

Recent advances in tea research

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INTRODUCTION

The presentation brought out the importance of tea in Kenya as a cash crop. The presenter laid emphasis on tea as a source of livelihood (directly and indirectly) to over five million Kenyans and dependants. Tea contributes to national economy (export earnings, 1st at 26% was Ksh 114 billion; USD\$1.2 million or 7% GDP). In addition, it was stated that tea is a rural based industry; contributing to rural poverty alleviation and value chain (cultivation-consumption).

The main players in research and extension in Kenyan tea sector include: i) Tea Research Institute, which is mandated to do research and development and funded by Kenya Tea Sector; ii) Kenya Tea Growers Associations, have technical departments such as JFK (ARD), Unilever (Research and Development), Eastern Produce Kenya Technical Department (TD); iii) Kenya Tea Development Agency (which has Research and Development Department); iv) AFFA: Tea Directorate, the regulatory body and has Technical, Marketing Services, Research and Extension); v) KETEPA is in charge of blending, packing, marketing (research); and vi) Nyayo Tea Zones Development, a corporation that deal with production and conservation.

HISTORY OF TEA RESEARCH

Research in tea was initiated by Brooke Bond Liebig Company Limited in 1949 within the African Tea Holdings Limited in Kericho. It served the whole of the Kenyan Tea Industry, and later the East Africa region. The department was taken over by East African Tea Growers and renamed TRIEA in 1951, thereafter registered in Uganda in 1957 and Tanzania in 1959. In 1977 the East African Community broke up. In 1980, the Government of Kenya, through the Tea Board of Kenya, took over the institute and established it as Tea Research Foundation of Kenya. In July 2014, the institute was renamed Tea Research Institute (TRI) under the Kenya Agricultural and Livestock Research Organization (KALRO).

FUNDING OF RESEARCH IN TEA

The funding of Tea Research Institute is stipulated in the Tea Act, CAP 343, and Legal Notice No. 331 of 1994. The funds are obtained from production cess or levy at 46 cents per kilogram which should be shared equally between Tea Directorate (regulatory and marketing body) and Tea Research Institute (research).

Currently Tea (Amendment) Act 2011, No. 4 of 2011 (gazetted on 22nd March 2011) introduced Advalorem Levy, which was assented on 21st March 2011 and date of commencement was 22nd March 2011 through Advalorem Levy Regulations by Minister of Agriculture Gazette Notice under Kenya Gazette Supplement No. 3 of 27th January 2012. The Advalorem Levy is 1% of value of all made tea at point of export or import. The effective date of implementation was 28th February 2012. The sharing ratio as follows: (i) TD 50%, (ii) TRI 40%, and (iii) 10% development and infrastructure for the Tea Industry.

TEA RESEARCH DEVELOPMENT IN KENYA AND THE EAST AFRICA REGION SINCE 1980

The Tea Research Institute of East Africa was established and operated between 1951 and 1979 with its headquarters at Kericho; and two research stations in Uganda at Rwebitaba (no longer in

existence) and Tanzania at Mirikitanda (now a lean Tea Research Institute of Tanzania, TRIT). It is important to note that elsewhere in Africa, the Tea Research Foundation in Central Africa collapsed in the mid-1990s due to funding problems and minimal activity.

In 2005, a five-year strategic plan was developed in Kenya to offer a vision for the future direction of the Tea Industry and to identify, in a participatory manner, priority areas of research and development. Currently Tea Research Institute Strategic Plan (2010-2015) is aligned to Kenya Vision 2030, Medium Term Plan II. The main areas of focus being: (i) Different programmes such as: developing and availing high yielding and quality tea; suitable tea varieties for diversified tea products; information on improved tea varieties, production and leaf handling technologies; and technologies for sustainable management of tea genetic resources (collection, diversity). Today, significant improvement of crop yields and production have been released with production of 50 commercial clones with an average yield potential of up to 8000 kg mt/hectare. (ii) Developing and availing best practices in tea manufacture: factory manuals; standards (MRLs, quality); profiling Kenyan tea (quality, health and nutritional parameters); Compliance standards to GMP and the Tea Standard ISO 3720; market potential/needs for new tea products; technologies for tea products diversification; technologies for product branding; and packaging technologies.

HEALTH BENEFIT OF TEA AND TEA PRODUCTS

Tea health benefits include: Hypertension suppression, diabetes lowering, anti-microbial, anti-allergy (anti-histamine), anti-carcinogenic (antioxidant activities neutralising free radicals moderating aging), dietary values (vitamins /minerals), and natural food colours. Specifically, the benefits are enumerated here below.

Kenya's purple tea is rich in anthocyanins

Kenya's purple tea is rich in anthocyanins, non-chlorophyll pigments, whose functions are: serve as antioxidants against environmental oxidative stress; elevate leaf temperatures in cold seasons, for instance, winter; protect cells against UV-B irradiation, pests and herbivores; and, provide beautiful coloration in flowers (tulips, roses, hibiscus, and jacaranda) and leaf coloration in autumn (fall).

Potential for tea product diversification using anthocyanin rich tea varieties

Malvidin are the major anthocyanin compounds in purple tea whose basic structure is the flavylium cation. Purple tea contains six major anthocyanins including: cyanidin, peonidin, petunidin, pelargonidin, delphinidin and malvidin. The predominant anthocyanin in CTC processed tea is malvidin. The variety TRFK 306 contains the highest amount of anthocyanins. The tea anthocyanins can be used in food colorants (confectioneries, toppings, ice-creams, jams), functional foods (beer, juices, wines); and nutraceutical (probiotic yoghurt).

Potential health benefits of tea anthocyanins and catechins

Reactive oxygen species (ROS) are produced in the body as a result of food intake, metabolism, exposure to mutagens and carcinogens. Imbalance between ROS and their detoxification results in oxidative stress (OS) which causes degenerative diseases, cancer and triggers apoptosis. The body has innate antioxidants, for instance, glutathione (GSH), which is rapidly depleted under excess OS. Lactate dehydrogenase (LDH) is an enzyme marker of OS which increases under increased OS and vice versa. An *in vitro* study was carried out to determine the effects of pure catechin (EGCG) and tea anthocyanin extract from cultivar TRFK 306 on t-Butylhydroperoxide (t-BHP) induced oxidatively stressed human kidney (HEK 293) cells.

Epigallocatechin gallate (EGCG) and tea anthocyanin extract significantly ($P < 0.001$) attenuated t-BHP induced LDH leakage and increased GSH levels in a concentration dependent manner

in treated cells. Anthocyanin rich tea from selected Kenyan cultivars may have cytoprotective effects against oxidative stressors.

Tea catechins and anthocyanins improve the integrity of cell membranes. Anthocyanin rich tea has cytoprotective effects against induced oxidative stress. Catechins and anthocyanins are dietary antioxidants which function as free radical scavengers. Tea anthocyanins do not cause oxidative stress (pro-oxidants) even in high concentrations. Therefore it is important to take tea for good health.

Antibacterial and synergistic properties of Kenyan Tea

Emerging scientific data from pharmacological and physiological studies continue to show that tea has beneficial effects on human health. Numerous environmental-friendly industrial cleaning agents, deodorizers and antimicrobial agents can be formulated using green tea. The tea grown in Kenya has been shown to have higher levels of polyphenols compared to that grown in Asia. Therefore, Kenyan tea can potentially be a good ingredient in many fast moving consumer goods. Kenyan tea was assayed for its antimicrobial activity. Effects of tea on MRSA ATCC 25923: TRFK 73/1 black tea (15), TRFK K purple black tea (16), AHP S15/10 white tea (17), BBK 35 black tea (18), TRFK 73/1 green tea (19), and TRFK 306/3 black tea (20). Chloramphenicol (positive standard control). MRSA ATCC 25923 was susceptible to the tea extracts.

Kenyan tea extracts and antibiotics can be used concurrently in combination to manage infections caused by Methicillin resistant *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922 and a clinical isolate of *Salmonella typhi*. Concomitant consumption of Kenyan tea extracts and antibacterial drug does not impair with the antibacterial activity of penicillin G and ampicillin. Kenyan tea extracts can be used as a household cleaner, for instance, they are potential as surface antibacterial agents (sanitiser).

Antifungal properties of Kenyan tea

Candida albicans, a fungus of the oral cavity and gastrointestinal tract in humans, represents one of the major causes of mucosal infection and systemic infection, which can be life threatening if not treated. *Cryptococcus neoformans* is a fungus which causes meningitis in immunocompromised individuals. With limited availability of antifungal drugs and the increasing incidence of opportunistic fungal infections, the emergence of drug resistance in fungal pathogens poses a serious public health concern. In this study Kenyan tea extracts were assayed for antifungal properties.

Minimum inhibitory concentrations for tea extracts against *C. albicans* ATCC 90028.

For instance, TRFK 303/577 black tea (1), Hanlu green tea (2), TRFK 306/3 purple coloured leaf un-aerated tea (3), Yabukita green tea (4), AHP S15/10 black tea (5), AHP S15/10 black tea buds (6), TRFK 6/8 black tea (7), Nystatin (positive standard control). Kenyan tea extracts have antifungal properties. *C. albicans* ATCC 90028 and *C. neoformans* were susceptible to tea extracts. Kenyan tea extracts can be used in management of fungal infections caused by *C. albicans* ATCC 90028 and a clinical isolate of *C. neoformans*. Polyphenols from Kenyan tea extracts can be used in formulation of body shampoos, soaps and other cosmetic products to manage fungal infections.

CONCLUSION AND WAY FORWARD

TRI (SEMC) Programme has addressed such as: agronomic practices for sustainable management; environmentally friendly energy sources; environmental auditing / conservation

of ecosystem; climate change (assess impacts); adaptation and mitigation strategies; promoting farm forestry practices; good agricultural practices; and plant nutrition.

The (EFACC) Programme has addressed areas including: evaluating technologies for appropriateness and cost effectiveness; packaging technologies appropriately for end users; developing and deploying appropriate technology transfer tools; disseminating appropriate technologies to end users; evaluating effectiveness of technology transfer tools; assessing uptake and impacts of developed technologies; conducting market research for developed technologies and providing technology backstopping to the research programmes; priority setting for technology transfer; and conducting outreach programmes.

TRI research dissemination is channelled through different tea publications such as: *Tea Growers Handbook*; *Annual Technical Reports*; *Tea Journal* (July and December); TRFK quarterly bulletins-technical handbooks/manuals; topical pamphlets and fliers/circulars; and TRI seminar proceedings (quarterly). The papers are in addition to Tea Directorate publications including: *Tea News* (quarterly); *TBK Statistics* (pamphlets); and *International Tea Committee-Annual Bulletin of Statistics*.

TRI has entered into broad areas of collaboration including; biotechnology; tea management; processing, packaging, value addition; socio-economics; technologies on machinery (harvesting, processing, packaging); management of pest and diseases; research into human health aspects of tea; environment; collaboration and capacity building (post doctorate, internships, among others); agricultural technology databank and the dissemination (workshops, extension services); clinical research on pharmacological value of different tea products; and consultancy.

TRI has identify the following threats to Kenyan tea: overproduction (GAP) (exports 95%, consumption 5%); overreliance on black CTC; high cost of tea production (labour, agricultural inputs, transport and energy); blending of Kenyan tea with cheap poor quality tea from other countries; non-drinking of tea among the youth; declining world tea prices; and high currency fluctuation (reduced income), among others.

There are many opportunities for Kenyan tea which include: consistency of high quality tea; ready availability of tea (wide region); all year production; Kenyan clones/varieties contain high levels of total polyphenols; health benefit of tea polyphenols; catechins, anthocyanins; and exporters use of research findings to enhance the value of the Kenyan tea.

Tea product diversification can be achieved through process adjustments to alter the traditional black CTC tea to produce green tea, oolong tea, and silver tips (white tea which are highly priced).

Tea branding and chemical profiling is done in various ways such as use of factory mark of origin (“garden mark”); geographical description “seasons and altitude”; profiling for tea constituents (total polyphenols, total catechins, total soluble solids, anthocyanins, antioxidant activity and catechins of special interest) and speciality tea (for example organic) or (selectively hand plucked tea, two leaves and a bud).

The current priority areas of research and service to the Tea Industry include: availing elite (high yielding and quality); availing low cost technologies; diversification (types: organic tea, purple, and silver tips, among others, and products such as oolong, green, orthodox, soap, biscuits, cakes, shampoos, and tea wines, among others, and value addition; branding of Kenyan tea (tea quality profiling); analysis (soil, leaf tissue, fertilizer/manures; DNA profiling; pest and disease identification); training and research; and technical advisory services.

In conclusion, the following questions require answers: What is the real value of tea to farmers? What can be done to improve? What does the customer want? Are you able to retain her or him? Processing? Marketing? and, What is your role?