration during lipid extraction and to allow accurate dry-weight-based lipid quantification.

LIPID EXTRACTION

Total lipids were extracted using a modified Folch method, which provides comprehensive lipid recovery from plant matrices. Each freeze-dried sample was transferred into a clean glass centrifuge tube, and 20 mL of chloroform–methanol (2:1, v/v) was added. The mixture was vortexed vigorously for 2 minutes, followed by ultrasonic treatment in an ice-water bath for 30 minutes to ensure complete cell lysis and lipid solubilization.

The tubes were then centrifuged at 4,000 rpm for 15 mins and the resulting superNDtant was carefully decanted into a separation funnel. To facilitate phase separation, 4 mL of 0.9% potassium chloride (KCl) solution (0.2 volume relative to the superNDtant) was added. The funnel was gently shaken and allowed to stand until distinct layers formed.

The upper (methanol–water) layer contained non-lipid impurities, while the lower (chloroform) layer contained the total lipid extract. The chloroform phase was collected through the stopcock into a pre-weighed, clean glass vial, and the solvent was gently evaporated to dryness under a stream of nitrogen gas in a warm water bath (40 °C) to prevent oxidation and degradation.

GC–MS Analysis

The extracted lipids were derivatized into fatty acid methyl esters (FAMEs) to improve volatility and thermal stability for gas chromatographic analysis.

Approximately 10–20 mg of lipid extract was transferred into a glass reaction vial, and 2 mL of boron trifluoride–methanol (BF_3–MeOH, 10–14%) was added as a transesterification catalyst. The vial was sealed with a Teflon-lined cap and heated at 80 °C for 60 min in a heating chamber to complete methylation. after cooling, 1 mL of hexane and 1 mL of distilled water were added to extract the FAMEs. The mixture was vortexed and allowed to separate into two phases. The upper hexane layer, containing the FAMEs, was carefully collected and passed through a small column of anhydrous sodium sulfate (ND_2SO_4) to remove residual moisture. The purified FAME extract was transferred into a GC vial for instrumental analysis.

Instrumental Conditions

An Agilent 7890A gas chromatograph coupled to a mass spectrometry detector (GC–MS) was employed to identify the fatty acid components. The separation was performed using a capillary column measuring 30 m × 0.25 mm × 0.36 µm. During analysis, the oven temperature was initially set at 100 °C and then programmed to increase to 280 °C at a rate of 50 °C per minute.

RESULTS AND DISCUSSION

Table 4.1 Fatty Acid content of the tea samples

Fatty Acids	SAMPLE CODE									
	GH	TM	PNP	STR	O&G	EG	LM	CSH	MG	EMR
Tetradecanoic	ND	3.30	ND	ND	ND	ND	ND	ND	ND	ND
11-Eicosenoic acid	ND	13.70	ND	ND	ND	ND	ND	ND	ND	ND
9,17-octadecatrienoic acid	ND	6.41	ND	ND	ND	ND	19.03	5.74	6.16	ND
9-Hexadecenoic acid	ND	1.54	ND	ND	ND	ND	ND	ND	ND	ND
Pentadecanoic acid	ND	ND	23.08	ND	ND	ND	ND	ND	ND	24.40
Hexanoic acid	ND	ND	14.54	ND	ND	ND	ND	ND	ND	ND
Hexadecanoic	ND	8.05	ND	12.58	ND	25.49	ND	15.91	17.21	ND
9,12-octadecaenoic acid	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.53
6.octadecanoic acid	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.85
Octadecanoic acid	ND	ND	ND	ND	ND	13.45	33.49	11.03	ND	20.23
9, octadecanoic acid.	ND	ND	ND	ND	ND	ND	ND	11.02	ND	5.95
N-hexadecanoic acid	ND	ND	ND	ND	ND	ND	36.40	9.89	24.30	11.62
Hexa-2,4-dienoic acid	ND	ND	ND	33.86	ND	ND	ND	5.52	ND	5.73
Octanoic acid	ND	ND	ND	ND	ND	ND	15.83	ND	ND	ND
Dodecanoic acid	ND	ND	20.46	ND	ND	ND	ND	ND	ND	ND
5,10-pentadecanoicacid (E,E)	ND	ND	9.77	18.27	ND	ND	ND	ND	ND	ND
Behenic acid	10.16	ND	ND	ND	ND	ND	ND	ND	ND	ND
Myristoleic acid	50.62	ND	ND	ND	ND	ND	ND	4.12	ND	ND
-9-Octadecenoic acid	ND	ND	ND	ND	ND	21.62	ND	ND	ND	ND
Hexadecenoic acid	ND	ND	ND	ND	ND	5.20	ND	ND	ND	ND
Octadecatrienoic acid	ND	ND	ND	ND	ND	3.20	ND	ND	ND	ND
Undecanoic acid	ND	ND	ND	ND	ND	23.03	ND	ND	ND	ND
9,12-octadecadienoic acid.	ND	ND	ND	ND	ND	2.94	ND	ND	ND	ND
Propanoic acid	ND	ND	10.31	ND	ND	ND	ND	ND	ND	ND
1,2-propanediamine, N, N	ND	ND	18.46	ND	ND	ND	ND	13.45	ND	N

STR=strawberry, MG=mango, TM=turmeric, CSH=cashew, PNP=pineapple, GH=ginger and honey, O&G=orange and garlic, LM=lemon. The fatty acid (FA) profiles of the tea samples were analyzed using GC–MS, revealing that saturated fatty acids (SFAs) were present in nearly all the samples. Among the identified compounds, palmitic acid (C16:0) was the most abundant fatty acid, followed by linoleic acid (C18:2) and stearic acid (C18:0). This observation aligns with previous reports on the fatty acid composition of tea leaves from various regions worldwide (Guo et al., 2021; Mahanta et al., 2010).

Oleic acid (C18:1), a monounsaturated fatty acid, was also detected in appreciable quantities. Literature suggests that oleic acid contributes to cholesterol reduction, improved blood pressure regulation, and a lower risk of stroke (Wolfram, 2007). The presence of oleic and linoleic acids indicates that herbal teas may serve as a dietary source of bioactive lipids with cardioprotective potential.

Fatty acids play a crucial role in energy storage, cell membrane structure, hormone production, and thermal insulation. Of particular importance are omega-6 and omega-3 fatty acids, which are essential, meaning they cannot be synthesized by humans and must be obtained through diet. Deficiency in omega-3 fatty acids has been linked to stroke, age-related cognitive decline, and Alzheimer's disease (Román et al., 2019).

Linoleic acid, an essential omega-6 fatty acid, supports the development and mainteNDnce of the nervous system and other physiological processes. Among omega-3 fatty acids, α-linolenic acid (ALA) is primarily derived from plant sources, whereas eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) origiNDte mainly from marine sources such as fish (Salem et al., 2015). The health benefits of omega-3 fatty acids are largely attributed to EPA and DHA, which exhibit strong anti-inflammatory effects by reducing leukocyte chemotaxis, pro-inflammatory eicosanoid production, and adhesion molecule expression (Gammone et al., 2019; Lorente-Cebrián et al., 2015).

Collectively, these biochemical actions modulate inflammatory pathways by decreasing cellular responsiveness in immune cells, such as neutrophils, macrophages, and the cells facilitating the resolution of inflammation (Calder et al., 2013). The detection of such fatty acids in herbal teas, even in trace amounts, highlights their nutraceutical potential and supports their inclusion in functioNDl food research.

CONCLUSION

This study demonstrates that herbal tea is one of the oldest, most affordable, and health-promoting beverages globally. Prepared from various herbs or their combiNDtions, these teas serve as NDtural sources of phytochemicals, antioxidants, minerals, vitamins, and bioactive lipids**.** The lipidomic analysis revealed that herbal teas contain a diverse range of saturated and unsaturated fatty acids**,** notably palmitic, oleic, linoleic, and stearic acids. These components contribute to their nutrition NDl and functioNDl properties, including antioxidant and cardioprotective effects.

Given their accessibility and beneficial composition, herbal teas represent a valuable nutraceutical resource**.** However, further well-designed clinical and biochemical studies are required to provide stronger evidence for their nutritioNDl profiles, lipid bioavailability, and health benefits**.** Such research will enhance public awareness and promote the integration of herbal teas into preventive nutrition and function NDl food systems.

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