The current issue and full text archive of this journal is available at
www.emeraldinsight.com/2042-5945.htm

Developing local processing technology for black and green tea and evaluation of conformance to ISO standard

Olusegun Aroyeun, Gerald Iremiren, Samuel Omolaja, Feyisara Abiodun Okelana, Olayiwola Olubamiwa, R.R. Ipinmoroti, Amos Oloyede, Semiu Ogunwolu Olalekan, Daniel Andrew and Christiana Olayinka Jayeola
Cocoa Research Institute of Nigeria, Ibadan, Nigeria
Fatai Abiola Sowunmi
Department of Agricultural Economics, Lagos State University, Ojo, Nigeria, and
Lukman Ola Odumbaku
Moshood Abiola Polytechnic, Abeokuta, Nigeria

Abstract

Purpose – The purpose of this paper is to describe a project designed with the aim of developing a black and green tea processing technology for Nigerian farmers and evaluate the conformance of the quality of the processed tea to the recommended international standard.

Design/methodology/approach – Locally processed and graded black teas were collected from Kakara and Bangoba for analysis. Different grades analyzed were Dust 1, Pekoe fanning (PF), broken pekoe (BP) and Fibre. Green tea was also processed from 21 tea clones selected from the Cocoa Research Institute, Kusuku Station tea plantation located at 1,840 m above mean sea level and analyzed for quality characteristics. The methods used for the quality of black and green teas analysis were in accordance with ISO standard: ISO 9768 method (revised) was used for determining % water extract, ISO 5498 for crude fibre, ISO 1575 for % total ash, and ISO 1577 for acid insoluble ash. Other additional quality parameters evaluated for black tea were theaflavins (TF), thearubigins (TR) and colour brightness (C Br) from another set of 17 clones using flavonost methods. Conformance to ISO standard were assessed in all tea locally processed by the farmers, in comparison to the ones processed under controlled conditions.

Findings – The results obtained in this study revealed that 59.2 per cent of the tea analyzed conformed to ISO 9768, 81.5 per cent to ISO 5498, 77.8 per cent to ISO 1575 and 96.3 per cent to ISO 1576 and 100 per cent conformed to ISO 1577 and 85.2 per cent to ISO 1578 respectively. In all, only 33 per cent of the processed tea conformed to international standard for black or green tea physical parameters. As for black tea, clones which conformed to correct TF, TR, CBR are UNK, 367, 19, 74, 354, 368, 369, 353, 357, 143, 14 and 108 respectively.

Practical implications – The paper shows that production of green tea and black tea can be done locally without loss of quality if good manufacturing practices and hygiene practices are followed.

Originality/value – The use of clonal materials sourced locally that conformed to ISO standard from Nigeria could create new products (black and green tea) with high economic values to the farmers.

Keywords Nigeria, Agriculture, Tea, Food technology, Quality standards, ISO, Tea quality, Theaflavins, Thearubigins, Colour brightness, Conformance

Paper type Research paper

World Journal of Science, Technology and Sustainable Development
Vol. 9 No. 4, 2012
pp. 317-324

2042-5945
DOI 10.1108/20425941211271513

Introduction

Tea beverages (from *Cammelia sinensis*, L.O. Kuntze) have been claimed to be the most widely consumed drinks after water (Owuor *et al.*, 2008). Due to the large demand, commercial production of the plant has been reported from as far as 49°N outer Carpathian in the former Soviet Union to as far as 33°S, Natal, South Africa (Shoubo, 1989) and from altitudes ranging from sea level in Kenya and Rwanda. The plant is adaptable to environment with large climatic variations. These variation in environment and growing condition are thought to cause variations in tea quality. The production of tea in Nigeria is carried out by Nigerian Beverage Production Company (NBPC), located on the Mambilla highland (1,430 m above sea level) and the fresh tea leaves used as raw materials for the production of tea is supplied by the farmers whose number is averagely 2,700, the membership cut across all the communities on the highland. Recently, the NBPC which is the only tea processing company could not utilize all the fresh leaves supplied by farmers due to low production capacity of their Lawrie Tea Processor and such farmers' tea leaves became wasted and their dependants' started to suffer because of inability to sell their farm produce. This led to mass movement from tea farming to arable farming as farmers began to experience poor eating habits, lack of health care, no training of children and standard of leaving dropped drastically. In order to reduce poverty due to this problem, this project was designed to study the effect of local tea processing on quality standard of black and green tea locally produced in Nigeria. By so doing farmers can be educated on the proper ways of processing their tea locally without necessarily jeopardizing quality.

Materials and methods

Fresh tea leaves were obtained from Mambilla Highland, Nigeria. The tea plantation was located at 1,430-1,840 m above mean sea level. The plantation belonged to the Cocoa Research Institute of Nigeria, Ibadan, Kusuku, Mambilla. The tea (green and black tea) were processed locally. The black tea were produced using orthodox method while green tea were processed using Chinese methods namely: plucking (1 + 1), withering, fixing (pan firing), rolling and drying using conventional oven. The 21 clonal materials were processed into green tea while 13 clones were processed into black tea using orthodox method. The morphological parameters of all the clonal tea materials were shown in Table I. The 21 fresh tea leaves were processed into green tea leaves comprising of 14 clonal materials obtained from tea germplasm plots which include: clone 228, 318, 68, 35, 61, 363, UNK, 367, 143, 357, 19, 25, 74 and 354 while the tea clones used in black tea processing were: UNK, 367, 19, 74, 354, 368, 369, 353, 357, 143, 14, 238 and 108. Clone 318 was also divided into two, 318 LL1/2 was a lowland variety for black tea processing (1 + 2) and (1 + 1) of the same clone for green tea production. Another clone 236 was also divided into two: 236 (sole) and 236 intercropped with eucalyptus. Clone 318 were processed using Japanese methods (plucking, withering, steaming and drying). Clone 228 was processed using Chinese method (plucking, withering, fixing, rolling and drying). Other tea analysed were China tea, grown in Nigeria and natural hybrid tea. Some other tea samples were collected after processing and grading from farmers in Kakara and Bangoba which are different green tea producing communities on the Mambilla Highland, Nigeria. The tea collected were of different grades namely, Dust 1, pekoe fanning (PF), broken pekoe (BP) and fibre, all from Kakara while only BP was collected from Bangoba. In all, the total, the total samples used were 21.

Table I. Morphological description of 24 tea clonal varieties on tea germplasm plot at CRIN, Kusuku

Number	Tea clones	Shape of leaf	Leaf serration	Leaf area (cm^2)	Leaf colour	Internodes (cm)	Nature of flowering/ seed production
1	1 and 2	Small and inward curving leaves	Closed serrated	2 × 1	Dark green	1.2	Has many flowers and seeds
2	367	Curved leaves	Wider serration	10 × 5	Light green	3	Rarely with flowers
3	19	Long, curved leaves	Normal	13 × 5	Light green	6	No flowers/seeds
4	74	Long, wide opened leaves	Wider serration	16 × 7	Light green	3	Rarely with their seeds
5	354	Small orange-like curved leaves	Closed	3.3 × 1.2	Dark green	8.5	No flowers/seeds
6	368	Long leaves	Wider serration	4.5 × 6.5	Light green	7	No flowers/seeds
7	369	Zigzag edges of leaves	Closed	12 × 5	Light green	6.5	No flowers/seeds
8	353	Slightly curved leaves	Wider serration	11 × 4.5	Light green	6	No flowers/seeds
9	357	Flat round-dish leaves	Wider serration	10 × 5.5	Green	8	Less flowers/seeds
10	143	Roundish flat leaves	Normal	10 × 4.5	Green	5	With flowers/seeds
11	14	Curved long leaves	Normal	12 × 4.5	Green	5.5	No flowers
12	238	Curved leaves	Closed serration	13 × 5	Green	6	No flowers
13	25	Long curved leaves	Normal	6.5-7 cm	Light green	6.5	No flowers
14	108	Wide leaves with bending edges	Wider serration	15.5 × 6.5	Light green	7	No flowers
15	363	Curved medium size leaves	Closed serration	12 × 5	Light green	6	No flowers
16	35	Wide leaves	Normal	13 × 6	Light green to yellow	3	Rarely with flowers
17	68	Long curved leaves	Closed	11.5 × 4	Light green	6	With flowers
18	61	Orange-like leaves	Closed	11 × 4	Dark green	5	Pronounced flowers/ seeds
19	228	Small orange-like leaves	Closed	6 × 3	Light green to yellow	5	With flowers
20	236	Small flat leaves	Closed serration	10 × 5	Dark brown leaves	2	With pronounced flowers/seeds
21	318	Long curved leaves	Closed	12 × 5	Green	6	Rarely with flowers

Quality assessment

The methods used for assessing the quality of black and green tea analysis were in accordance with ISO standard as shown in Table II. ISO 5498 for crude fibre, ISO 1575 for per cent total ash, ISO 1577 for acid insoluble ash. As for black tea, the quality parameters analysed were theaflavins (TF), thearubigins (TR) and colour brightness (CBR) using Roberts and Smith (1963) methods conformance to ISO standards were measured in all the samples.

Results and discussion

According to Table I, it was observed that 59.2 per cent of the analysed tea samples conformed with ISO 9768, 81.5 per cent to ISO 5498, 77.8 per cent to ISO 1575 and 96.3 per cent to ISO 1576 and 100 per cent to ISO 1577 and 85.2 per cent to ISO 1578, respectively (Table III).

According to Table IV, the flavour components of the clone UNK, seemed to be a unique one. Its TF of 0.8145 per cent and TR of 9.5 per cent were not significantly different from black tea processed in Nyassaland with TF and TR of 0.855 and 9.5 per cent, respectively (Roberts and Smith, 1963; Owuor *et al.*, 2008). Another possible factor that can also be responsible for different contents of TF and TR as evidenced in this study is fermentation time. Black tea processed from Nigeria seemed to have high TF and TR values because of the higher fermentation time than Malawi which used 110 minutes, a fermentation time lesser than the one used in this study (120 minutes). The difference in fermentation time reflected in the values obtained for both the TF and TR of tea from Kenya, Malawi and Nigeria (Table V). The TF of Nigerian black tea was second to that of Kenya known for producing very high quality black tea in the world. The trend in their TF is in the order, Kenya (27.2 μmol/g) > Nigeria (22.3 μmol/g) > Malawi (21.5 μmol/g). Clone UNK showed a higher value than the TF reported by Roberts and Smith (1963) and for Malawi tea. Although the fermentation time used in Malawi was the same with the time used to ferment Kenyan tea, one would have expected a similar %TF similar to Malawi tea and lesser than Nigerian tea but this was not so and could be due to the differences in the clonal properties of fresh tea leaves in the processing of the black tea from the three countries. The method of black tea processing used in this study is different from the popular CTC method, yet the quality is not significantly different from some tea

Table II. Minimum chemical requirements for black and green tea

Characteristics	Requirement Black tea	Green tea	Test method
Water extract % m/m minimum	32	32	
Total ash % m/m			
Maximum	8	8	
Minimum	4	4	ISO 1575
Water soluble ash % (m/m) of total ash minimum	45	45	ISO 1576
Alkalinity of water soluble ash as KOH % (m/m)			
Minimum	1.0	1.0	
Maximum	3.0	3.0	ISO 1578
Acid insoluble ash % m/m			
Maximum	1.0	1.0	ISO 1577
Crude fibre % m/m			
Maximum	16.5	16.5	ISO 5498

Number	Tea clone	% H_20 extract	% total ash	% H_20 soluble ash	% acid insoluble ash	% alkaline insoluble ash	% crude fibre	% moisture content
1	236 under Eucalyptus	41.6	6.2	66.6	0	1.1	8.3	8.94
2	228	42	6.5	67	0	1.1	8.3	6.72
3	318	42	6.2	67	0	1.0	12.5	9.69
4	68	42	6.3	66.6	0	1.1	12.5	3.36
5	35	43.4	4.3	50	0	0.9	8.6	11.72
6	61	42	4.2	50	0	0.7	20.8	9.57
7	363	21.7	6.3	67	0	1.3	20.8	15.22
8	236(sole)	42	6.3	67	0	0.9	4.3	9.37
9	SRD 318	42	6.5	67	0	1.1	13.0	3.73
10	PRD 228	43.4	6.5	67	0	1.3	8.7	11.31
11	UNK	21.7	9.6	67	0	1.3	8.3	9.43
12	367	22.7	6.5	67	0	0.8	4.5	–
13	143	22.7	6.5	66.7	0	1.6	12.5	8.0
14	357	21.7	6.4	66.7	0	1.3	8.7	6.0
15	19	43.5	6.5	66.7	0	1.3	8.7	8.0
16	25	41.7	4.3	50	0	1.3	9.1	8.0
17	74	43.5	6.4	66.7	0	1.1	8.3	6.0
18	354	43.5	6.5	66.7	0	0.9	4.3	8.0
19	318 (LL) $2^1/2$	43.5	8.5	50.0	0	1.4	9.1	6.0
20	318 (LL) $1^1/2$	45.5	6.5	66.7	0	1.5	8.7	8.0
21	China tea	22.7	6.5	66.7	0	1.4	13.6	8.0
22	Natural hybrid tea	21.7	6.4	66.7	0	1.4	8.3	6.0
23	BT dust –1(KK)	22.7	8.9	50.0	0	1.2	4.6	10.0
24	BT (PF) (KK)	41.7	8.7	50.0	0	1.1	8.7	8.0
25	BT (BP) (KK)	22.7	6.7	66.7	0	1.3	8.7	10.0
26	BT (BP) BA	22.7	8.9	50.0	0	1.3	16.7	10.0
27	F (KK)	22.7	15.9	28.6	0	1.0	18.2	12.0

Notes: BT, black tea; PF, pekoe fanning; BP, broken pekoe; KK, Kakara; BA, Bangoba; F, fibre; LL, low land; SRD, steaming, rolling and drying; PRD, pan fixing, rolling and drying

Table III.
Chemical components of processed black and green tea in Nigeria

Number	Clone	%TF	%TR	%TF: %TR
1	UNK	0.8145	9.5	0.08
2	367	0.374	8.35	0.05
3	19	0.36	7.40	0.05
4	74	0.558	12.82	0.05
5	354	1.001	9.05	0.11
6	368	1.823	9.16	0.20
7	369	0.207	17.40	0.01
8	353	0.196	5.29	0.04
9	357	0.45	7.59	0.06
10	143	0.997	16.39	0.06
11	14	0.306	9.48	0.03
12	238	0.997	10.95	0.09
13	108	0.198	8.85	0.02

Notes: $\%TF = 6.25 \times E_c \times f_1$; $\%TR = 12E_D + 6.25(E_A - E_c) \times f_2$

Table IV.
Clonal variation in the theaflavin and thearubigin contents of black teas

processed using CTC method. The $E_{380}//E_{460}$ ratio of CTC processed tea is a good index of quality and the tea processed in Nigeria did not differ significantly from the ratio of CTC manufactured BP grade in NE India. Some values of TF and TR are also considered as query grade due to their high TF or TR values when compared to the normal good grade values (Roberts and Smith, 1963). Clone 368 with TF of 18.3 per cent was considered a query grade since its value is higher than query grade black tea of 1.63 per cent TF from South India as reported by Roberts and Smith (1963). This could be due to analytical error or some errors during the analysis might have been responsible for the exaggerated values obtained. The value of the TF and TR of black tea used in this study are not significantly different from tea from other countries like India and Sri Lanka producing Ceylon tea. The %TR of black tea in Nigeria was not significantly different from medium quality tea from Sri Lanka. Clone 19 with TF of 0.36 per cent is also not significantly different from BP grade of Ceylon tea. As for the TR of the same clone 19 (7.4 per cent), its value is also similar to %TR of query grade of tobacco cut manufactured black tea from South India. Some of the quality values for black tea in Nigeria like TF and TR also compared favourably well with tea from Russia. Clone 14 TF (0.31 per cent) and TR (9.48 per cent) were not significantly different from a sample of black tea from Russia having TF of 0.33 per cent (TR, 9.5 per cent), a quality regarded as plain tea. The CBR of clone 14 (15.9 per cent) can compare favourably well with CBR of tea conventionally processed in Nyassland with CBR value of 18.8 per cent which was prepared with distilled water. This indicated that water used in the preparation of tea infusion can have a significant influence on the characteristics CBR of tea. Its CBR is also not significantly different from Assam orange pekoe prepared with main water (15.0 per cent). Clone 143 also followed this trend in CBR of 18.7 per cent). Clone 143 and 238 with TF of 0.97 per cent are not significantly different from CTC manufactured tea (PF grade) having 1.0 per cent TF and 16.39 per cent TR. These values were obtained after 120 minutes fermentation of the CTC manufactured tea which seemed to be similar to the fermentation time used in this study. When comparing black tea produced in China, the TF of Nigerian clone 357 used in this study is higher (0.45 per cent) than Lapsong Sonchoung (0.19 per cent) without significant differences in TR clone 357 having 7.59 per cent and Lapsoung Souchoung 7.8 per cent. Clone 108 and 353 have TF of 0.196 per cent which is favourably comparable with Lapsong Sonchoung from China.

Table V.
Comparison of quality of black tea from Nigeria to other tea from other tea producing countries of the world due to fermentation time

Particular	Source	Fermentation time (minutes)
Theaflavin (μmol/g)		
27.2	Kenya	110
21.5	Malawi	110
22.3	Nigeria	120
Thearubigin (%)		
15.5	Kenya	110
9.21	Malawi	110
10.04	Nigeria	120
Brightness (%)		
25.8	Kenya	110
22.5	Malawi	110
15.7	Nigeria	120

Conclusion

This study has established the conformance of both green and black tea produced from Nigeria to international standard and the quality of the black tea can compare favourably well with qualities of black tea from some other leading black tea processing of the world such as India, Sri Lanka, India, Nyassaland, Russia and China amongst others.

References

Owuor, P.O., Obanda, M., Hastings, E.N. and Wilson, L.M. (2008), "Influence of region of production on clonal black tea chemical characteristics", *Food Chemistry*, Vol. 108, pp. 263-71.

Roberts, E.A.H. and Smith, R.E. (1963), "Phenolic substances of manufactured tea II. Spectrophotometric evaluation of tea liquors", *Journal of the Science of Food and Agriculture*, Vol. 14, pp. 889-900.

Shoubo, H. (1989), "Meterology of the tea plant in China. A review", *Agriculture and Forestry Meterology*, Vol. 47, pp. 19-30.

About the authors

Olusegun Aroyeun assumed duty at the Cocoa Research Institute of Nigeria in 1999. Earlier, between 1995 and 1998, he taught Chemistry and Mathematics at the Premier Grammar School, in Abeokuta, Ogun state. At the Cocoa Research Institute of Nigeria Aroyeun attained the rank of Chief Research Officer in the Crop Processing Unit of CRIN in 2009, under the Product Development programme. He completed his PhD in the Department of Food Technology at the University of Ibadan, Nigeria. He won two international awards on tea in 2004 and 2007 in Shizouka Japan. He is an international scientist who has presented papers in various countries, including Hungary, Italy, China, South Africa, Japan and most currently the USA. He is a prolific writer and has many international journal papers to his credit. He is currently the Head of Station of the Cocoa Research Institute of Nigeria, Kusuku, Mambilla. Olusegun Aroyeun is the corresponding author and can be contacted at: aroyeun2000@yahoo.co.uk

Gerald Iremiren is the former Executive Director of the Cocoa Research Institute of Nigeria, Ibadan. He is a Professor of Agronomy who has taught at different Universities, such as the University of Benin and the Federal University of Technology Akure. He is also a former Commissioner of Agriculture in Edo State.

Samuel Omolaja is an Assistant Director at the Cocoa Research Institute of Nigeria and Technical adviser to the Executive Director. He is a plant breeder of an international standard and the Head of Group, Plant Breeding and the programme leader of the Tea programme.

Feyisara Abiodun Okelana is the present Acting Executive Director/Chief Executive Officer of the Cocoa Research Institute of Nigeria, Ibadan. She is an entomologist and a brilliant research scientist on coffee and tea entomology.

Olayiwola Olubamiwa is the Director (Research) at the Cocoa Research Institute of Nigeria and the Head of Department of Product Development. He is a seasoned Scientist in Biochemistry/Nutrition. He has many international journal articles to his credit and is a widely travelled man who has presented papers in various international forums.

R.R. Ipinmoroti is an international scientist of high repute who did his PhD on Tea. He undertook his post doctoral fellowship programme in Japan, under JIRCAS. He is the Head of Station at the Cocoa Research Institute of Nigeria, Uhomora, Edo State, Nigeria. He has attended many international conferences to present research papers.

Amos Oloyede is an Agronom in the Agronomy group of the Cocoa Research Institute of Nigeria. He works extensively on the agronomy of cocoa kola, coffee and tea. He is the acting Coordinator of the National Cocoa Seed Garden Project of the Federal Government of Nigeria.

Semiu Ogunwolu Olalekan is a PhD holder in Food Processing/Preservation Technology. He has many scholarly papers in Chocolate Research and has a wide research experience in cashew processing technology and cocoa processing.

Daniel Andrew is a Soil Scientist at the Cocoa Research Institute of Nigeria. He is a Research scientist working on cocoa, coffee and tea. He has worked extensively on soil fertility.

Christiana Olayinka Jayeola is currently the Head of Division, Crop Processing and Utilization Unit and the Programme Leader of the Product Development Programme. She has wide international experience on cocoa processing, cashew processing, kola processing and coffee processing.

Fatai Abiola Sowunmi is a Lecturer at the Lagos State University Ojo, Lagos State, Nigeria. He is an Agricultural Economist and a doctoral student at the University of Ibadan, Nigeria. He has many international journal articles to his credit.

Lukman Ola Odumbaku is a PhD student at the University of Agriculture, Abeokuta, Ogun State in the Department of Food Science and Technology. He lectures at the Moshood Abiola Polytechnic, Abeokuta, Ogun state in the Food Technology department.