Clonal variations in the oil content and physico-chemical parameters of Kenyan tea (*Camellia sinensis*) seed oil

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A Paper presented at the
Kabarak University 4th Annual International Research Conference,
15th to 18th July, 2014.
Kabarak, Nakuru, Kenya.

Introduction

- The tea plant (*Camellia sinensis* (L.) O. Kuntze) plant is mainly cultivated for its leaves whence different types of tea products are made *viz.*, **white**, **green**, **oolong** and **black** teas to mention but a few

- These are manufactured via different methods manufacture of young tender tea shoots which vary considerably on their impact on the **formative and degradative** patterns of various cellular components resulting in the aforementioned products

- Kenya specializes in the production of **CTC black tea,** over **95%** of which is sold in bulk in the global market mainly via the Mombasa auction

- Kenya is the **largest exporter** of black tea in the world **(**over 24%, International Tea Committee**, 2013)**

The tea Industry

- Despite these, Kenya has continued to be a producer of processed tea at **primary level** with **very little product differentiation and value addition**.

- This has **constrained** growth in **profitability**. Consequently, TRFK has recognized the need to **review its strategic direction** and refocus its energies on new growth paths which will reshape the future tea industry.

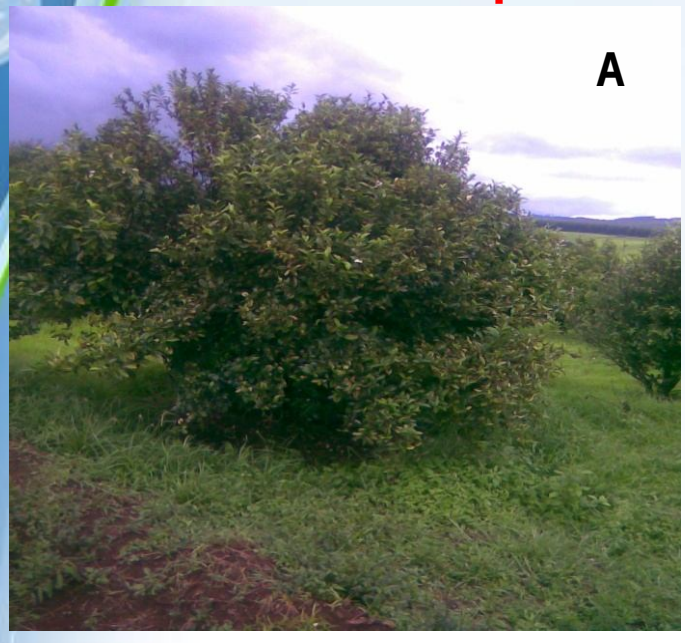
- TRFK has since developed a **Strategic Plan for the period 2010- 2015** in line with several Government guiding policies the **Agricultural Sector Development Strategy** (ASDS) for the period 2009-2020, **Vision 2030**, **National Development Plan** and the **Medium Term Plan 2008-2012**.

- The Strategic Plan envisions development of research capacity along the entire value chain of tea.

- The plan particularly recognizes the **need to diversify tea products** and the need to develop technologies for **value addition** so as to **enhance farmers' earnings**. These measures are also expected to open up **new market niches for Kenyan tea**

Product diversification in the Kenyan tea industry - Tea Seed Oil

In its natural state, the tea plant can grow to a height of **30-40** feet and can **produce seeds that contain oil**



A = A fully grown tea plant

B = Part of the tea plant with mature tea seeds

Tea Seed Oil

- Previously tea seed oil has been obtained from *C. sasaqua* (56-70 % and *C. sinensis* 16-20 % oil seed content)
- Being of plant origin, various health benefits have been attributed to tea seed oil just like other vegetable oils
- It is a pale amber-green fixed oil with a sweet herbal aroma and is the main **cooking oil** in some southern provinces of China. It has also been used for **soap making** and other industrial purposes
- It is similar to olive oil in its **excellent storage qualities** and **low content of saturated fats** with a fatty acid profile comprising of about 80 % oleic acid
- Is rich in **vitamin E** and other **antioxidants** and contains no natural trans fats, contains squalene and flavonoids
- Stable and suitable in nutritional properties, has an identical shelf life to that of olive oil at 60^0C

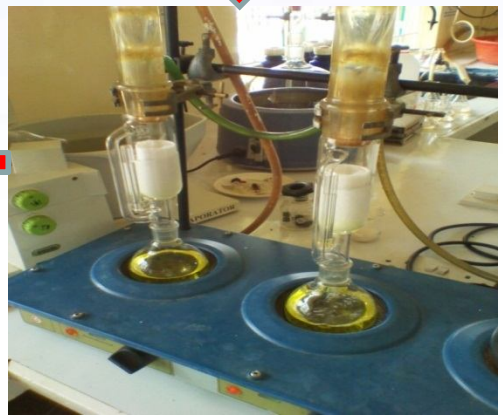
Why Tea Seed Oil?

- Previously tea seed oil has been obtained from *C. sasaqua* (56-70 %) and *C. sinensis* (16-20 %) in other countries especially China
- Its is a pale amber-green fixed oil with a sweet herbal aroma and is the main **cooking oil** in some southern provinces of China. Further, it has been for **soap making** and other industrial purposes
- Tea seed oil is similar to olive oil in its excellent storage qualities and low content of saturated fats with a fatty acid profile comprising of about 80 % oleic acid
- Tea seed oil is also **rich in vitamin E** and other **antioxidants** and contains no natural trans fats, contains squalene and flavonoids
- Stable and suitable in nutritional properties, has an identical shelf life to that of olive oil at 60^0C
- Being of plant origin, various health benefits are attributed to vegetable oils

Materials and Methods

Dehusking

Milling



Soxhlet extraction

Characterization of the oils

- ✓ **% oil content** - Method by Paquot, 1979
- ✓ **Iodine value (IV)** - Wij's method: AOCS (cd 1-25, 1988) and expressed as gI_2/100 g of oil
- ✓ **Saponification value (SV)** - AOCS method cd 3-25 (AOCS, 1978) with slight modifications and expressed as mgKOH/g oil
- ✓ **Peroxide value (PV)** - IUPAC method 2.501 (Paquot, 1979) with slight modifications and expressed as meqO_2/ kg of oil
- ✓ **Free fatty acid (FFA) composition** - AOCS Ca. 5a-40 (AOCS, 1978) with slight modifications and expressed as % oleic acid

Characterization of the oils

- ✓ **Total polyphenol content –** determined spectrophotometrically at 725nm using gallic acid as a standard (Samaniego *et al.*, 2007)

- ✓ **Antioxidant Activity** – determined using the 2,2'-diphenyl-1-picryl-hydrazyl (DPPH) assay (Morales and Jimenez-Perez, 2001) with slight modifications (Henares and Morales, 2007)

- ✓ **Total catechin content** – quantified by a **High Performance Liquid Chromatographic** (HPLC) system (Shimadzu LC 20 AT) fitted with a UV-Visible detector at 278nm using caffeine as a standard. Total catechins (% flavonoids) was calculated as the summation of individual catechins content in the tea seed oil

- ✓ **Fatty acid profile** – determined by **Gas Chromatography** (GC) according to the IUPAC 2.302 method (Paquot, 1979) with modifications

Results

Oil sample	Oil content (%)	IV (gI2/100 g)	SV (mgKOH/g)
TRFK91/1	22.0	90.8	187.4
TRFK301/3	17.0	86.7	186.5
TRFK301/4	17.6	89.9	182.3
TRFK301/5	17.9	91.4	181.9
GW-Ejulu	23.4	89.8	186.8
K-Purple	24.4	91.4	181.8
TRFK306	25.2	90.6	181.4
SFS150	21.6	92.0	186.8
***Corn**	17.4	120.5	190.6
***Sunflower**	37.9	127.2	190.8
***Soybean**	18.6	127.8	189.1
Mean	**22.1**	**99.8**	**186.0**
CV (%)	**4.18**	**2.16**	**1.00**
LSD ($p \leq 0.05$)	**1.6**	**3.7**	**3.2**

Results

Oil sample	Peroxide value (meqO_2/kg)				Free fatty acids (% oleic acid)			
	Day 0	Day 7	Day 14	Day 21	Day 0	Day 7	Day 14	Day 21
TRFK91/1	3.44	3.54	3.65	3.80	1.30	1.36	1.44	1.50
TRFK301/3	3.26	3.38	3.43	3.49	1.08	1.29	1.44	1.58
TRFK301/4	3.27	3.36	3.50	3.58	1.04	1.20	1.21	1.37
TRFK301/5	3.32	3.43	3.57	3.65	1.12	1.22	1.28	1.37
GW-Ejulu	3.29	3.36	3.45	3.56	1.13	1.25	1.31	1.39
K-Purple	3.40	3.52	3.66	3.77	0.89	1.12	1.23	1.34
TRFK306	3.35	3.44	3.54	3.70	1.19	1.33	1.34	1.50
SFS150	3.36	3.63	3.79	3.91	0.99	1.15	1.27	1.40
*Corn	2.58	3.08	3.70	3.89	2.03	2.25	2.33	2.48
*Sunflower	1.96	2.22	2.43	2.55	0.98	1.26	1.42	1.52
*Soybean	2.13	2.43	2.61	2.79	1.20	1.29	1.41	1.55
Mean	3.04	3.22	3.40	3.52	1.17	1.34	1.43	1.54
CV (%)	7.1	5.6	4.3	4.3	12.1	8.5	8.1	5.9
LSD ($p \leq 0.05$)	0.37	0.31	0.25	0.26	0.24	0.19	0.19	0.15

Results

Oil sample	TP (mg/LGA)	TC-% flavonoids ($\times 10^{-3}$)	AC (% DPPH inhibition)
TRFK91/1	0.038	5.04[b]	16.7
TRFK301/3	0.036	6.38[b]	15.6
TRFK301/4	0.038	4.76[b]	17.9
TRFK301/5	0.036	4.86[b]	14.4
GW-Ejulu	0.043	9.02[a]	20.7
K-Purple	0.038	9.79[a]	15.7
TRFK306	0.040	5.89[b]	21.1
SFS150	0.038	5.11[b]	19.6
*Corn	0.025	1.87[c]	34.8
*Sunflower	0.029	0.71[c]	12.9
*Soybean	0.028	1.62[c]	14.1
Mean	0.035	5.01	18.5
CV (%)	4.29	19.09	22.0
LSD ($p \leq 0.05$)	0.002	1.60	6.9

Results

Clone	Oleic	Linoleic	Linolenic	Palmitic	Stearic	Others
TRFK91/1	57.7	13.6	2.0	21.7	3.6	1.5
TRFK301/3	60.0	12.8	1.4	21.7	3.0	1.1
TRFK301/4	60.6	13.7	2.8	19.5	2.7	0.9
TRFK301/5	56.5	15.0	2.3	22.3	3.1	0.7
GW-Ejulu	57.9	13.3	2.0	21.4	2.8	2.6
K-Purple	58.9	13.6	1.6	21.2	3.2	1.5
TRFK306	58.6	13.4	1.7	20.4	4.2	1.7
SFS150	59.3	13.7	1.1	21.0	4.1	0.8
Mean	58.7	13.6	1.9	21.2	3.3	1.3
CV (%)	5.1	8.9	43.4	5.0	24.1	62.6
LSD	5.8	2.4	1.6	2.0	1.6	1.6

Summary of properties of Kenyan tea seed oil

Kenyan Tea (*Camellia sinensis*) seed oil	
Appearance	Golden yellow
Oil content (%)	16-25
Iodine value (gI_2/100 g)	86-91
Saponification value (mgKOH/g)	181-187
Free fatty acids (% oleic acid)	< 1.5
Peroxide value ($meqO_2$/kg)	< 3.5

Conclusions

- Kenyan tea seeds contain high quality oil
- The oil is stable due to characteristics shown by the markers of oxidative stability analyzed
- The oil has polyphenols and exhibit antioxidant activity which also contributes to its stability
- It is predominantly unsaturated with oleic acid being predominant (56 – 60 %)
- Clonal variations in the physico-chemical parameters assayed were evident
- These process has by-products : **husks and cake**

Recommendations

- Effects of **dehydration** and **extraction** methods (pressing, sohxlet, sonication, S-CO2) in oil yield and quality should be carried out
- **Acceptability** and **palatability** tests should be carried out on Kenyan tea seed oil to ascertain its use
- Extensive **G×E trials** should be done based on which best clones with respect to seed production and oil yield can be picked for commercialization purposes in different industrial sectors (cooking, soap and detergent, oil, furnishes and paints, among others)
- The **physico-chemical** characteristics of the **by-products** of this process should be extensively assayed for possible recommendations on potential uses (organic manure, mushroom production, chicken and livestock feed among others)

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