Comparative evaluation of strawberries fruits and leaves using Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy

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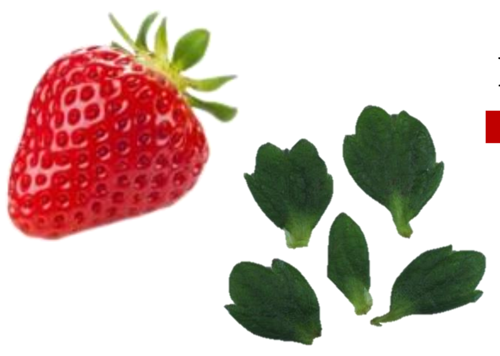
Introduction

The strawberry is one of the most economically important fruits worldwide and is characterized by unique organoleptic properties and important nutritional value. The cultivated strawberry (*Fragaria x ananassa*), one of the newest domesticated plants, cultivated since the early 18th century in Europe [1]. The present study was conducted to evaluate comparatively the phytochemicals profile from strawberry (*Fragaria* × *ananassa*) fruits and leaves using Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR). ATR-FTIR is a widely used, rapid, direct and non-destructive analytical technique to identify the functional groups present in plant materials and to elucidate the structure of their phytochemical constituents. The interpretation of ATR-FTIR spectra bands, ranged among 4000-499 cm^{-1}, revealed the presence of characteristic compounds in fruits and leaves of strawberry, such as physical pigments, aromatic compounds, esters, polyphenols, and carbohydrates. The most important findings are summarized below. Therefore, ATR-FTIR technique can successfully and non-destructively evaluate the phytochemical profile of fruits and vegetables, finding significant applications in their quality control.

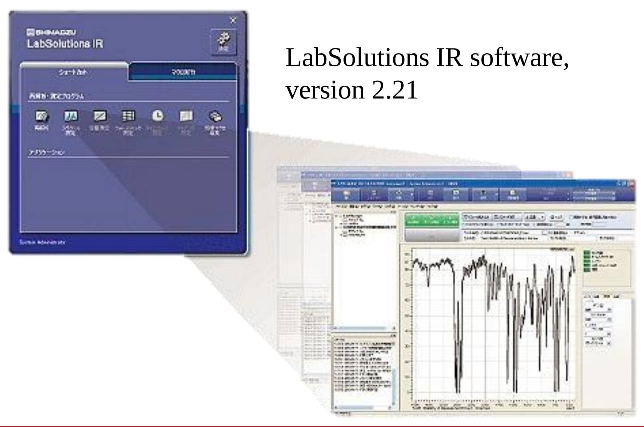
Materials and Methods



FTIR measurement

Shimadzu, IRAffinity-1S FTIR Spectrometer, Kyoto, Japan

Data extraction/ processing



LabSolutions IR software, version 2.21

Interpretation

Results and Discussion

Regions (cm^{-1})	Functional group/assignment	Strawberry fruits' intensities	Strawberry leaves' intensities
3600-3645	O-H stretch Nonbonded hydroxyl group	-	0.014±0.002
3380-3385	presence of bonded N–H/O–H stretching of amines and amides/alcohols and hydroxyl compounds	0.006±0.001	0.003±0.001
2954	C-H Asymmetric stretching vibration of methyl-group CH_3 of acyl chains of lipids and chlorophyll	-	0.013±0.003
2916-2920	Asymmetric CH_2 stretching mode of the methylene chains in lipids and chlorophyll	0.317±0.040	0.792±0.022
2848-2855	symmetrical C-H stretching vibrations of methyl CH_3 and methylene CH_2 groups of lipids or chlorophyll	0.181±0.030	0.605±0.023
1730-1742	carbonyl (–C=O) stretching vibration of ester group in chlorophyll and triglycerides	0.111±0.014	0.103±0.013
1687	carbonyl (C=O) stretching vibration of ketone group in chlorophyll	-	0.019±0.005
1630 -1647	C=C stretching vibration of cis-olefins or bending vibrations of hydroxyl groups of water, carbohydrates, organic acids and phenols	0.171±0.012	0.007±0.002
1510-1520	C=C-C Aromatic ring stretch	0.010±0.005	0.014±0.003
1472	bending vibrations of $–CH_2–$	-	0.016±0.005
1457-1465	scissoring bending vibrations of the CH_2 and CH_3 aliphatic groups or monosaccharides	0.020±0.006	0.038±0.002

Regions (cm^{-1})	Functional group/assignment	Strawberry fruits' intensities	Strawberry leaves' intensities
1417-1420	C-H rocking and O-H bending vibrations	-	0.006±0.001
1350-1378	Bending vibrations of CH_2 groups terminal (CH_3) groups symmetric bending or O-H bending vibration of the C-OH group	0.017±0.004	0.006±0.002
1230-1245	stretching vibration of C–O ester groups in esters, polysaccharides, glycosylated anthocyanins and organic acids	0.046±0.006	0.013±0.002
1143- 1155	C–O stretching of carbohydrates equivalent to v(C-O-C) glycosidic bound	0.023±0.009	0.020±0.005
1100-1105	C-O stretching in secondary alcohols and/or the stretching of the C–O band of the C–O–C linkage in polysaccharides	0.058±0.011	0.029±0.004
1049-1055	C-O stretching attributed to sucrose	0.011±0.003	0.008±0.003
1022-1033	C-O stretching in primary alcohols and/or pyranose ring of glucose	0.068±0.013	0.017±0.005
966-968	[–HC=CH– (trans) bending] olefin reflector outside stretching vibration peak δ(–HC=CH–, trans-) out-of-plane deformation	-	0.009±0.002
720-750	cis –HC=CH− group of disubstituted olefins out-of-plane bend	0.004±0.002	0.016±0.001
610-680	Alkyne C-H bend	0.001±0.001	-
523	in-plane bending β(C-C-C), β(C-O-C) in glycosidic linkage	0.009±0.002	-

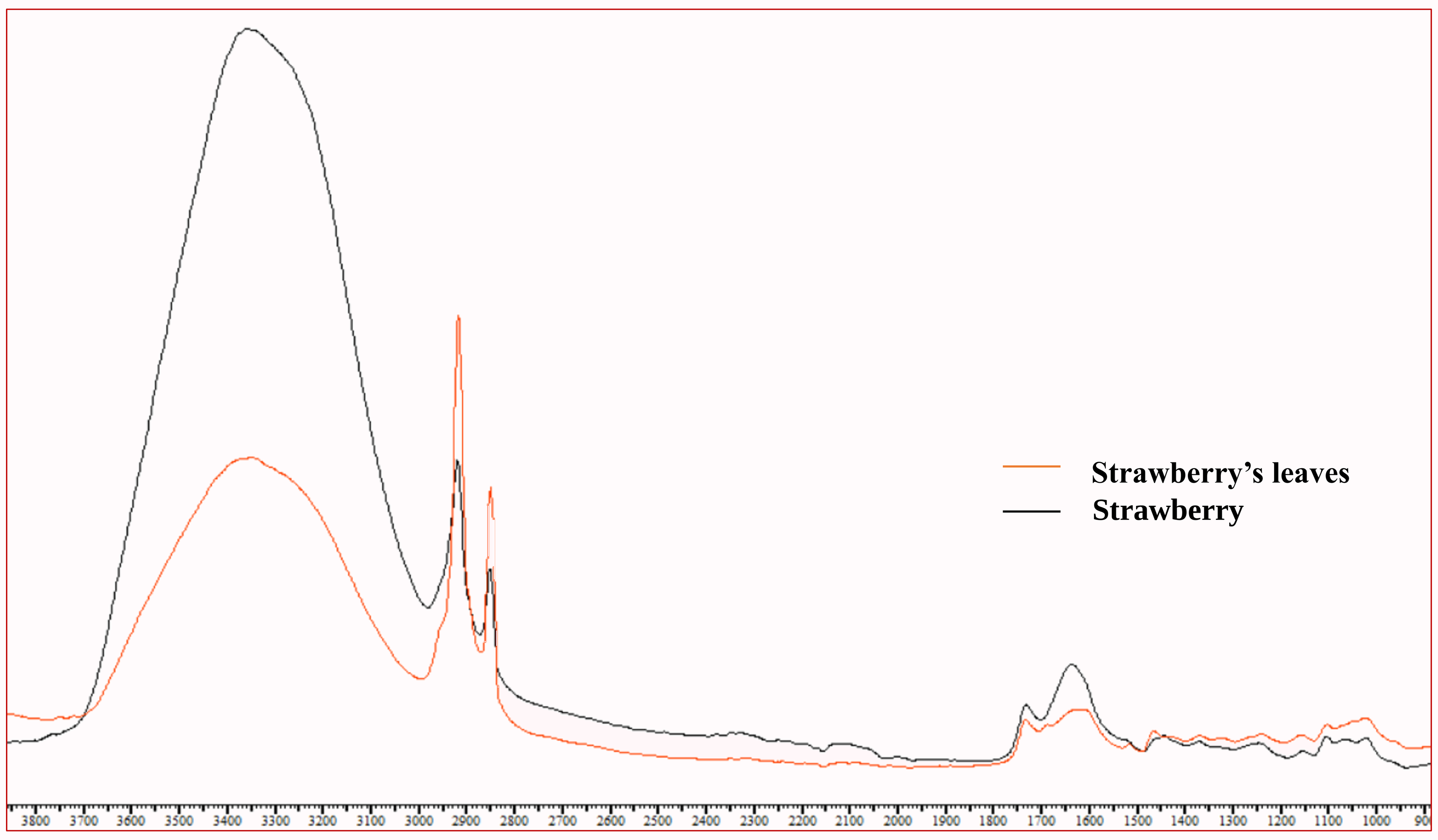
1 The intensities related to $C(sp^3)$-H stretching and bending vibrations such as these at 2922, 2854, 1472 and 1462 cm^{-1}, which are associated with the presence of chlorophyll [2] and aliphatic compounds, exhibited significant higher intensities in strawberry leaves than in fruits.

2 The bands at 3630 and 1687 cm^{-1}, which are corresponded to the O-H stretch in phenols and to C=O stretch of ketone group in chlorophyll, respectively, were detected only in strawberry leaves.

3 The bending vibration of hydroxyl group (O-H), present in water at 1635 cm^{-1} [3], showed significant higher intensities in strawberry fruits than in leaves.

4 The bands at 1420 and 966 cm^{-1} which are related to the bending vibrations of *cis*-C(sp2)-H in chlorophyll and of *trans*–HC=CH– in carotenoids, respectively, were detected only in strawberry leaves.

5 The bands at 1238, 1105 and 1030 cm^{-1} which are related to the stretching vibrations of C–O in esters, organic acids and carbohydrates [4], displayed significant higher intensities in strawberry fruits than in leaves.



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