

## Supplementary information

### Characterisation of volatile compounds associated with the flavour of flatbreads: effect of sorghum, cassava and whole or dehulled, red and white cowpea flours

<sup>1</sup>Rita Dankwa, <sup>2</sup>Sefater Gbashi, <sup>3</sup>Oluwafemi Ayodeji Adebo, <sup>4</sup>Heikki Aisala, <sup>1</sup>Eugenie Kayitesi, <sup>1</sup>Henriette L. de Kock

#### Author affiliation(s)

<sup>1</sup>Department of Consumer and Food Sciences, University of Pretoria, Private Bag X20, Hatfield, Pretoria 0028, South Africa.

<sup>2</sup>Department of Biotechnology and Food Technology, Faculty of Science, University of Johannesburg, Doornfontein Campus, P.O. Box 17011, Gauteng, South Africa.

<sup>3</sup>Centre for Innovative Food Research (CIFR), Department of Biotechnology and Food Technology, Faculty of Science, University of Johannesburg, Doornfontein Campus, P.O. Box 17011, Gauteng, South Africa.

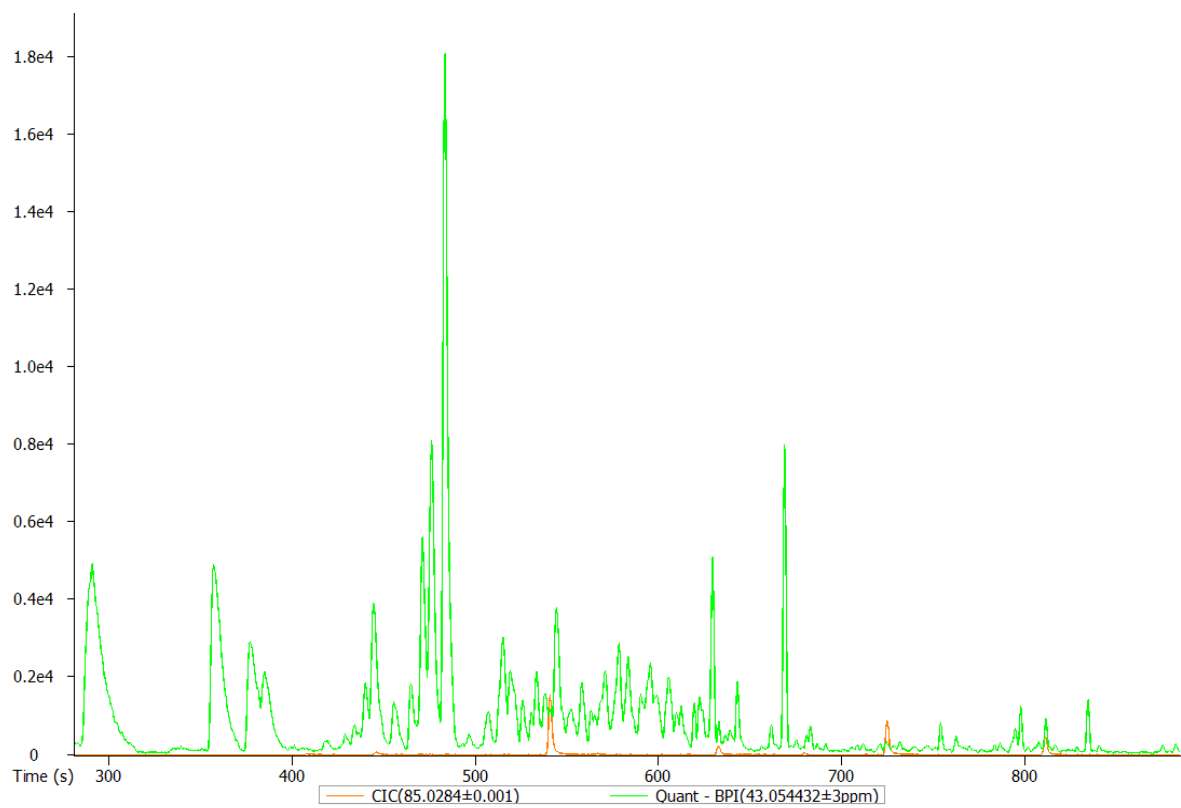
<sup>4</sup>VTT Technical Research Centre of Finland Ltd., Tietotie 2, 02044 Espoo, Finland.

\*Corresponding author

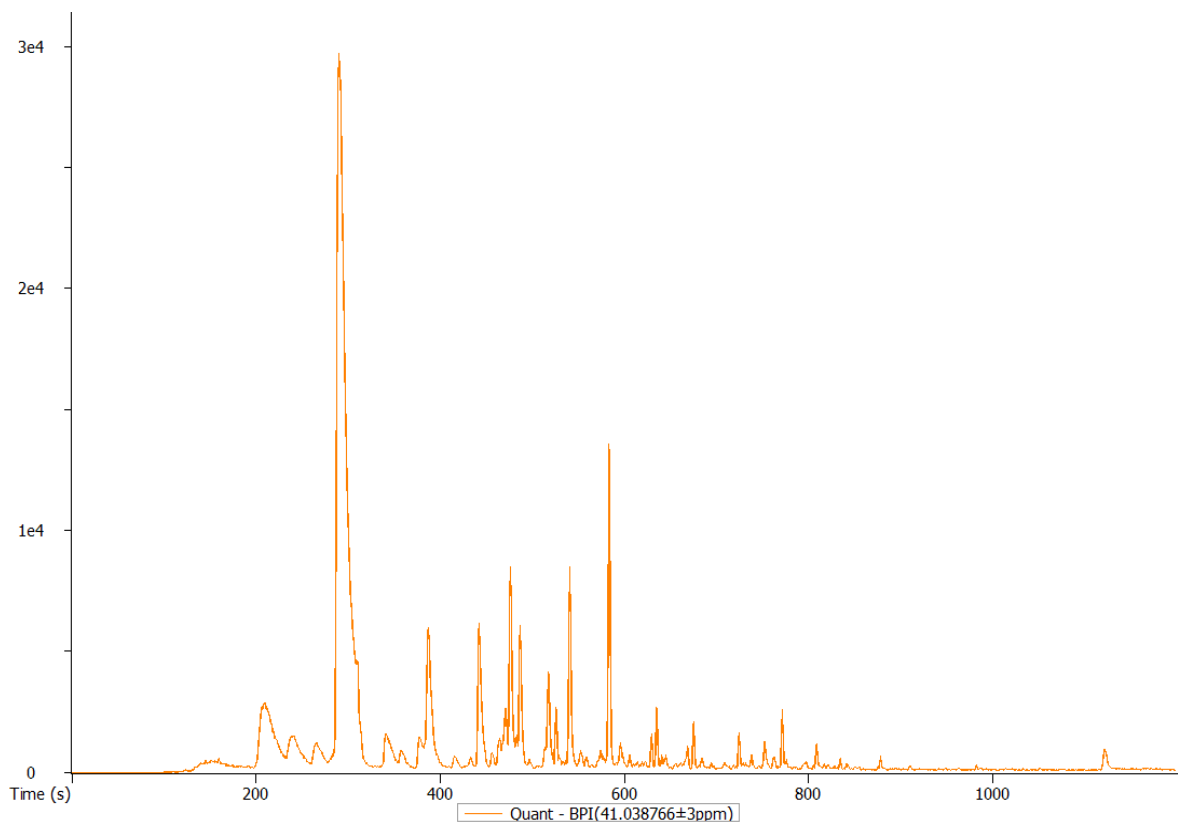
Email address: [riette.dekock@up.ac.za](mailto:riette.dekock@up.ac.za)

## Supplementary 1

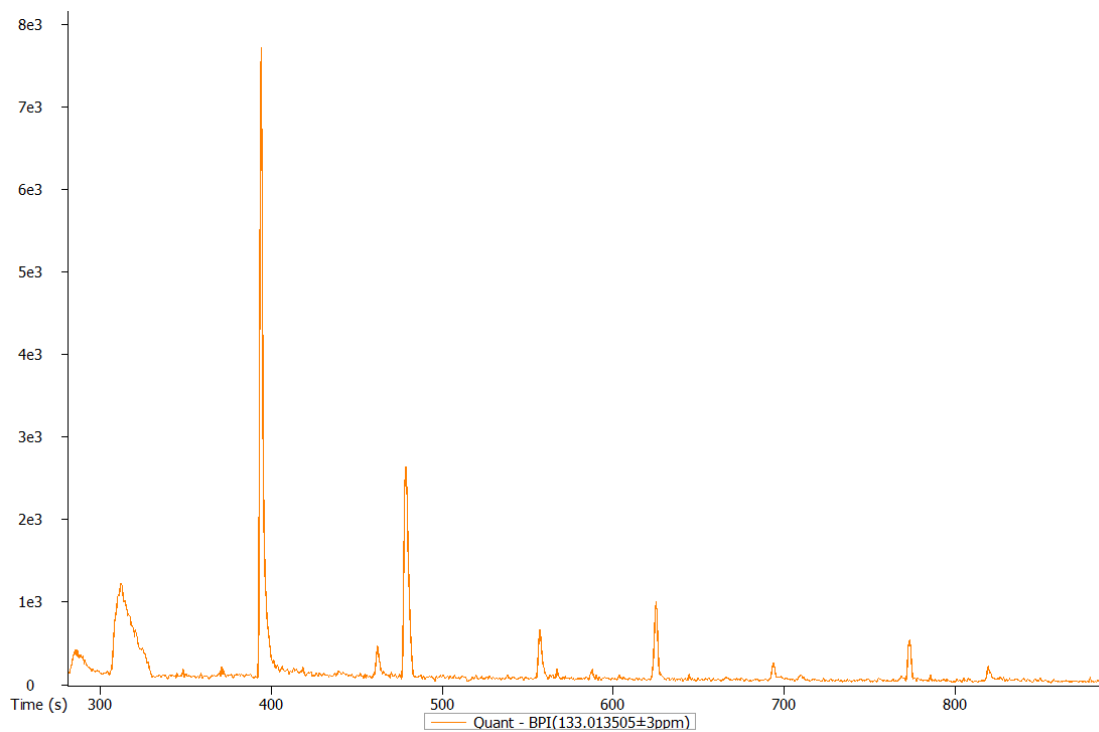
### S1. GC-TOF-HRMS Chromatograms of flatbreads from sorghum, cassava starch and cowpea flours



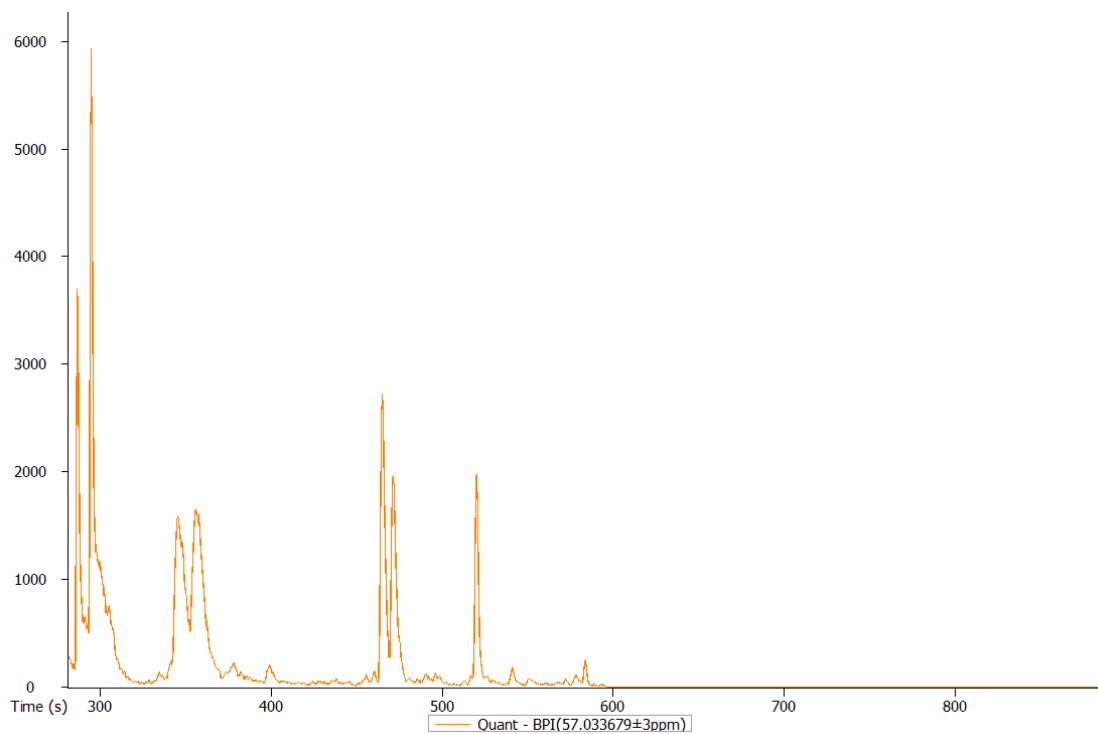
**Figure 1.** GC-TOF-HRMS Chromatogram of red non-tannin sorghum flatbread (XFSorg<sup>f</sup>)



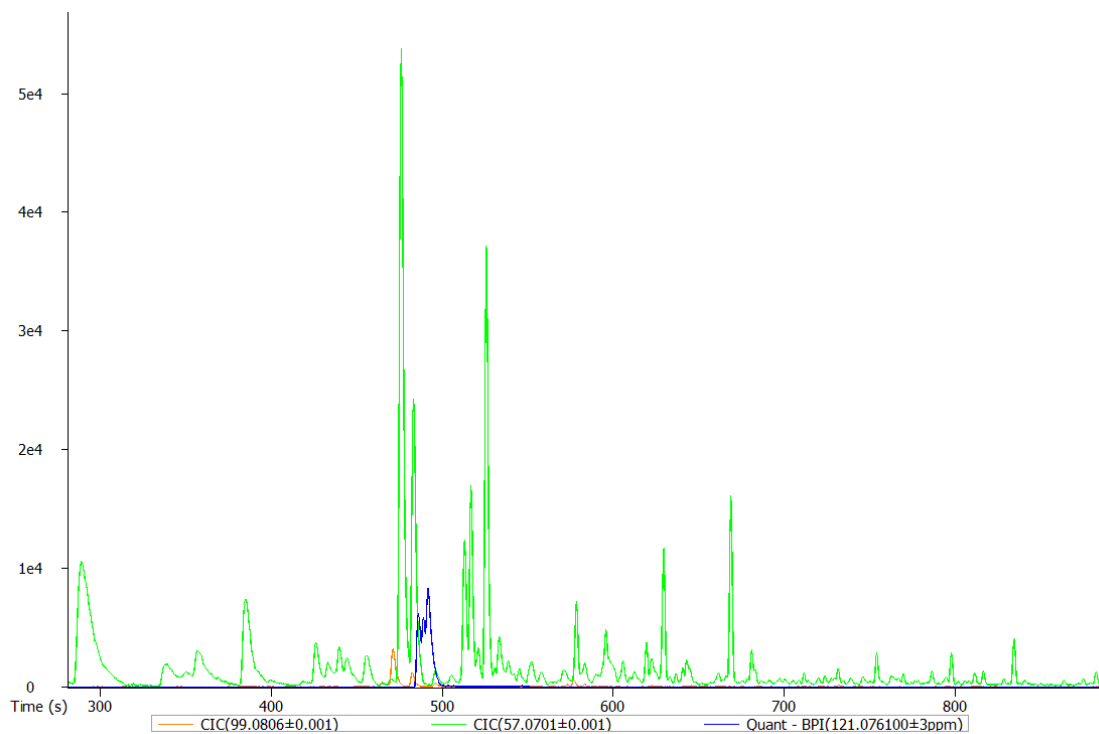
**Figure 1.** GC-TOF-HRMS Chromatogram of cassava starch flatbread (CS<sup>f</sup>)



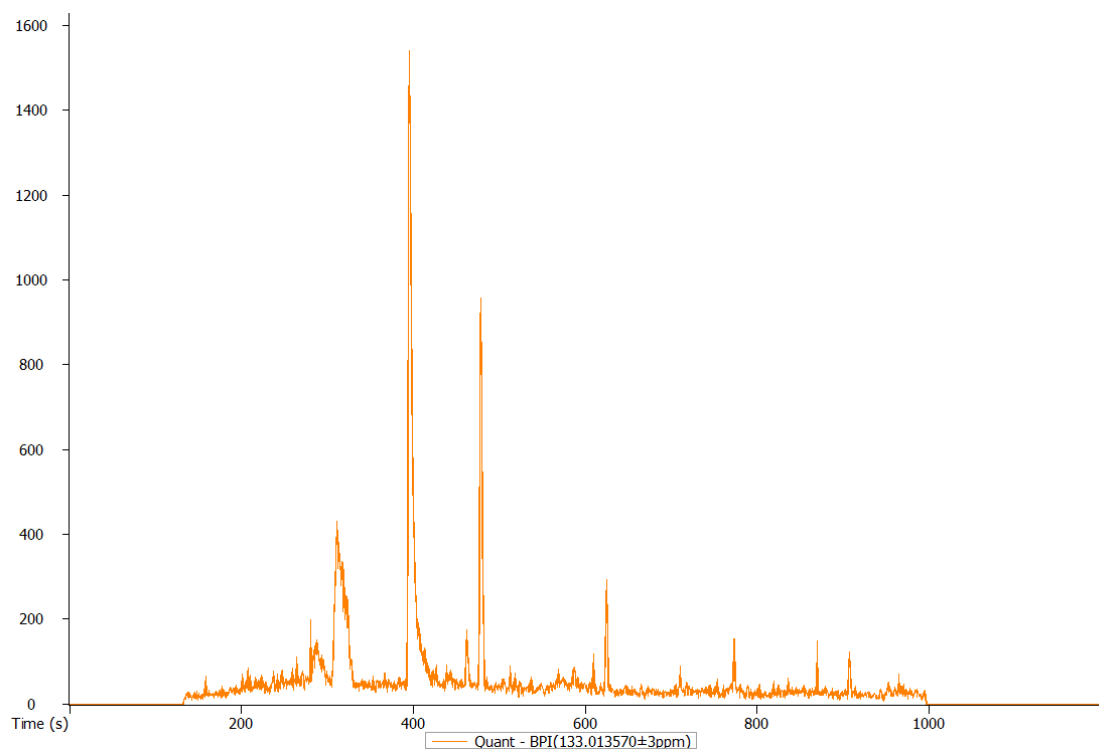
**Figure 2.** GC-TOF-HRMS chromatogram of whole red cowpea flatbread (WRC<sup>f</sup>)



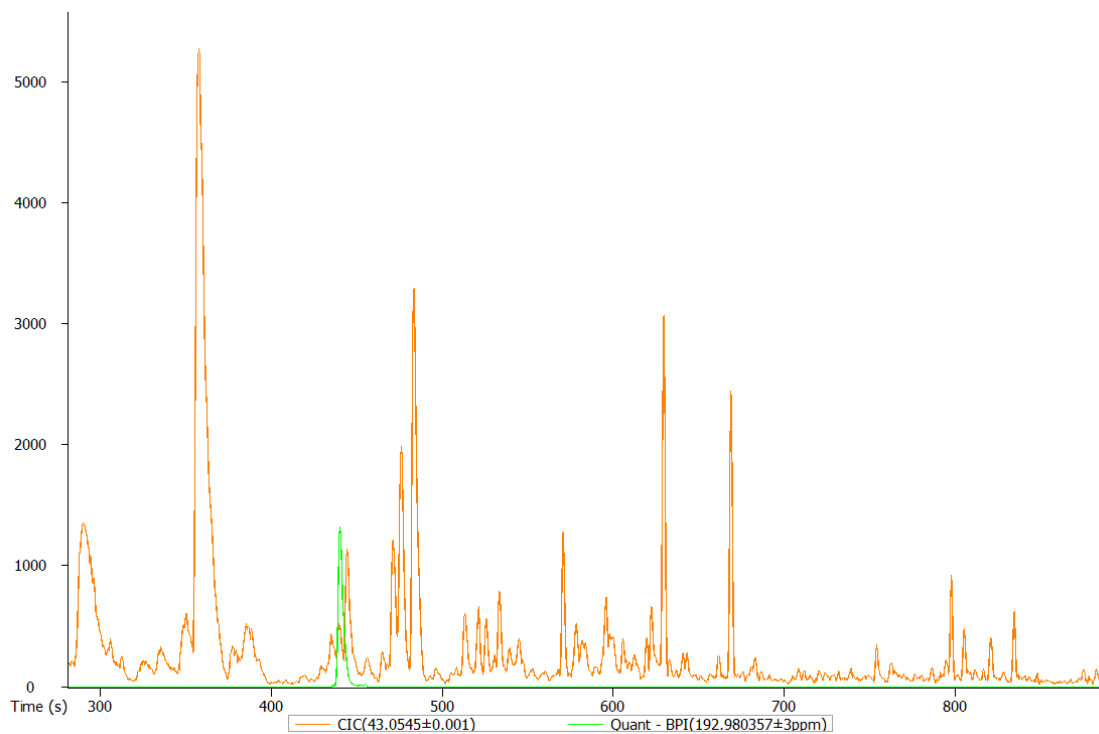
**Figure 3.** GC-TOF-HRMS chromatogram whole white cowpea flatbread (WWC<sup>f</sup>)



**Figure 4.** GC-TOF-HRMS chromatogram dehulled red cowpea flatbread (DRC<sup>f</sup>)

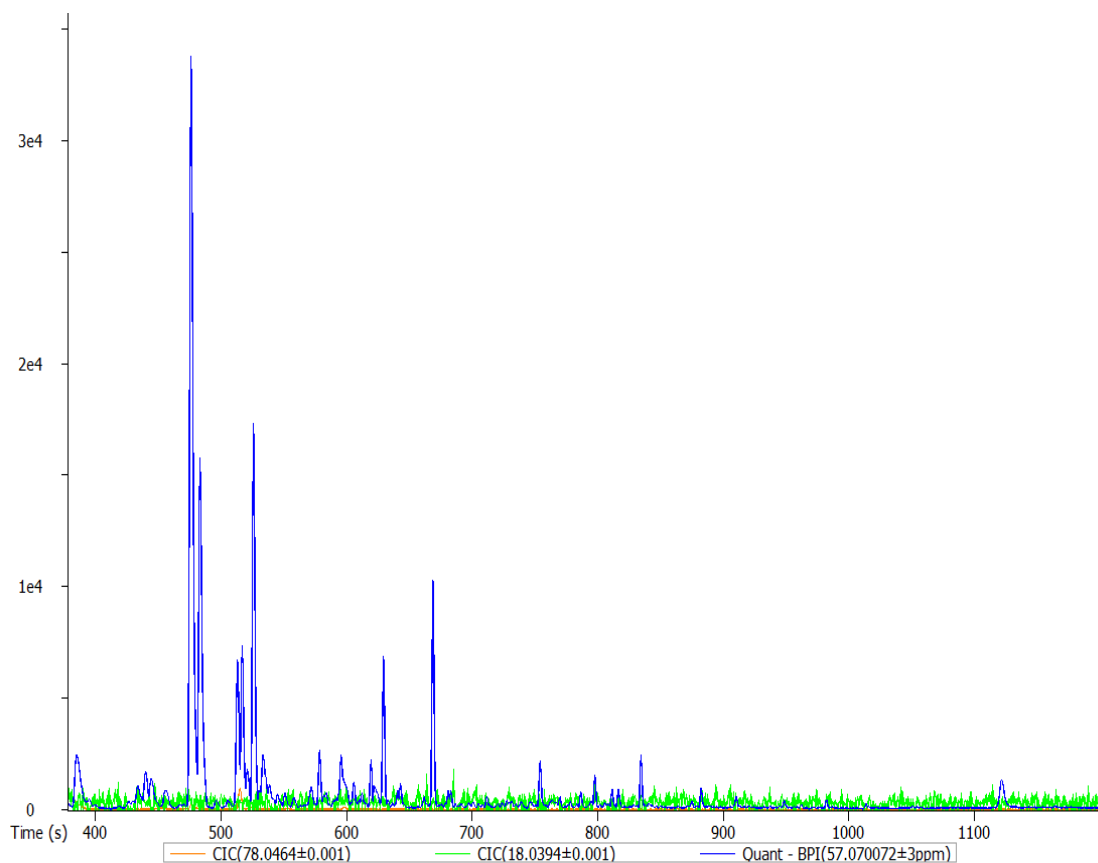


**Figure 5.** GC-TOF-HRMS chromatogram of dehulled white cowpea flatbread (DWC<sup>f</sup>)

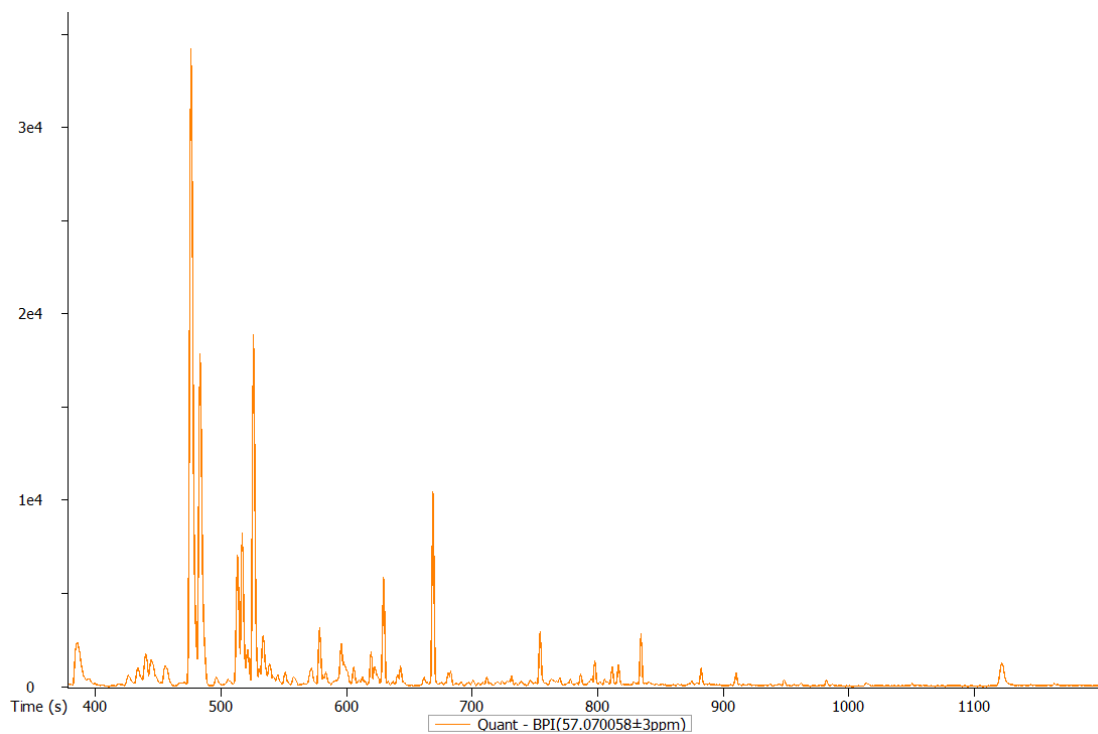


**Figure 6.** GC-TOF-HRMS chromatogram wheat flatbread (WH<sup>f</sup>)

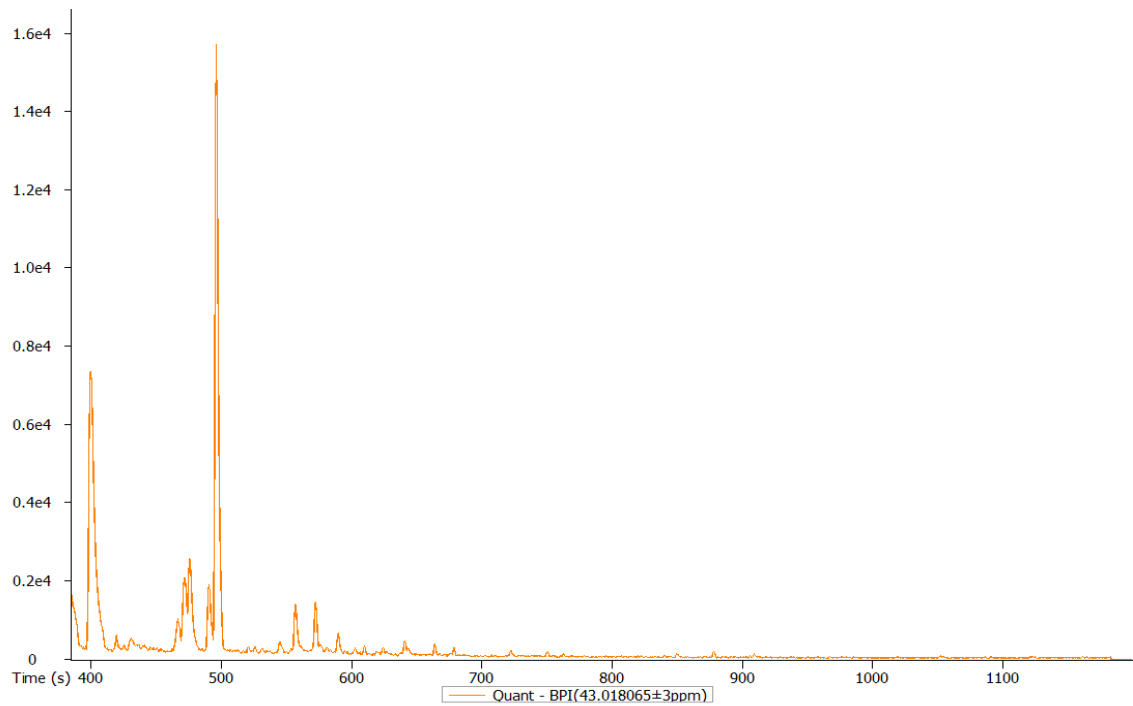
**Chromatograms of sorghum-cowpea composite flour flatbreads**



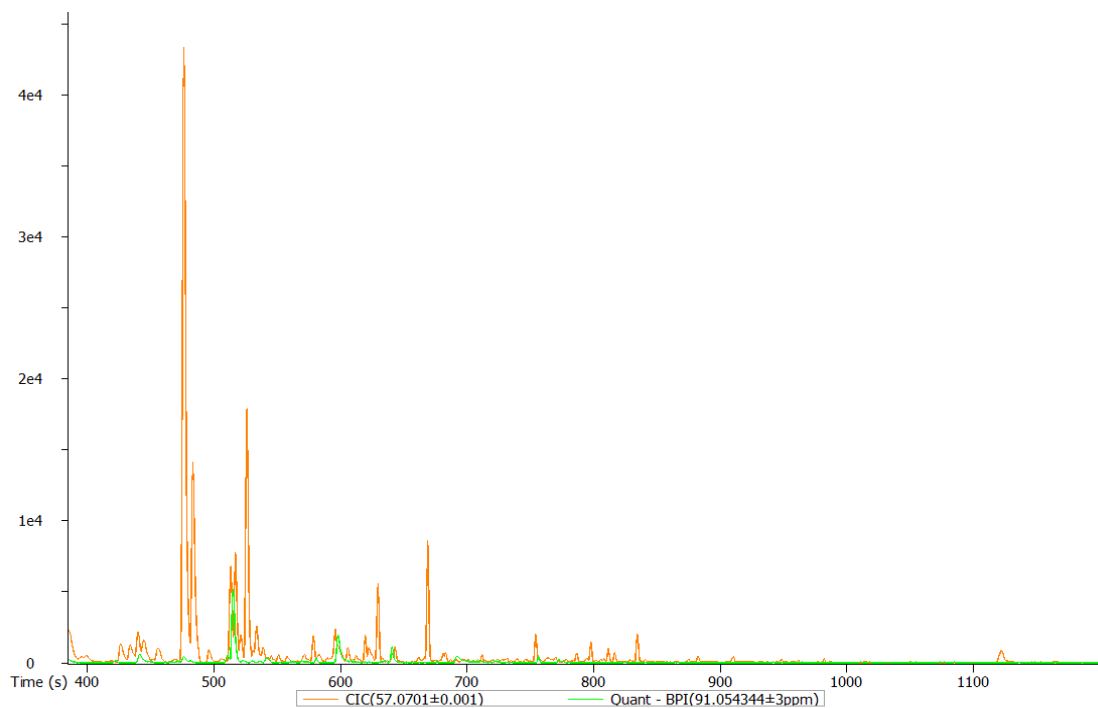
**Figure 7.** GC-TOF-HRMS chromatogram sorghum-whole red cowpea flatbread



**Figure 9.** GC-TOF-HRMS chromatogram sorghum-dehulled red cowpea flatbread

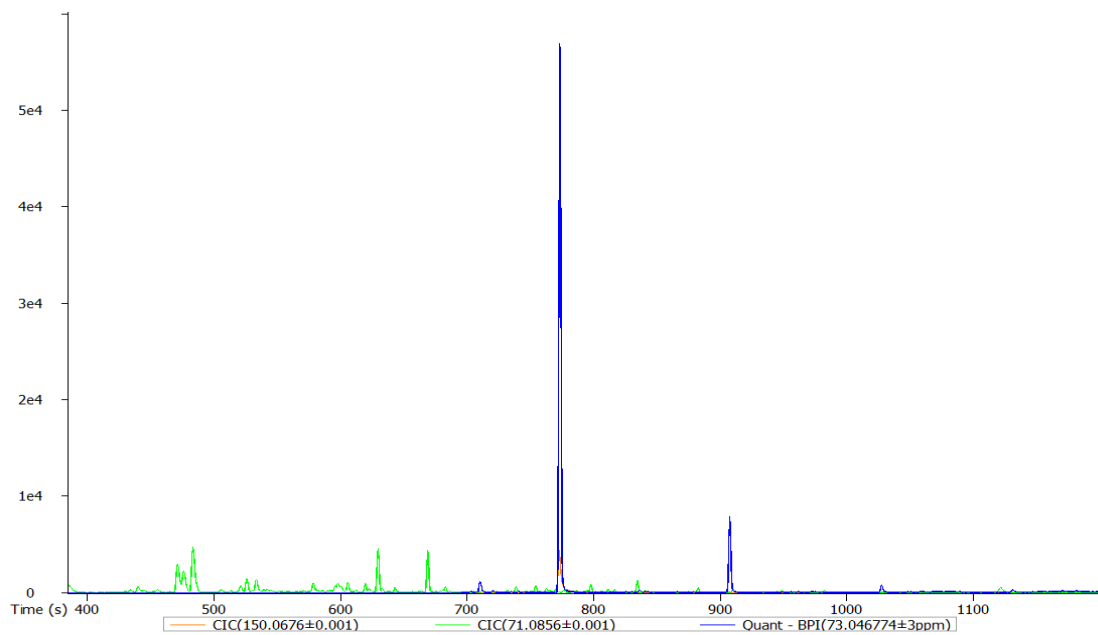


**Figure 10.** GC-TOF-HRMS chromatogram of sorghum-whole white cowpea flatbread

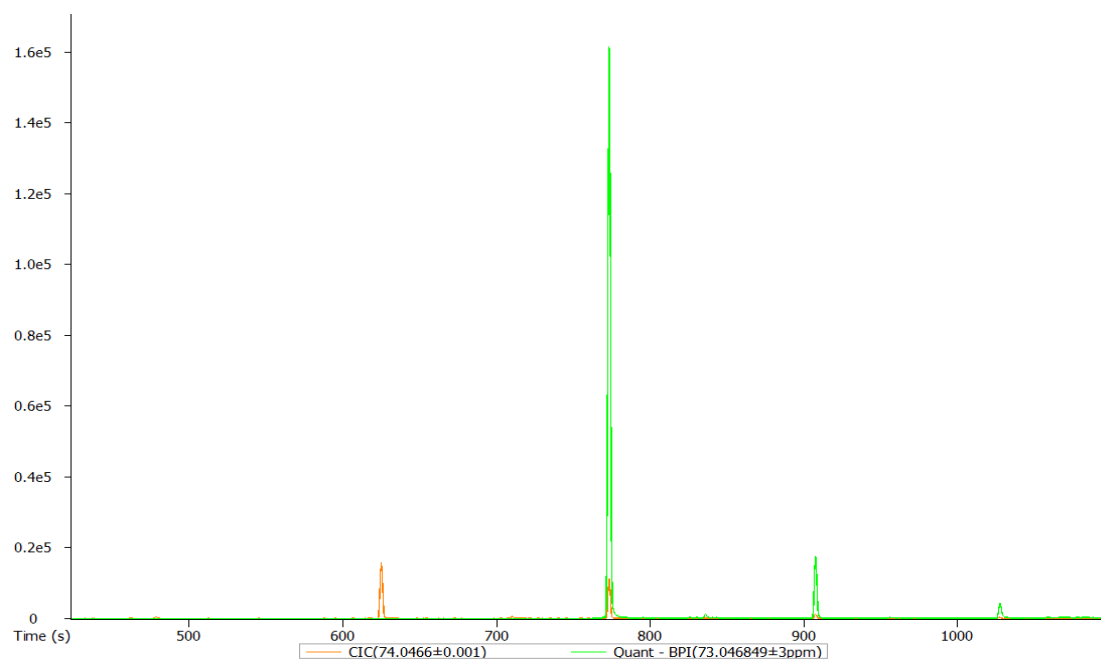


**Figure 11.** GC-TOF-HRMS chromatogram of sorghum-dehulled white cowpea flatbread

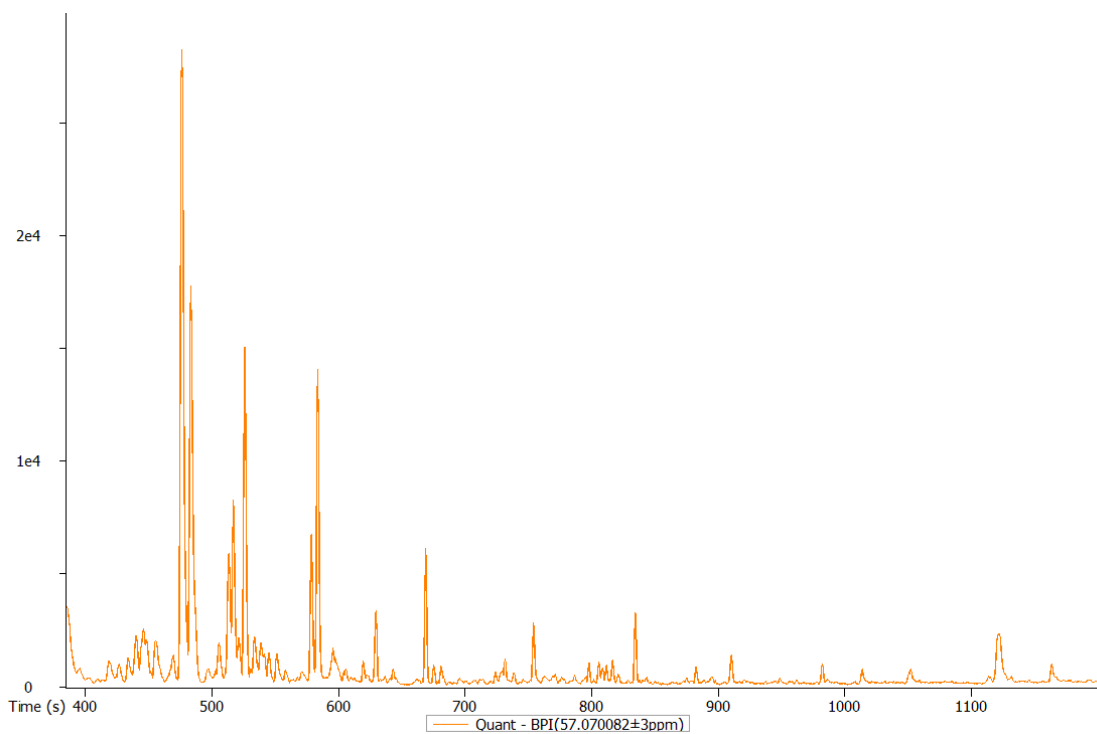
**Chromatograms of sorghum-cassava-cowpea composite flour flatbreads**



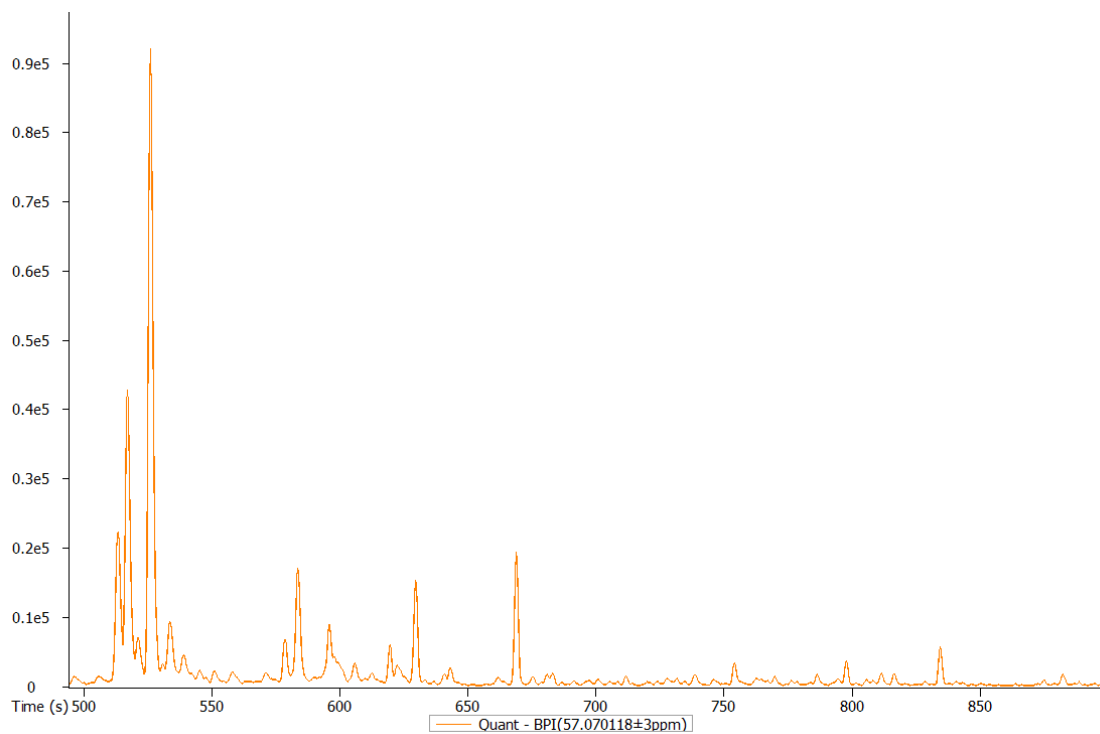
**Figure 12.** GC-TOF-HRMS chromatogram of sorghum-cassava-whole red cowpea flatbread (XFSorg-CS-WRC<sup>f</sup>)



**Figure 13.** GC-TOF-HRMS chromatogram of sorghum-cassava-dehulled red cowpea flatbread (XFSorg-CS-DRC<sup>f</sup>)

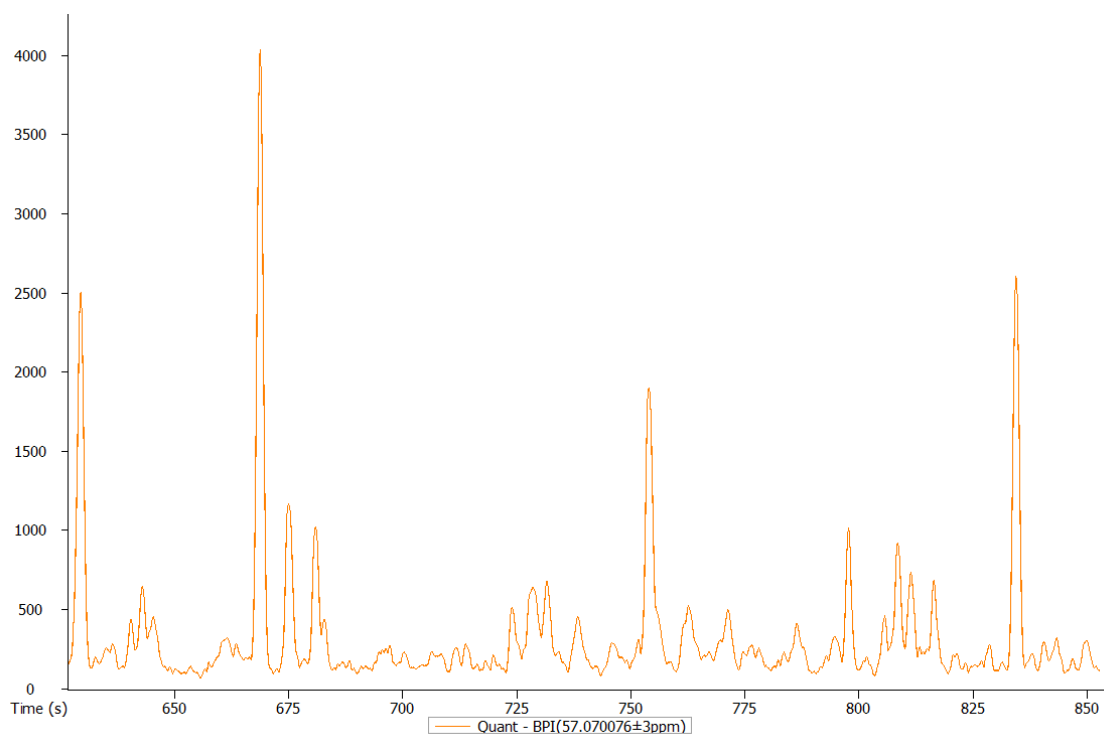


**Figure 14.** GC-TOF-HRMS chromatogram of sorghum-cassava-whole white cowpea flatbread (XFSorg-CS-WWC<sup>f</sup>)

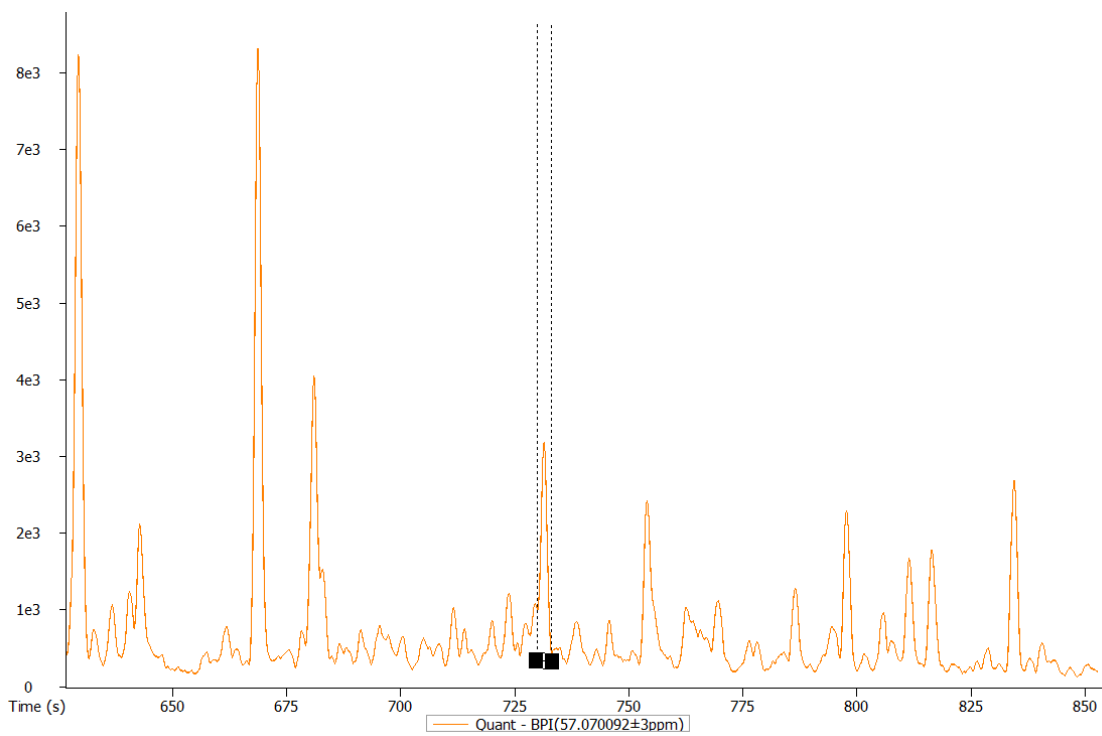


**Figure 15.** GC-TOF-HRMS chromatogram of sorghum-cassava-dehulled white cowpea flatbread (XFSorg-CS-DWC<sup>f</sup>)

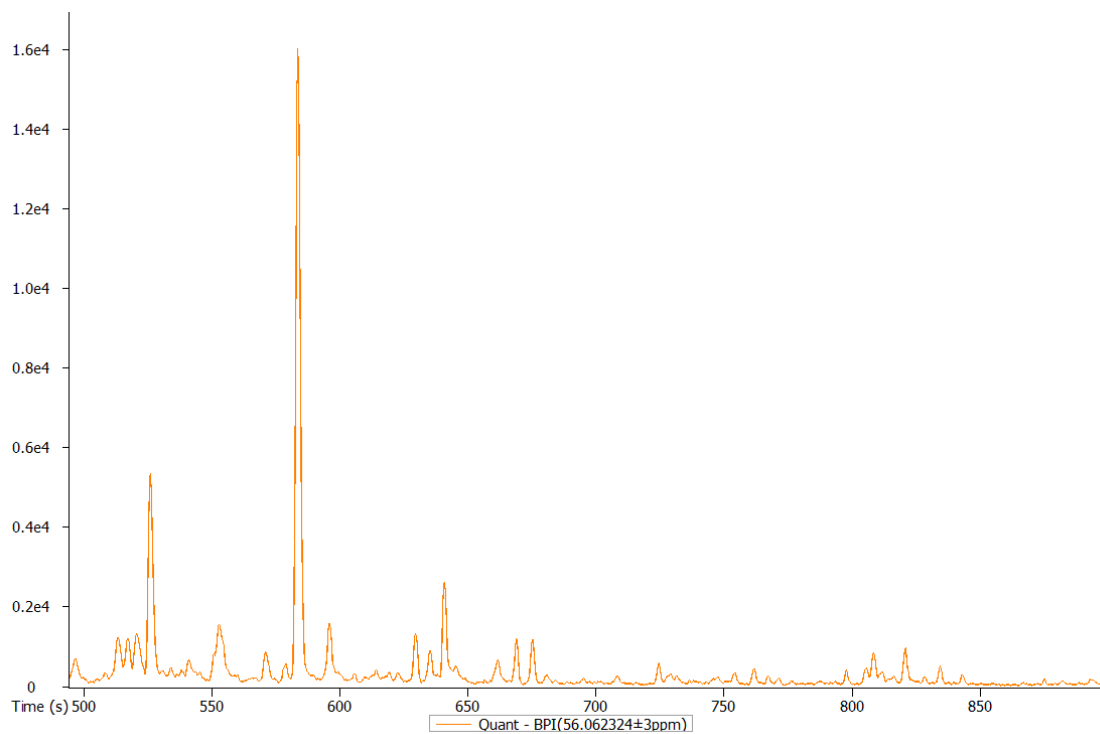
## Chromatograms of Cassava-cowpea composite flour flatbreads



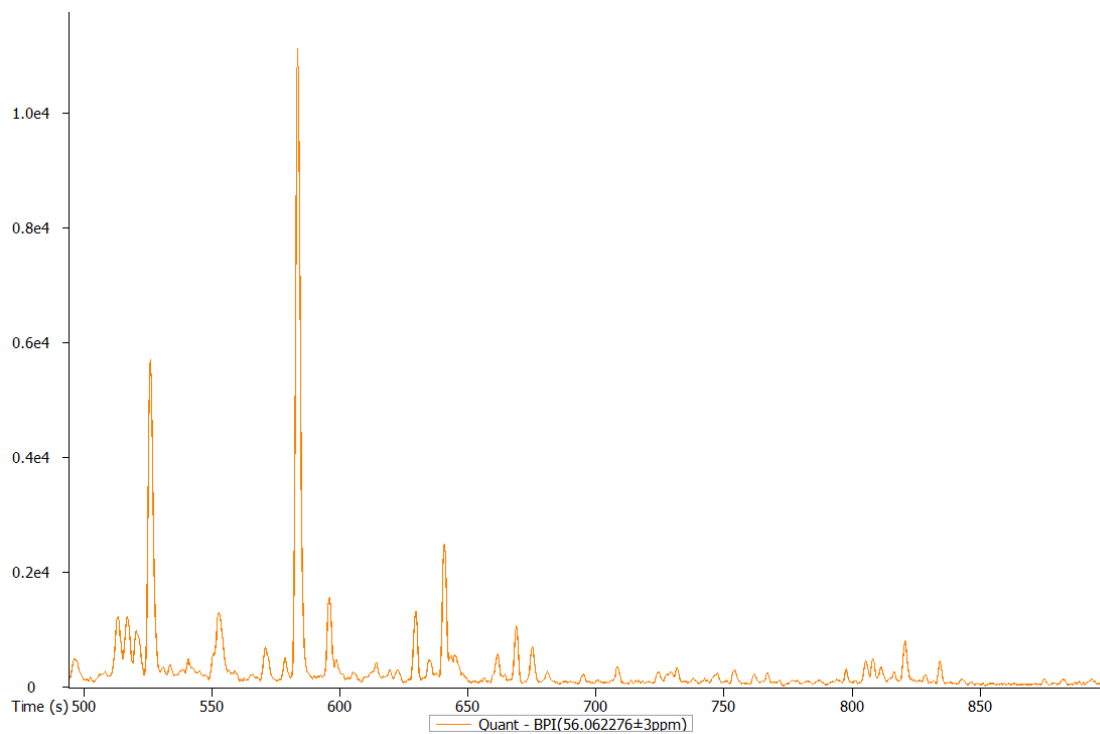
**Figure 16.** GC-TOF-HRMS chromatogram of cassava-whole red cowpea flatbread (CS-WRC<sup>f</sup>)



**Figure 17.** GC-TOF-HRMS chromatogram of cassava-dehulled red cowpea flatbread (CS-DRC<sup>f</sup>)



**Figure 18.** GC-TOF-HRMS chromatogram of cassava-whole white cowpea flatbread (CS-WWCf)



**Figure 19.** GC-TOF-HRMS chromatogram of cassava-dehulled white cowpea flatbread (CS-DWC<sup>f</sup>).

## Supplementary 2

### S2. Mean peak area of volatile compounds detected in single flour flatbreads

Compounds	CS <sup>f</sup>	DWC <sup>f</sup>	DRC <sup>f</sup>	XFSorg <sup>f</sup>	WWC <sup>f</sup>	WRC <sup>f</sup>	WH <sup>f</sup>
<b>Hydrocarbons</b>	<b>CS<sup>f</sup></b>	<b>DWC<sup>f</sup></b>	<b>DRC<sup>f</sup></b>	<b>XFSorg<sup>f</sup></b>	<b>WWC<sup>f</sup></b>	<b>WRC<sup>f</sup></b>	<b>WH<sup>f</sup></b>
Decane	-	-	730314	566795	342741	714891	-
Hexadecane	-	-	300836	-	58098	-	-
Tridecane	-	-	-	-	93499	397373	72827
<b>Ketones</b>							
1-Hepten-3-one	250659	-	-	-	-	-	-
2-Heptanone	730775	-	-	--	-	-	-
2-Octanone	-	2957 10	-	-	-	1353163	-
2-Decanone	-	-	-	-	54919	-	-
3-Octanone	-	-	-	-	-	507101	59101
<b>Esters</b>							
Benzyl acetate	-	-	-	-	-	107191	-
2-Phenylethyl acetate	-	-	-	-	-	132309	-
Hexyl acetate	-	1405 38	1582588	-	1050855	6112999	-
Pentyl acetate	-	-	555866	-	-	3896896	-
Ethyl 3-hydroxybutanoate	-	6297 77	1286525	-	-	-	-
Hexyl propanoate	-	-	228508	-	-	-	-
Ethyl acetate	-	-	-	-	204849	-	-
Linalyl acetate	-	-	-	-	43406	-	-
Ethyl octanoate	-	-	-	-	13218	55624	-
S-Methyl 3-methylbutanethioate	-	-	132954	-	-	-	-
<b>Alcohols</b>							
1-Hexanol	-	2824 118	5435887	576250	-	-	652946
1-Nonen-3-ol	-	-	-	-	90056	-	-
1-Octen-3-ol	163481	2019 39	449001	-	-	453035	-
Phenylethyl Alcohol	163584	1585 33	226439	-	88618	223108	-
2,3-Butanediol	-	4939 186	25974534	398063	1417705	3444181	110273
Benzyl alcohol	-	7196 3	-	-	-	-	-
1-Octanol	-	7418 2	155114	-	-	-	-
Ethanol	-	-	6422	-	-	-	-

1-Heptanol	-	1347 97	-	-	-	-	-
1-Hepten-3-ol	-	-	-	-	-	-	83884
(E)-3-Hexen-1-ol	-	-	-	-	1042316	-	-
(E)-2-Hexen-1-ol	-	-	224978	-	-	-	-
2-(Methylthio)ethanol	-	3843 50	-	-	-	177748	-
<b>Aldehydes</b>							
Hexanal	4870648	-	-	-	-	-	-
Heptanal	423115	-	-	-	-	-	-
(Z)-2-Heptenal	331708	-	-	-	-	-	-
(Z)-2-Decenal	46854	-	-	-	-	-	-
Nonanal	411579	-	-	-	-	-	-
2,4-Decadienal	197628	-	-	-	-	-	-
(E, E)-2,4-Decadienal	252505	-	-	-	-	-	-
(E)-2-Nonenal	74950	-	-	-	-	-	-
(E)-2-Octenal	306237	-	-	-	-	-	-
Octanal	239624	-	-	-	-	-	-
<b>Acids</b>							
Pentanoic acid	774123	-	301368	-	-	-	-
Nonanoic acid	-	-	-	-	-	-	-
Acetic acid	6110080	-	-	-	-	-	-
<b>Benzene derivatives</b>							
Naphthalene	-	-	33022	-	13281	-	-
2-Methoxyphenol	-	-	-	91160	-	-	-
Terpene & Terpenoids							
D-Limonene	74912	-	-	-	-	-	-
<i>m</i> -Cymene	-	-	-	-	94036	281859	-
$\beta$ -Caryophyllene	-	-	56539	-	-	-	-
L-Limonene	-	2912 33	1235486	1915193	2798572	5045766	-
<b>Sulphur and nitrogen</b>							
Dimethyl trisulfide	-	-	-	-	-	103824	-
Benothiazole	-	-	-	-	-	99018	-
4-Methylthiazole	-	-	77188	-	-	-	-
<b>Furans</b>							
2-Pentylfuran	4007865	-	-	2288093	-	2480063	-
1-(2-furanyl)-2-butanone	-	7984 94	2612641	-	-	-	-
<b>Pyrazines</b>							
2-Ethyl-6-methylpyrazine	-	4812 0	125779	-	-	-	-
3-Ethyl-2,5-dimethylpyrazine	-	1149 78	310255	-	-	-	-
2-Isoamyl-6-methylpyrazine	-	-	63390	-	-	-	-
2,5-dimethylpyrazine	-	-	424736	-	-	-	-

Trimethylpyrazine	-	-	660176	-	-	-	-
2,6-Diethylpyrazine	-	-	-	-	45493	-	-
2-Ethyl-3-methylpyrazine	-	-	-	-	-	84082	-

- Means compound not detected; WH<sup>f</sup> = Wheat flatbread; XFSorg<sup>f</sup> = sorghum flour flatbread; CS<sup>f</sup> = Cassava starch flatbread; WWC<sup>f</sup> = Whole red cowpea flatbread, DWC<sup>f</sup> = Dehulled white cowpea flatbread, DRC<sup>f</sup> = Dehulled red cowpea flatbread.

### Supplementary 3

**S3.** Mean values of volatile compounds differentiating flatbreads from the white cowpea and red cowpea variety.

<b>Aroma compound</b>	<b>WC</b>	<b>RC</b>	<b>p-value</b>
1-octen-3-ol	134626	451018	<b>0.004</b>
Decane	342741	721060	<b>0.000</b>
Phenylethyl alcohol	123575	224773	<b>0.020</b>

WC = White cowpea variety; RC = Red cowpea variety