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EFFECTS OF A POLYHERBAL TEA INFUSION ON BLOOD LIPIDS, FASTING GLUCOSE, AND HAEMATOLOGY IN ALBINO RATS FOLLOWING SUB-CHRONIC EXPOSURE

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ABSTRACT

This study investigated the impact of sub-chronic oral administration of polyherbal tea infusions on lipid profile, fasting blood glucose, and haematological parameters in albino rats. The tea formulation, packaged in teabags, consisted of green and black tea (*Camellia sinensis*), ginger rhizome, and clove buds. Thirty albino rats (8–10 weeks old) were randomly assigned into ten groups (n = 3). Group A received water, Groups B–G received varying formulations of the polyherbal infusion, Groups H and I received sweetened preparations, and Group J received a commercially available tea infusion. Treatments were administered orally for 21 consecutive days. Biochemical and haematological analyses revealed formulation-dependent effects. Total cholesterol and LDL levels were significantly elevated ($p < 0.05$) in several treatment groups, while triglyceride levels were significantly reduced ($p < 0.05$) in Groups G–I. HDL concentrations increased significantly in selected groups compared to the water control, although values were lower than those observed with the commercial tea. Haematological indices showed improved red blood cell count, haemoglobin concentration, packed cell volume, and platelet counts in multiple treated groups ($p < 0.05$), suggesting possible hematinic benefits. Mean corpuscular haemoglobin remained unchanged. Fasting blood glucose levels increased significantly in some groups but decreased in others relative to controls. Weight gain was also significantly higher in selected groups. In conclusion, the polyherbal tea formulations demonstrated both beneficial and potentially adverse metabolic effects, depending on composition.

KEYWORDS: Haematological Indices, Lipid Profile, *Camellia sinensis*, Ginger

Introduction

Tea, derived from dried *Camellia sinensis* leaves, holds the esteemed title of being the most widely consumed botanical beverage, surpassing even coffee, chocolate, and fruit drinks (Zayapor and Syahida, 2023). Its rich legacy is deeply entrenched in a global drinking culture that has evolved dynamically over centuries, shaped by geographical, temporal, and cultural

influences (Zayapor and Syahida, 2023). Beyond its delightful array of flavours, tea boasts a remarkable versatility compared to its caffeinated counterpart, coffee, evident on the shelves of markets worldwide. This versatility is propelled by consumers' growing inclination towards botanical remedies for combating chronic ailments such as metabolic syndrome, encompassing cardiovascular heart disease, diabetes, and hypertension (Dias *et al*., 2013). Tea's anti-obesity effects have garnered attention, alongside its potential in alleviating allergic rhinitis syndromes (Peiris *et al*., 2019) and contributing to healthy aging by mitigating cognitive decline (Divya and Ashok, 2019). Over the years, an escalating interest in natural product innovation has fuelled the consumption of tea leaves and their ready-to-drink (RTD) counterparts for diverse health objectives. These RTD products may be crafted from fermented tea, such as kombucha, or blends of tea leaves with medicinal herbs, or even solely from herbal infusions known as tisanes, each targeting specific niche functions.

Tea primarily exists in three main types: Green tea, oolong tea, and black tea. The distinctions among these varieties hinge on their antioxidant content and the degree of fermentation they undergo (Dufresne and Farnworth, 2001; Kodagoda and Wickramasinghe, 2017). Historically, tea found its roots in Chinese culture around 2737 BC, initially revered as both a beverage and a medicinal elixir. Today, its popularity transcends borders, with nearly every country embracing its charms. Leading tea producers include China, India, and Kenya, despite tea cultivation occurring on six continents (Khan *et al*., 2008). Remarkably, global tea production and consumption collectively amount to approximately three billion kilograms annually (Khan and Muktar, 2008). This study determined the effects of orally administered infusions of six different blends of a polyherbal formulation composed of varying proportions of green tea, black tea, ginger, and clove; on Lipid profile, Haematological Indices, and fasting blood glucose in Albino rats, in order to establish their safety profile through sub-chronic toxicity assessment.

MATERIALS AND METHODS

Experimental Animals

Thirty (30) healthy male albino Wistar rats were obtained from the animal house of faculty of Veterinary Medicines University of Nigeria Nsukka and were used as the animal model for this study. The animals were housed in a controlled environment with standard conditions of temperature, humidity and light-dark cycles. The animals were allowed free access to feed and water *ad libitum.* They were allowed to acclimatize to the environment for 7 days before the commencement of the study.

Plant materials

Dried leaves of black and green teas (*Camellia sinensis*), dried rhizomes of ginger (*Zingiber officinale*) and dried buds of clove (*Syzygium aromaticum*) were bought from the traders in the open market in Kano and shipped to Afikpo Ebonyi State.

Bagging of Plant Material

One hundred (100)g each of the different formulations containing adequately mixed dried ground plant materials were processed into about 40 tea bags and heat sealed such that each tea bag contains 2.5g of green tea, black tea, ginger and clove in the following percentage composition:

Table 1 Composition of the different blends

	% Composition of Plant Materials			
Formulations	**Green Tea**	**Black Tea**	**Ginger**	**Clove**
Polyherb Tea-F1	40	40	15	5
Polyherb Tea-F2	55	25	15	5
Polyherb Tea-F3	25	55	15	5
Polyherb Tea-F4	80	0	15	5
Polyherb Tea-F5	0	80	15	5
Polyherb Tea-F6	50	50	0	0

METHODS

Experimental Design

This study was conducted by randomizing 30 male albino rats into 10 groups of 3 animals each. The rats were randomly assigned to different treatment groups according to the experimental design below:

Experimental Design

Group A 3 Albino rats orally administered water for 21 days
Group B 3 Albino rats orally administered Extracts of Formulation 1 for 21 days
Group C 3 Albino rats orally administered Extracts of Formulation 2 for 21 days
Group D 3 Albino rats orally administered Extracts of Formulation 3 for 21 days
Group E 3 Albino rats orally administered Extracts of Formulation 4 for 21 days
Group F 3 Albino rats orally administered Extracts of Formulation 5 for 21 days
Group G 3 Albino rats orally administered Extracts of Formulation 6 for 21 days
Group H 3 Albino rats orally administered Extracts of Formulation 3+ Sucrose for 21 days
Group I 3 Albino rats orally administered Extracts of Formulation 3 + Honey for 21 days
Group J 3 Albino rats orally administered Extracts of commercially available tea for 21 days

Extraction of Infusion

A tea bag was randomly selected and placed in 200ml of boiling drinking water at 100^{o}C and the tea was allowed to extract with occasional stirring for 30 minutes. This resulting infusion was allowed to cool to room temperature (25^{o}C) and thereafter, orally administered to the animals once daily for 21 days.

Administration of Tea Infusion

About 0.3ml of water (Group A) and 0.3ml of cooled infusion obtained from 1 tea bag daily was orally administered to each rat each using steel cannula.

Quantitative Phytochemical screening

Qualitative phytochemical screening of the different formulations (F1- F6) infusions were carried out to evaluate the presence of major classes of secondary metabolites using established standard analytical procedures (Sofowora, 1993; Trease & Evans, 2002). Alkaloids were detected by characteristic precipitation reactions with Dragendorff's, Mayer's, and Wagner's reagents. Reducing sugars were identified by the formation of a brown cuprous oxide precipitate after boiling with Fehling's solutions A and B, while total glycosides were detected by the formation of a brick-red precipitate following acid hydrolysis with dilute sulfuric acid, neutralization with 10% sodium hydroxide, and subsequent treatment with Fehling's solution. Cardiac glycosides were confirmed by the appearance of a yellow precipitate upon reaction with bromine water. Flavonoids were identified by the formation of a yellow precipitate with lead acetate, a dark green precipitate with ferric chloride, or an orange coloration upon the addition of concentrated sulfuric acid. Phenolic compounds were confirmed by a transparent red coloration with iodine solution, a white precipitate with 10% lead acetate, or a dark green to bluish-black complex following the addition of 5% ferric chloride solution (Harborne, 1998). Tannins were identified by a blue-green coloration with ferric chloride or emulsion formation in 10% sodium hydroxide solution for hydrolysable tannins. Phlobatannins were detected by the formation of a red precipitate after treatment with 10% hydrochloric acid, while saponins were confirmed by the production of a persistent and stable froth following vigorous shaking of the extract (Sofowora, 1993).

Determination of Biochemical and Haematological Parameters

Blood samples obtained by ocular puncture on day 22 were processed into serum for biochemical parameters. For Haematology, whole blood obtained through occular puncture were used. Spectrum Diagnostics assay kits (Egypt) were used to determine the lipid profile according to the manufacturer's instructions. Haematology was determined using an autohaemoanalyser while fasting blood glucose was determined using Accu-chek glucose monitor. Weights of the animals before and after oral administration were recorded

Results

Qualitative phytochemical screening (Table 2) showed that all six polyherbal tea formulations contained varying amounts of important bioactive compounds. Flavonoids were abundant in F1, F2, F4, and F6, while phenolic compounds were highest in F1–F3 but were not detected in F6. Alkaloids were present in all formulations, with the highest levels observed in F1, F3, and F4. Tannins and saponins were detected in most formulations but were absent or present in lower amounts in F4 and F5. Cardiac glycosides were most abundant in F4, whereas glycosides were detected only in F6. Overall, F1 and F3 exhibited the richest and most balanced phytochemical profiles, while F5 showed the lowest abundance of most phytochemical constituents.

Sub-chronic administration of the polyherbal tea infusions significantly influenced lipid profile, haematological indices, fasting blood glucose, and body weight when compared with control groups.

In Table 3 mean serum total cholesterol was significantly elevated ($p < 0.05$) in Groups C, E, F, H, and I relative to both the water control (Group A) and the commercial tea control (Group

J). Additionally, triglyceride concentrations were significantly reduced ($p < 0.05$) in Groups G, H, and I compared with Groups A and J.

High-density lipoprotein (HDL) levels were significantly increased ($p < 0.05$) in Groups D, E, and F compared with Group A but were significantly lower ($p < 0.05$) when compared with Group J. Low-density lipoprotein (LDL) concentrations were significantly elevated ($p < 0.05$) in Groups C, E, F, G, H, and I relative to Group A, whereas Group D showed a significant reduction ($p < 0.05$) compared with both control groups.

Haematological analysis results in Table 4 revealed significant increases ($p < 0.05$) in red blood cell counts in Groups B and I compared with Groups A and J. Haemoglobin concentration was significantly elevated ($p < 0.05$) in Groups B–I relative to Group A but did not differ significantly ($p > 0.05$) from Group J. Packed cell volume (PCV) increased significantly ($p < 0.05$) in Groups B, D, E, F, and I compared with Group A, with no significant difference ($p > 0.05$) relative to Group J. Mean corpuscular haemoglobin (MCH) showed no significant differences ($p > 0.05$) across groups. Platelet counts were significantly higher ($p < 0.05$) in all treatment groups compared with Group A but were comparable ($p > 0.05$) to Group J.

Fasting blood glucose levels result in Table 5 were significantly elevated ($p < 0.05$) in Groups F–I compared with Group A, though not significantly different ($p > 0.05$) from Group J. Groups B–E showed significant reductions ($p < 0.05$) relative to Group J but did not differ significantly ($p > 0.05$) from Group A. All groups showed an increase in body weight after the 21-day treatment period.

Results of mean weight of the animals in Table 5 shows that Mean weight gain ranged from 54.03 ± 13.64 g (Group H) to 89.87 ± 7.87 g (Group J). Groups E and J recorded the highest weight gains, with significant differences ($p < 0.05$) compared with the indicated groups, whereas Group H showed the lowest weight gain.

Table 2 Result of the phytochemical screening results for the 6 formulations

Phytochemicals	F1	F2	F3	F4	F5	F6
Alkaloids	+++	++	+++	+++	+	+
Reducing Sugars	++	++	++	ND	+	++
Glycosides	ND	ND	ND	ND	ND	++
Cardiac Glycosides	+	+	ND	+++	+	+
Flavonoids	+++	+++	++	+++	+	+++
Phenolics	+++	+++	+++	++	++	ND
Tannins	++	+	++	+	+	+++
Saponins	++	+	++	ND	+	++
Plantains	++	+	+	ND	+	+

ND= Not Detected, + = sparsely present, ++ = moderately present, +++= Abundantly present

Table 3. Changes in Mean values of the haematological parameters of the treatment and control groups

Groups	**RBC (×10⁶/µL)**	**HB (g/dL)**	**PCV (%)**	**MCV (FL)**	**MCH (pg)**	**Platelets ((×10³/µL))**
A	6.12 ± 0.42	12.00 ± 0.58	43.66 ± 1.43	68.4 ± 0.83	19.33 ± 0.56	274.33 ± 29.23
B	8.18 ± 0.23^{ac}	16.00 ± 0.58^{a}	58.96 ± 1.44a	70.0 0± 1.12^{d}	20.13 ± 0.49^{cd}	413.33 ± 9.03^{a}
C	5.48 ± 0.77	10.00 ± 1.16^{bcd}	36.83 ± 5.48^{cd}	62.93 ± 1.40	17.63 ± 0.56	371.00 ± 32.01
D	7.47 ± 0.69	15.00 ± 0.58	52.73 ± 1.91	65.73 ± 0.55	17.4 0± 0.42	499 .00± 20.01^{ab}
E	7.42 ± 0.68	15.33 ± 0.88	58.50 ± 4.03	66.26 ± 4.03	18.83 ± 0.54	489.67 ± 2.03^{ab}
F	7.51± 0.36	15.00 ± 0.57	51.63 ± 0.79	64.63 ± 1.36	18.10 ± 0.46	547.00 ± 12.85
G	7.67 ± 0.23	14.67 ± 0.33	53.23 ± 1.44	68.6 0± 1.06	18.67 ± 0.30	583.67 ± 21.72
H	7.30 ± 0.44	14.33 ± 0.88	48.40 ± 3.74	67.70± 1.12	18.53 ± 0.55	543.33 ± 13.53
I	13.61 ± 2.80^{abd}	15.00 ± 0.58	55.57 ± 2.06	66.97 ± 1.60	17.53 ± 0.78	524.00 ± 20.55
J	7.40 ± 0.50	14.00 ± 1.15	50.6 0± 2.26	64.53 ± 1.07	17.30 ± 0.81	412 .00± 81.26^{abc}

Thirty (30) albino rats were randomly assigned to ten groups (n = 3). Group A received water, Groups B–G received extracts of Formulations F1–F6, Groups H and I received Formulation F1 supplemented with sucrose and honey, respectively, while Group J received a commercially available tea extract. All treatments were administered orally for 21 days. Values are mean ± Standard Error of Mean (SEM). Superscripts a, b, c and d represent mean values that are significantly different ($p < 0.05$) when compared with water administered groups, commercially available tea controls and those administered with infusion of Polyherb F3 sweetened with sugar and honey respectively

Table 4. Changes in the mean values of the lipid profile parameters for the controls and treatment groups

Groups	Total Cholesterol (mg/dL)	Triglycerides (mg/dL)	HDL Cholesterol (mg/dL)	LDL Cholesterol (mg/dL)
A	49.64 ± 2.57	47.25 ± 1.23	22.22 ± 3.84	17.95 ± 2.57
B	53.72 ± 4.03[a]	52.56 ± 2.38[bc]	21.48 ± 1.56[d]	18.97 ± 2.49
C	56.02 ± 0.58	49.41 ± 2.51[bc]	24.38 ± 2.11	22.72 ± 0.83
D	47.17 ± 1.66[bc]	49.28 ± 5.22	25.18 ± 2.20	13.82 ± 2.66[bcd]
E	58.97 ± 2.01	52.53 ± 2.90	27.40 ± 4.11	23.34 ± 0.31
F	59.05 ± 7.33	60.90 ± 4.61[abcd]	38.92 ± 2.47[ac]	23.55 ± 7.17
G	51.58 ± 0.71	36.47 ± 4.89	18.41 ± 3.87	26.94 ± 2.85[a]
H	54.57 ± 0.55	16.50 ± 3.28[a]	25.47 ± 2.80	40.85 ± 1.70[d]
I	56.99 ± 1.83	16.03 ± 2.69[a]	21.43 ± 2.96	44.16 ± 2.48[ad]
J	46.25 ± 4.37[bc]	23.84 ± 2.24	39.94 ± 3.63[a]	25.95 ± 5.33

Thirty (30) albino rats were randomly assigned to ten groups (n = 3). Group A received water, Groups B–G received extracts of Formulations F1–F6, Groups H and I received Formulation F1 supplemented with sucrose and honey, respectively, while Group J received a commercially available tea extract. All treatments were administered orally for 21 days. Values are mean ± Standard Error of Mean (SEM). Superscripts a, b, c and d represent mean values that are significantly different ($p < 0.05$) when compared with water administered groups, commercially available tea controls and those administered with infusion of Polyherb F3 sweetened with sugar and honey respectively

Table 5. Mean values of the pre- and post- treatment weights of the controls and treatment groups

Group	Pre Weight Male (g)	Post Weight Male (g)	Weight Difference Male (g)
A	113.08 ± 10.65	181.83 ± 2.33	68.75 ± 12.25
B	113.24± 4.18	180.55± 9.74	67.31 ± 6.58
C	97.03 ±1.63	159.43 ± 10.99	62.41 ± 7.12
D	93.93± 3.48	158.72 ± 5.01	64.79 ± 7.67
E	101.61± 15.31	190.39± 7.75	88.77 ± 12.08[ab]
F	103.74± 3.85	181.83 ± 2.33	68.05 ± 8.17
G	116.34± 9.04	192.93 ± 7.37	76.59 ± 12.01
H	113.93± 10.85	183.36 ± 11.57	54.03 ± 13.64[cd]
I	101.11 ± 21.25	172.9 0± 5.91	71.88 ± 29.18
J	115.12 ± 1.26	204.32± 7.26	89.87 ± 7.87[ac]

Thirty (30) albino rats were randomly assigned to ten groups (n = 3). Group A received water, Groups B–G received extracts of Formulations F1–F6, Groups H and I received Formulation F1 supplemented with sucrose and honey, respectively, while Group J received a commercially available tea extract. All treatments were administered orally for 21 days. Values are mean ± Standard Error of Mean (SEM).

Superscripts a, b, c and d represent mean values that are significantly different ($p< 0.05$) when compared with water administered groups, commercially available tea controls and those administered with infusion of Polyherb F3 sweetened with sugar and honey respectively

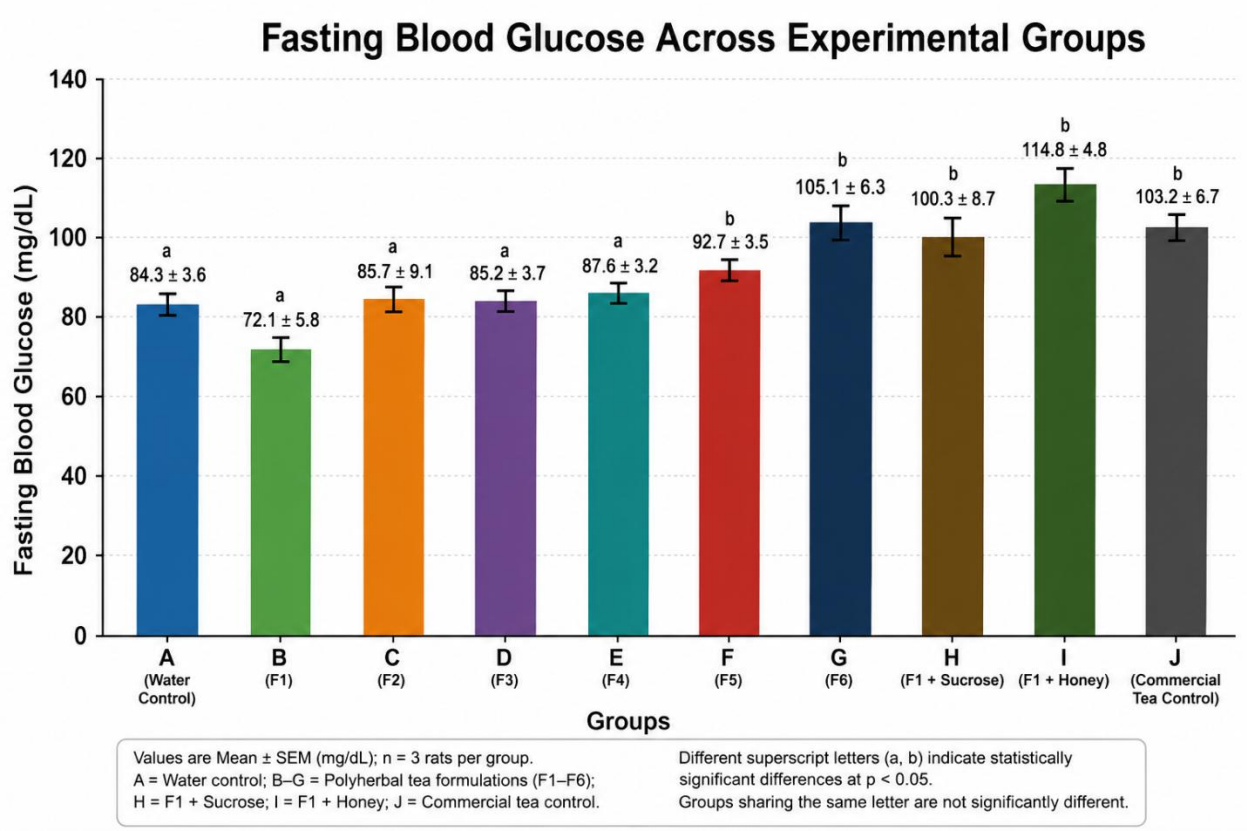

Figure 1. Changes in mean fasting blood glucose concentrations (mg/dL) of the different groups

Discussion

This study determined the effects of orally administered infusions of six different blends of a polyherbal formulation composed of varying proportions of green tea, black tea, ginger, and clove—on Lipid profile, Haematological Indices, and fasting blood glucose in Albino rats, in order to establish their safety profile through sub-chronic toxicity assessment.

The 21-day sub-chronic administration of the various polyherbal tea formulations produced distinct metabolic and physiological responses, indicating that the biological activity of each formulation depended not only on its ingredient composition but also on its phytochemical profile. Phytochemical screening revealed appreciable variations in the distribution and relative abundance

of secondary metabolites across the six formulations. Formulations F1 and F3 were particularly rich in alkaloids, phenolics, flavonoids, saponins, and tannins, whereas F4 contained abundant alkaloids, flavonoids, and cardiac glycosides but lacked detectable saponins and phlobatannins. F5 showed comparatively lower concentrations of most phytochemicals, while F6 was distinguished by the presence of glycosides and high tannin content but lacked detectable phenolic compounds. These differences suggest that the observed physiological responses were likely determined by the synergistic or antagonistic interactions among these phytochemicals rather than by the botanical ingredients alone.

The elevations in serum total cholesterol and LDL cholesterol observed in Groups C (F2), E (F4), and F (F5) indicate that the lipid-lowering potential of the formulations depended on maintaining an appropriate balance of bioactive phytochemicals. Although F4 possessed abundant flavonoids and alkaloids together with a high concentration of cardiac glycosides, the absence of detectable saponins and phlobatannins, combined with only moderate phenolic content, may have diminished its hypolipidemic activity. Saponins have been reported to reduce intestinal cholesterol absorption through the formation of insoluble cholesterol complexes, while phenolic compounds and flavonoids suppress hepatic cholesterol synthesis by modulating HMG-CoA reductase activity and enhancing LDL receptor expression (Musial, Kuban-Jankowska, & Gorska-Ponikowska, 2020). Consequently, the lack of these complementary phytochemicals in F4 may partly explain the pronounced increase in LDL cholesterol despite its high green tea content. Likewise, the comparatively weak phytochemical profile of F5, characterized by reduced flavonoids, phenolics, alkaloids, tannins, and saponins, may have limited antioxidant protection against lipid peroxidation and impaired normal lipid metabolism.

Conversely, the reduction in LDL cholesterol observed in Group D (F3) may be attributed to its richer and more balanced phytochemical composition. F3 contained abundant alkaloids and phenolics together with appreciable quantities of flavonoids, tannins, and saponins. These phytochemicals are known to exert complementary antioxidant and hypolipidemic effects through activation of AMP-activated protein kinase (AMPK), inhibition of lipogenesis, enhancement of fatty acid oxidation, and attenuation of oxidative modification of LDL particles (Ghorani, Al-Khalifa, & Shafiee-Nick, 2023). The coexistence of multiple antioxidant phytochemicals may therefore have produced greater biological efficacy than formulations containing high concentrations of only one or two constituents.

The significant reductions in triglyceride concentrations observed in Groups G (F6), H, and I further support the importance of phytochemical interactions. Although F6 lacked detectable phenolic compounds, it contained abundant flavonoids, tannins, saponins, reducing sugars, and was the only formulation in which glycosides were detected. Tannins and flavonoids have been shown to suppress hepatic lipogenesis by downregulating Sterol Regulatory Element-Binding Protein-1c (SREBP-1c) and its associated lipogenic enzymes while simultaneously enhancing fatty acid oxidation (Zeng *et al*., 2025). In addition, glycosides have been reported to improve lipid metabolism through antioxidant and anti-inflammatory mechanisms. These combined activities may explain the favourable triglyceride-lowering effect observed despite the absence of detectable phenolics.

The haematological findings also appear closely related to the phytochemical composition of the formulations. Significant increases in red blood cell count, haemoglobin concentration, and packed cell volume were observed particularly in Groups B (F1) and I (F1 + Honey). These groups received F1, which demonstrated one of the richest phytochemical profiles, containing abundant alkaloids, flavonoids, phenolics together with appreciable tannins, saponins, cardiac glycosides, and phlobatannins. Flavonoids and phenolic compounds are well recognized for their ability to neutralize reactive oxygen species, thereby protecting erythrocyte membranes against oxidative damage and prolonging erythrocyte survival (Obasi & Ogugua, 2024). Saponins have additionally been reported to support immune and hematopoietic functions, while alkaloids may stimulate bone marrow activity through immunomodulatory mechanisms. The simultaneous presence of these phytochemicals may therefore account for the apparent enhancement of erythropoiesis observed in animals treated with F1.

The comparatively smaller haematological responses observed in formulations with reduced phytochemical diversity further support this interpretation. F5, which exhibited generally lower concentrations of most phytochemicals, produced less pronounced improvements in haematological indices, suggesting that optimal haematological activity may require the combined action of several antioxidant phytochemicals rather than the predominance of a single constituent. Similarly, the consistent increase in platelet count across the treatment groups may reflect the immunostimulatory properties of alkaloids, flavonoids, saponins, and phenolic compounds, all of which have been reported to enhance bone marrow function and regulate inflammatory responses (Aladejana & Aladejana, 2023).

The fasting blood glucose results likewise correspond with the phytochemical composition of the formulations. Groups B to E maintained lower or relatively stable fasting blood glucose concentrations compared with the commercial control. This effect may be attributed primarily to the high flavonoid and phenolic contents of F1, F2, F3, and F4. Tea polyphenols, together with flavonoids and ginger-derived phytochemicals, have been shown to inhibit α-amylase and α-glucosidase, reduce intestinal glucose absorption, improve insulin sensitivity, and enhance glucose uptake through activation of the PI3K/Akt signalling pathway (Zhu *et al*., 2024; Yan *et al*., 2020). The abundant antioxidant phytochemicals present in these formulations may also have protected pancreatic β-cells from oxidative stress, thereby contributing to improved glucose homeostasis.

In contrast, the elevated fasting blood glucose observed in Groups F (F5) and G (F6) may reflect differences in phytochemical composition. F5 contained relatively low concentrations of flavonoids, alkaloids, phenolics, tannins, and saponins, which may have weakened its antihyperglycemic potential. Although F6 contained abundant flavonoids and tannins, the absence of detectable phenolic compounds may have reduced the synergistic antioxidant effects required for optimal glucose regulation. Furthermore, supplementation with sucrose or honey in Groups H and I introduced an additional dietary carbohydrate load that may have partially counteracted the glucose-lowering activity of the phytochemicals by increasing hepatic glucose production and postprandial glucose availability (Nakagawa *et al*., 2023).

Body weight changes also appeared to reflect differences in phytochemical composition. The significantly greater weight gain observed in Group E (F4) and the commercial control suggests that the absence of detectable saponins and phlobatannins in F4 may have reduced inhibition of

dietary lipid absorption and limited thermogenic activity. Saponins have been associated with reduced intestinal fat absorption and improved energy metabolism, whereas flavonoids and phenolic compounds promote fatty acid oxidation through activation of AMPK and inhibition of pancreatic lipase (Ghorani *et al*., 2023; Zeng *et al*., 2025). In contrast, formulations containing broader phytochemical diversity, particularly F1 and F3, demonstrated comparatively lower weight gain, suggesting that the combined presence of phenolics, flavonoids, tannins, alkaloids, and saponins may have produced greater metabolic efficiency and enhanced energy expenditure.

Conclusion

In conclusion, the phytochemical screening findings provide strong biochemical support for the biological activities observed during the study. Formulations possessing a richer and more balanced phytochemical profile, particularly F1 and F3, consistently demonstrated more favourable effects on lipid metabolism, haematological parameters, glucose regulation, and body weight than formulations characterized by reduced phytochemical diversity or the absence of key bioactive constituents. The results suggest that the therapeutic potential of these polyherbal tea formulations depends not only on the proportions of green tea, black tea, ginger, and clove but also on the qualitative and quantitative interactions among their constituent phytochemicals. Such synergistic interactions likely underpin the antioxidant, hypolipidemic, hematopoietic, and antihyperglycemic properties observed, emphasizing the importance of phytochemical optimization during formulation development.

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Conflict of Interest

The authors wish to declare no conflict of interest

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