Lipidomic Response to Coffee Consumption

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May 2021 - Jul 2021

COURSE REPORT

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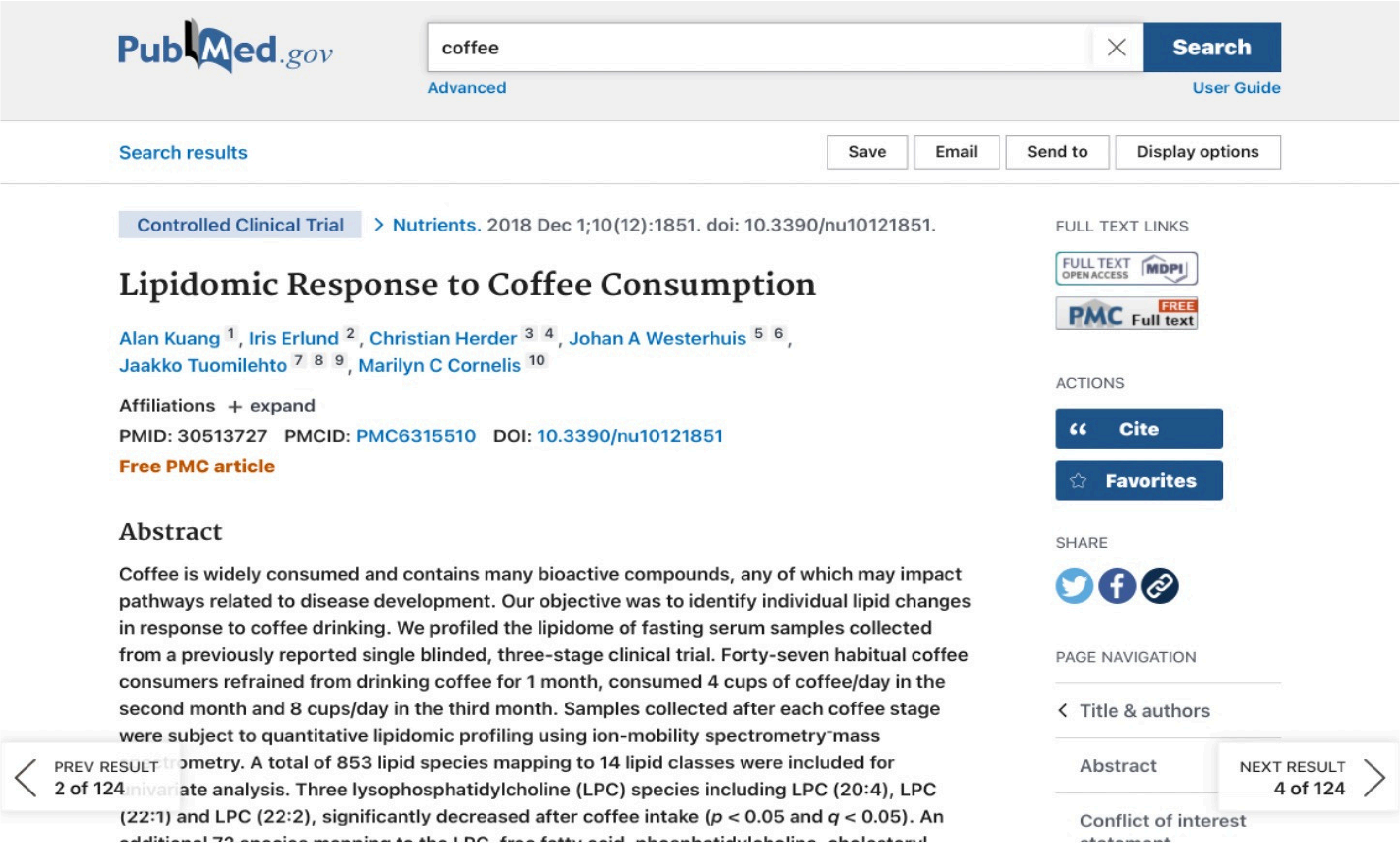
PART 01



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Lipidomic Response to Coffee Consumption

Alan Kuang [1], Iris Erlund [2], Christian Herder [3 4], Johan A Westerhuis [5 6], Jaakko Tuomilehto [7 8 9], Marilyn C Cornelis [10]

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Abstract

Conflict of interest

Abstract

Coffee is widely consumed and contains many bioactive compounds, any of which may impact pathways related to disease development. Our objective was to identify individual lipid changes in response to coffee drinking. We profiled the lipidome of fasting serum samples collected from a previously reported single blinded, three-stage clinical trial. Forty-seven habitual coffee consumers refrained from drinking coffee for 1 month, consumed 4 cups of coffee/day in the second month and 8 cups/day in the third month. Samples collected after each coffee stage were subject to quantitative lipidomic profiling using ion-mobility spectrometry–mass ometry. A total of 853 lipid species mapping to 14 lipid classes were included for ate analysis. Three lysophosphatidylcholine (LPC) species including LPC (20:4), LPC (22:1) and LPC (22:2), significantly decreased after coffee intake (p < 0.05 and q < 0.05). An

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Kuang A, Erlund I, Herder C, Westerhuis JA, Tuomilehto J, Cornelis MC. Lipidomic Response to Coffee Consumption. Nutrients. 2018 Dec 1;10(12):1851. doi: 10.3390/nu10121851. PMID: 30513727; PMCID: PMC6315510.

PLANT
(IMAGE AND COMPONENT STRUCTURE)

PART 02

01

CAFFEINE

- Source of bitterness
- Increases cell metabolism rate
- Stimulates the central nervous system, heart, and respiratory system
- Reduces muscle fatigue
- Acts as a diuretic, helping to excrete excess sodium from the body
- Excessive caffeine can lead to toxicity

02

CHLOROGENIC ACID

- Source of acidity
- Boiling breaks it down to produce quinic acid
- Excessive chlorogenic acid will lead to bitterness in coffee

03

FATS

Primarily consists of:

- Acidic fats: Contains acids varies in strength based on type
- Volatile fats: Source of coffee aroma, evaporates when exposed to air

04

PROTEINS

- Mostly from the endosperm, not in high amounts
- During brewing, most do not dissolve, and extraction is limited

01

SUGARS

- Source of coffee's sweetness
- Contributes to the color

02

FIBERS

- Source of coffee's color
- The fiber in raw beans will carbonize during roasting, combining with caramelized sugars to form the coffee's coloration

03

MINERALS

- Includes ash, iron (from food sources), sulfur, phosphorus, potassium, nitrogen, and silica
- Has a minimal effect on the flavor of coffee
- Overall, they only contribute a slight earthy taste

04

MOISTURE

- Raw beans contain approximately 11% moisture content

INTRODUCTION TO THE FUNCTIONS FROM PAST RESEARCH

PART 03

Coffee is one of the most widely consumed beverages in the world and is associated with many diseases, such as type 2 diabetes (T2D) and cardiovascular diseases.

Coffee is the primary source of caffeine for many people, but it also contains hundreds of other chemicals, many of which may influence pathways **related to disease development or prevention.**

FUNCTIONS OF THE FOOD OR COMPONENTS IN THIS ARTICLE

PART 04

1. Three types of lysophosphatidylcholine (LPC) species, including **LPC (20:4), LPC (22:1), and LPC (22:2)** ($p < 0.01$ and $p < 0.05$), were identified.

2. In a comprehensive **lipid analysis**, over 100 metabolites were significantly associated with coffee intake, including **flavonoids, caffeic acid, lignans, endogenous cannabinoids, and fatty acids (butyrate) metabolites.**

3. Lipid molecules are a subset of metabolites that are widely present and play essential roles in various biological functions.

4. Lipids are directly exposed to **intracellular and extracellular changes**, leading to various **self-modifications.**

5. Understanding how coffee influences **lipid metabolism** will provide a deeper insight into the biological mechanisms by which coffee may impact health.

RESEARCH EVIDENCE

PART 05

Coffee Intake INCREASE

Total cholesterol in serum
High-density lipoprotein (HDL) cholesterol
Apolipoprotein AI
Concentration of adiponectin

INCREASE

TOTAL CHOLESTEROL IN SERUM

- A type of lipid in the body
- Two types: **Bound and free combined** they are called total cholesterol

HIGH-DENSITY LIPOPROTEIN (HDL) CHOLESTEROL

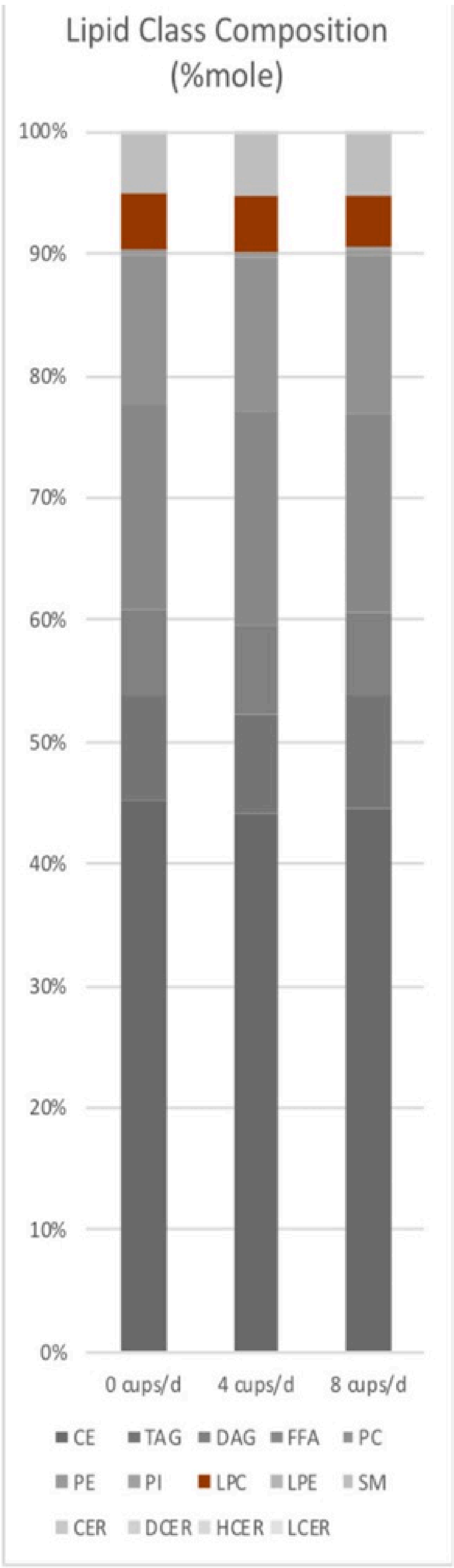
- Considered the "**good**" cholesterol
- **Transports** cholesterol from peripheral tissues **to the liver for metabolic storage**
- **Higher levels** provide a **protective effect** on the arteries

APOLIPOPROTEIN AI

- Apolipoprotein **attached to HDL and chylomicrons**
- When HDL transports cholesterol from peripheral tissues back to liver cells, Apolipoprotein AI **serves as a component of HDL** and **plays an important role in lipid metabolism**

CONCENTRATION OF ADIPONECTIN

- **Produced and secreted** by **adipocytes**
- Involved in **regulating glucose** and **lipid metabolism balance** in the body
- Its main functions are to **regulate energy balance** and **suppress inflammatory** responses
- Can **inhibit** the **formation of fatty acids**, **reduce gluconeogenesis**, and **increase muscle uptake of glucose**, thus lowering blood sugar and potentially even preventing atherosclerosis



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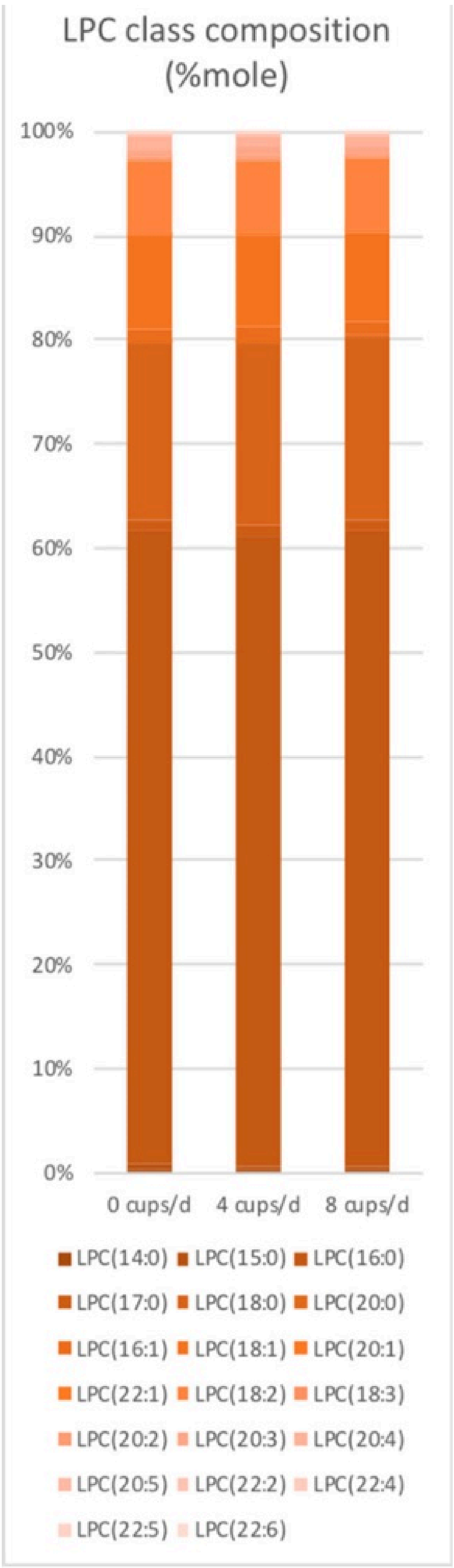

(b)

PCA or Multilevel PCA
Did not show clear separation of coffee stage samples.

01

No significant abnormal values were detected.

02

Serum lipid class concentrations (data not shown) or distribution related to coffee intake **did not show significant changes.**

03

Table 1

Significant lipid markers of coffee consumption *.

Lipid Class †	Lipid Species	Group Effect		Fold of Change §		
		p-Value	*q*-Value	4 Cups/0 Cup	8 Cups/0 Cup	8 Cups/4 Cups
CE	CE(20:4)	0.0296	0.4529	0.9	0.92	1.02
FFA	FFA(20:3)	0.0021	0.297	0.9	0.87	0.96
	FFA(20:4)	0.0012	0.2492	0.95	0.87	0.91
	FFA(22:2)	0.0481	0.4529	0.95	0.89	0.94
	FFA(22:6)	0.0415	0.4529	0.98	0.89	0.91
TAG	TAG47:1-FA17:0	0.0483	0.4529	1.26	1.4	1.11
	TAG51:3-FA15:0	0.0401	0.4529	0.82	0.91	1.11
	TAG52:4-FA16:1	0.0317	0.4529	0.8	0.92	1.15
	TAG52:5-FA16:1	0.0329	0.4529	0.77	0.89	1.16
	TAG52:5-FA20:5	0.05	0.4529	1.07	1.25	1.18
	TAG52:6-FA16:1	0.041	0.4529	0.78	0.9	1.14
	TAG53:3-FA16:0	0.0211	0.4529	0.88	0.87	1
	TAG53:3-FA18:1	0.0242	0.4529	0.9	0.93	1.03
	TAG53:4-FA16:0	0.0229	0.4529	0.84	0.89	1.07
	TAG53:4-FA18:2	0.0289	0.4529	0.82	0.88	1.08
	TAG53:5-FA18:3	0.048	0.4529	0.87	0.92	1.06
	TAG54:3-FA18:1	0.0354	0.4529	0.82	0.9	1.09
	TAG54:3-FA20:1	0.0368	0.4529	0.84	0.94	1.13
	TAG54:4-FA20:1	0.0306	0.4529	0.82	0.94	1.14
	TAG55:3-FA18:1	0.0353	0.4529	0.82	0.86	1.05
	TAG55:4-FA18:1	0.0198	0.4529	0.82	0.85	1.04
	TAG55:5-FA18:1	0.0208	0.4529	0.77	0.83	1.08
	TAG56:3-FA18:1	0.0103	0.4529	0.81	0.87	1.07
	TAG56:3-FA20:1	0.0155	0.4529	0.79	0.86	1.09
	TAG56:4-FA18:1	0.0124	0.4529	0.8	0.87	1.08
	TAG56:4-FA20:1	0.0314	0.4529	0.71	0.81	1.14
	TAG56:4-FA20:2	0.0141	0.4529	0.84	0.88	1.05
	TAG56:5-FA18:1	0.0221	0.4529	0.83	0.9	1.09
	TAG56:5-FA20:2	0.0051	0.4529	0.77	0.84	1.08
	TAG56:5-FA20:3	0.0215	0.4529	0.83	0.89	1.08
	TAG56:5-FA20:4	0.0447	0.4529	0.84	0.91	1.07
	TAG56:6-FA18:2	0.0132	0.4529	0.77	0.88	1.13
	TAG56:6-FA20:2	0.0206	0.4529	0.76	0.84	1.11
	TAG56:6-FA20:3	0.0077	0.4529	0.77	0.85	1.1
	TAG56:6-FA20:4	0.0306	0.4529	0.81	0.88	1.08
	TAG56:7-FA18:2	0.0457	0.4529	0.8	0.91	1.14
	TAG56:7-FA20:3	0.042	0.4529	0.79	0.85	1.07
	TAG56:7-FA22:4	0.0484	0.4529	0.87	0.92	1.06
	TAG56:7-FA22:5	0.0384	0.4529	0.85	0.95	1.12
	TAG56:9-FA20:4	0.0458	0.4529	0.83	0.92	1.11
	TAG56:9-FA22:6	0.0229	0.4529	0.85	0.92	1.08
	TAG57:8-FA22:6	0.0093	0.4529	0.87	0.91	1.04
	TAG58:10-FA20:5	0.0161	0.4529	0.86	0.94	1.09
	TAG58:10-FA22:5	0.0391	0.4529	0.74	0.84	1.14
	TAG58:10-FA22:6	0.0388	0.4529	0.72	0.8	1.11
	TAG58:7-FA22:4	0.0294	0.4529	0.81	0.89	1.11
	TAG58:7-FA22:5	0.0109	0.4529	0.79	0.85	1.07
	TAG58:8-FA20:4	0.0324	0.4529	0.85	0.9	1.06
	TAG58:8-FA22:5	0.0386	0.4529	0.79	0.85	1.08
	TAG58:9-FA22:5	0.0478	0.4529	0.78	0.86	1.1
	TAG60:10-FA22:5	0.0349	0.4529	0.85	0.9	1.06
	TAG60:10-FA22:6	0.0357	0.4529	0.82	0.92	1.13
	TAG60:11-FA22:5	0.0038	0.4529	0.8	0.92	1.16
LPC	LPC(15:0)	0.0142	0.4529	0.95	0.92	0.97
	LPC(17:0)	0.0017	0.2886	0.96	0.9	0.93
	LPC(18:1)	0.0423	0.4529	0.98	0.93	0.95
	LPC(20:2)	0.0094	0.4529	0.95	0.89	0.93
	LPC(20:3)	0.0362	0.4529	0.94	0.91	0.96
	LPC(20:4)	<0.0001	0.0088	0.94	0.87	0.93
	LPC(22:1)	<0.0001	0.0313	0.91	0.78	0.86
	LPC(22:2)	<0.0001	0.0051	0.94	0.79	0.84
PC	PC(17:0/20:4)	0.0183	0.4529	0.91	0.91	1
	PC(18:0/16:1)	0.0274	0.4529	1.09	1.3	1.19
	PC(18:0/18:3)	0.0375	0.4529	1.13	1.24	1.1
	PC(18:0/20:2)	0.0143	0.4529	1	1.11	1.11
	PC(18:0/20:3)	0.0361	0.4529	0.96	1.08	1.12
	PC(18:1/20:4)	0.0152	0.4529	0.92	0.91	0.99
PE	PE(18:0/20:1)	0.0203	0.4529	0.97	1.12	1.16
	PE(O-16:0/18:2)	0.0301	0.4529	1.08	1.19	1.11
	PE(O-18:0/20:3)	0.0458	0.4529	0.98	1.12	1.15
	PE(P-16:0/18:2)	0.0246	0.4529	1.07	1.18	1.1
	PE(P-16:0/22:4)	0.025	0.4529	0.89	1.01	1.14
	PE(P-18:0/18:2)	0.0406	0.4529	1.04	1.15	1.1
DCER	DCER(24:0)	0.0475	0.4529	1	1.1	1.1
LCER	LCER(26:1)	0.0097	0.4529	0.95	1.08	1.13

01

A total of 75 lipid species were at least nominally associated with coffee intake, and **8 of these lipid species were highlighted.**

02

The variations between previously identified clinical and metabolic markers responding to coffee and the 75 identified markers were **correlated with** the variations in the key **lipid species** identified in this analysis.

TAG (Triacylglycerol) Variations

The **increase** in TAG caused by coffee is unrelated to the decrease in TAG.

Source of Metabolites

The varied metabolites decrease in response to coffee but may **not directly originate** from the coffee itself.

Lipid Signaling Molecules

Some metabolites, such as butyrate and endogenous cannabinoids, are lipid signaling molecules that may represent other metabolic pathways.

Changes in Lipids and Metabolites

These changes are **inconsistent** with the clinical markers of coffee-related responses.

LPC Species and Coffee Intake

LPC (**16:1a**), LPC (**18:1a**), and LPC (**20:4a**) showed a **negative correlation** with **blood lipid levels** and **habitual coffee consumption**, particularly when comparing a higher intake (>100 mL/day) to no intake (0 mL/day).

Lipid Markers Linked to T2D Risk

- Only three lipid markers were associated with the risk of T2D: **LPC (18:0), SM (16:0), and FFA (18:1).**
- These lipid species did not change in response to coffee consumption in this study.

Biological Uncertainty

The lower levels of LPC suggest an uncertainty about how this translates to human disease conditions. Changes could influence these diseases or conditions in coffee intake.

Lipid Pathway Changes

Low and high coffee intake **affect different lipid pathways**, suggesting a distinct impact on lipid metabolism.

Clinical and Inflammatory Marke Variations

Some clinical lipids and **inflammatory markers** change in response to coffee, but current reports are inconsistent, highlighting the need for more precise analysis.

PC Species Exception

The increase in PC species containing FA (18:0) **correlates with LPC, TAG, and butyrate changes**, but only in high coffee intake (8 cups). This suggests a delayed response to coffee intake.

TAGS Analysis

Variations in **TAGs** are linked to the presence of distinct triacylglycerol subunits, resulting in a significant separation in lipid profiles.

MECHANISM OF ACTION

PART 06

Caffeine Stimulates Lipolysis

Coffee's caffeine stimulates fat breakdown in **acute settings**, but the mechanism behind the reduction of LPC with habitual coffee drinking is still unclear.

Increased Resistance to Oxidative Damage

After drinking coffee, **LDL shows increased resistance to oxidative damage** (a source of LPC). This may be explained by the incorporation of caffeic acid into LDL.

Polyphenols' Protective Role

Polyphenols in coffee, including caffeic acid, reduce the production of LPC caused by oxidation.

CONCLUSION

PART 07

1 COMPREHENSIVE LIPID METABOLISM ANALYSIS

This was the first detailed study of lipid changes influenced by coffee consumption.

2 CONTROLLED COFFEE INTAKE

The study effectively controlled the amount of coffee consumed to observe its effects.

3 KEY FINDINGS

Coffee alters triacylglycerol metabolism, building on previous metabolic research.

4 NEW PATHWAYS IDENTIFIED

The study uncovered new metabolic pathways, offering insights into how coffee may positively affect health.

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PART 08

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Thank You!