Industrial Utilization of Tea Extract

Dr. T. Takeo*

Abstract

The paper deals with growing industrial utilization of tea extract, which is a new product. Utilization of tea extract in several areas such as dye, deodorant, sterilization agent and medical agent have been developed. Antioxidant activity of catechins that occur in green tea leaves has been seen to be effective. As a preserving agent of fatty and raw food tea extract dyed cloth shows attractive colour and possessed properties of microbial growth inhibition as also deodorant properties, In Japan T-shirts, underwears, etc, are treated with tea extract, tea extract has been shown to have inhibiting effect on *S. mutans* and is utilized for dental care. Other uses include pharmacy, food items, *etc.* Other claims include that tea extract and anti-inflammatory properties.

1. Introduction

In the last 15 years the utilization pattern of tea extracts has grown worldwide. The utilization of tea extracts in several substances such as dye, detergent, deodorants and anti-carries agents for tooth have been developed. It has also been claimed as a chemopreventive agent for cancer and a cure for cardiovascular and inflammatory diseases.

2. The Technology of Tea Extract Powder Production

2.1. The starting point of the tea extract powder is made tea. Green tea leaves are also used in India. These materials of low-grade tea shoots and tea waste utilization naturally have economic benefits. The method of production is as follows: (Fig. 1) (Yayabe, 1989)

Experiments are generally made with hot water (sometimes aqueous ethanol). Tea leaves are infused by about 20-30 times w/w of hot water at 80-90°C for 5 minutes. This is followed by separation, centrifugation and concentration (30-40%) followed by spray-drying. Green tea extract powder made by this process is graded as tea Polyphenol 30. It is stated that this extracts about 25-30% of green tea polyphenol and around 20% of catechins (Table1). It is claimed that the green tea extracts made this way are commercially accepted by users.

* Director, Central Research Institute, IT-OEN Ltd., Mekami 21, Sagara-Cho Haibara-gun, Shizuoka 421.05, Japan.

2.2. The Preparation of High Grade Green Tea Extracts

Column chromatography technique is also practiced (Fig. 1). Tea Polyphenol 60 and 90 that have high content of tea polyphenol are produced from the tea Polyphenol 30. In this process green tea polyphenols are absorbed on artificial resin column such as hydrophilic, vinyl-copolymer, styrene-vinyl-benzene and metacrylate resins. Other elements dissolve in green tea extracts are polysaccharides, amino-acids and caffeine which are not absorbed on column and washed out by water. Then the tea polyphenol fraction is eluted out by aqueous ethanol (30-60% concentration). On this purification process, only pure ethanol is used as an elution solvent. The purified tea polyphenol is made into a powder by spray drier. The properties of tea polyphenol 60 and 90 powders are summarized in Table 1. These tea polyphenol products are used as ingredients for supplementary foods.

3. Use of Green Tea Extracts

3.1. Use as Antioxidative Agent

Tea catechins in green tea extract have strong antioxidation activity, especially epigallocatechin-gallate shows about 10 times higher antioxidation activity for lionoleic acid and also vegetables or animal fats than those of α-tocopherol and BHA (Fig. 2) (Matsuzaki, 1985). Recently the aqueous solution of green tea extracts have been used as purifying agents of fatty or raw foods, such as sausage, ham or raw fish by coatings on these

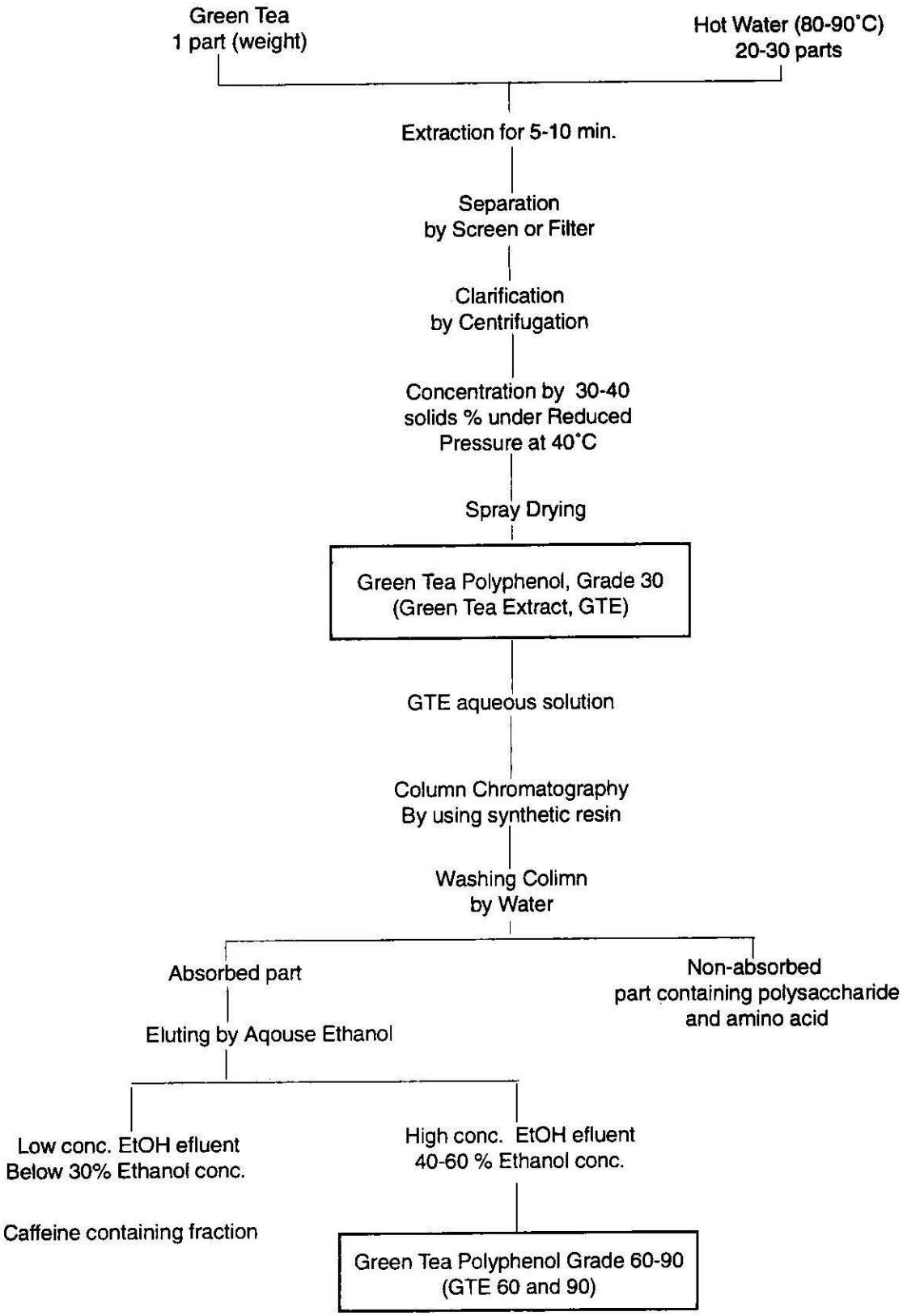

Fig. 1: The Flow Sheet of Production Process for Manufacture of Green Tea Extract

Table 1: Composition of Green tea Polyphenol (% dry weight)

		Total polyphenol	Total Catechin	EC	EGC	ECg	EGCg	Caffeine
Green Tea polyphenol	30	24	24	2	8	1	13	4
	60	60	48	5	5	9	29	13
	90	93	83	trace	trace	6	77	0.1

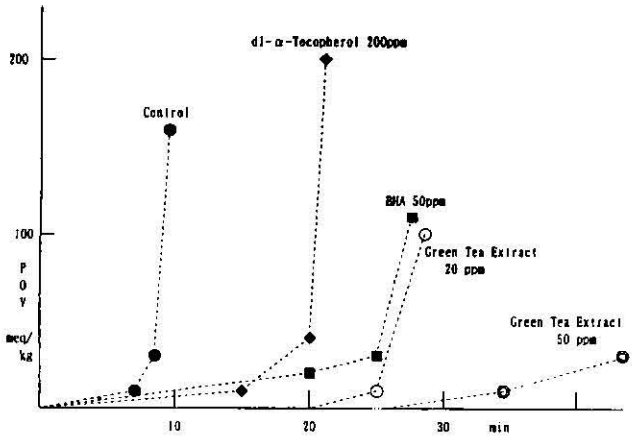

Fig. 2 Antioxidative Activity of Green Tea Extract on lard by AOM Test at 97.8°C

surfaces at processing and drying stage as an antioxidant.

3.2. Use as Dye and Deodorant Agent

Wood, silk, synthetic resin yarn are also dyed in green tea extract aqueous solutions (1:20) containing 10% tea polyphenol 30 with metal-mordant at 60°C for 6 hours. After washing the dyed yarns with water, the weight of the yarn increases from 3-5%. By using several kinds of metal-mordant, the colour of the yarn changes to pale-green, yellow-green, yellow and brown. Even after repeated washing it could be seen that the coloured yarn was maintained for at least one year.

The characteristics of green tea extracts dyed yarn are as follows:

1. Effective deodorant activities with trimethyl-amine, methylmercaptan, hydrogen-sulphide and ammonia gas. The results are shown in Table 2.

2. Sterilization effect on bacteria, such as *E. coli*, *S. aureus*, *K. pheumoniae*, *C. albicans*, and *fungi like T. rubrum* and *M. audouini* which cause trichophylosis (Table 3).

Each odor substance and yarn were sealed in a small vessel and odor concentration in a headspace of vessel was determined by gas chromatography.

It has been shown that tea extract dye cloths or garments made from it like T-shirt, W-shirt, blouse and socks made of yarn dyed with green tea extract are not susceptible to infection with micro-organisms and possess strong deodorant effects for smells caused by sweat. These are sold in the Japanese fashion market. Further, green tea extracts dyed cloths is especially prepared as underwear or overwear for patients in Japanese hospital.

3.3 Use as a Cleaning Detergent

It has been known from past experience that tea extract has the ability to wash away oily substances. Ozone layer destruction by Freon gas (Chloro-Fluoro-Carbon, CFC) used as cleaning gas is

Table 2: The Deodorant Effect of Dying Yarn with Green Tea Extract

	Incubation Period (min)		
	0	30	60
	Odor	Concentraction	(ppm)
Trimethylamine	20	5	0
Methylmercaptane	10	3	3
Hydrogen sulfide	30	3	0
Ammonia	400	150	100

Table 3: The Sterlization Effect of Dying Fiber with Green Tea Extract

	Cell number/ ml	
	Start	180 min
BACTRIA		
Staphlococcus aureus	10^7	$>10^1$
Escherichia coil	10^7	$>10^1$
Methicillin Resistance S. aureus (MRSA)	10^6	$>10^1$
FUNGI		
Trchophyton rubrum	10^5	$>10^1$
Mucor audouini	10^6	$>10^1$

Culture condition: 30°C

becoming a problem for environment. In Japanese electronic industry, new detergents are being investigated as substitute for Freon gas. The advantages of Oolong tea extract are: (1) A non-organic and eco-friendly substance whose waste is easily disposable; (2) The detergent is safe, non-toxic and non-inflammable; (3) For washing oily fabrics, this is a good detergent.

3.4 Use in Dental Care

These catechins have strong inhibitory effect on *S. mutans*, which causes caricus tooth. The minimal inhibitory concentration of epigallocatechin gallate in concentration of 50-100 µgm per ml as shown in Table 4 (Hattori, 1990). In the concentration of 20 mg per ml of green tea extract powder, the number of *S. mutans* are decreased from 10^7 to 10^2 for 3 minutes. From these results, it is claimed that foods or water containing 0.1% of green tea extract are effective as tooth care.

Dental plaque is caused by deposition of extra-cellular glucan produced from sugar in foods by glucosyltransferase of *S. mutans* (Hattori, 1990). The deposition of dental plaques on the wall of tooth makes dorms where anaerobic bacteria like *P. gingivalis* grows and lactic acid as a metabolite is accumulated. Peridontal diseases are caused through this process (Kakuta, 1994). As shown in Table 4, catechins inhibit the presence of anaerobic bacteria in mouth. By mouth washing three times in a day with green tea extract, aqueous solution containing 0.25% of tea polyphenol, the deposition of

Table 4: The Minimal Inhibitory Concentration (MIC) of Green Tea Catechin (EGCg) for *S. mutans* and Periodontopathic bacteria

	MIC (mg/ml)
S. mutans[3)]	0.05-0.1
P. gingivalis[5)]	5.0
A. viscosus[5)]	1.0
P. thetaiotaomicron[5)]	0.25
P. fluorescens[5)]	0.05
C. gingivalis[5)]	0.5

bacterial difficulty is effectively disposed (Kaneko, 1993). Oolong tea extract also shows the high activity on the prevention of oral plaque deposition (Nakahara, 1993). The decrease of the deposition of dental plaque is useful to project teeth from periodical diseases and also to keep the mouth clean by decreasing mouth odour formed in dental plaque dorms (Unno, 1996).

In recent years green tea extracts have been marketed in Japan for their ability to diminish mouth odour. Also candies and chewing gums containing green tea extract are sold in the confectionery market as dental care candies and tooth deodorants.

4 Use in Supplementary Foods

4.1 Anti-atherosclerosis Food

Green tea polyphenol (catechin) has an anti-hyperchloresteremic effect (Maramatsu, 1986). Dietary green tea polyphenol decreases the plasma cholesterol concentration and increases the fecal excretion of cholesterol and total lipids in high cholesterol-fed rats, as shown in Table 5. It has been revealed that orally administered extracts decreases cholesterol absorption from the wall of rat intestine by using (Ohno, 1995) C-cholesterol (Ikeda, 1992).

The formation of insoluble compound between cholesterol and ECGg, the coprecipitation of this complex from bile salt micelles, and the reduction of lymphatic absorption rate of cholesterol from intestinal wall induce decreasing of cholesterol concentrates in plasma. From these results it is considered that green tea polyphenol has an effective in prevention of hypercholesteremia. Recently, it has been recognized that orally administered catechins are absorbed through the

Table 5: Effect of Tea Catechins on Lipid Concentrations In rat (Muramatsu, 1986) Plasma and Liver

	25% Casein Food	25% Casein Food + 15% Lard	25% Casein Food + 15% Lard +1%Cholesterol	25% Casein Food +15%Lard +1%Cholesterol +2% Catechins
Plasma Total Cholesterol(mg/dl)	94.0±3	117.0±9	142.0±7	110.0±6
Plasma Free Cholesterol(mg/dl)	28.4±1.1	28.7±5.3	26.2±2.5	21.5±1.8
Plasma Cholesterol Ester(mg/dl)	65.8±2.2	87.9±6	116.0±8	88.4±4.8
HDL Cholesterol(mg/dl)	56.1±2.5	55.1±1.4	46.8±7.7	49.0±4.6
Liver Total Lipids(mg/dl)	30.8±1.4	69.9±3.9	225.0±12	104.0±2.1
Liver Cholesterol(mg/dl)	4.45±0.13	5.61±0.28	28.5±1.1	18.4±1.9
Excreted amounts of Dry Feces(mg/2days)			1.03±0.04	2.08±0.21
Ingested Total Lipid(mg/2 days)			4.91±0.22	4.01±0.23
Excreted Total Lipids (mg/2 days)			289.0±8	343±13
Ingested Cholesterol (mg/2 days)			266.0±12	223±13
Excreated Cholesterol(mg/2 days			139.0±6	217±10

wall of intestine, transported into plasma and circulates in human subjects (Unno, 1995; 1996). Furthermore, it is recognized that the anti oxidative ability of LDL (Low Density Lipoprotein) in plasma is increased by EGCg dissolved in plasma (Hirano, 1998). It is known as the French paradox that polyphenols in red wine is effective in suppressing coronary diseases in Europeans (Frankel, 1993). Green tea polyphenol is also expected to have anti-cardiovascular disease effect from its anto-hypercholesteremic effect and anti-oxidative effect on LDL in plasma similar to polyphenols in red wine.

4.2 Cancer Preventive Food

Tea receives much attention as a protective agent for prevention of cancer in human beings. In the last 30 years anti-carcinogenic effects of green tea extracts and catechins have been studies in many countries and it has revealed significant inhibitory effects against carcinogenesis in different organs such as skin, stomach, duodenum, colon, liver, pancreas and lungs which has been established by animal experiments. Further, it has been recognized that green tea extract has cancer preventive effect for stomach, colon and lungs by conducting epidemiological studies (Ohno, 1995; Zheng, 1996). From these reports it is considered that cancer preventive effects of green tea extracts in human being can be revealed not only in organ specific cancer but also in incidents of all organs as a whole.

Cancer prevention effect of green tea extract has not been studied adequately in human beings. Recently some systematic studies and an intervention study in human cancer have been studied. From a study it has been observed that daily green tea consumption is associated with reduction of cancer incidents or mortality among Japanese population, as shown in Table 6 (Nakachi, 1997).

Though the mechanism of cancer prevention induced by orally administered green tea extract or catechins is not clearly established, it is considered that the radical scavenger effect of catechins uptake in the intestine of human beings may effectively inhibit the induction and prevention of cancer.

4.3 Anti-allergy and Anti-inflammatory Effects

Recently, antiseptic, anti-inflammatory (Nakazato, 1998) and anti-allergic effects (Shiosaki, 1997) of green tea extract and catechins content has been used in skin care.

Table 6: The relation between Ages of Cancer Death and Daily consumption of Green Tea

Daily Consumption of Green Tea (cups/day)		Age (Years) ≤3	4-9	≥10	All Categories
Subject	Men	66.4±1.8 (41)	69.5±1.3 (66)	70.0±1.5 (46)	68.8±0.9 (153)
	Women	67.3±2.3 (31)	70.7±1.4 (59)	75.1±2.6 (19)	70.7±1.1 (109)
	Both Sexes	66.8±1.4 (72)	70.1±0.9 (125)	71.5±1.3 (65)	69.5±0.7 (262)

( ): The Number of Cancer Deaths

Anti-allergic effect of immediate type allergy of tea extracts and catechins are shown by the Passive Cutaneous Anaphylaxis (PCA) reaction in rats as shown in Table 7. From these results it is expected that tea extracts and catechins have anti-allergic effects.

Tea Extract and tranilast were orally administrated before 60 min of the injection of antigen.

Anti-inflammatory activity of Oolong tea extract is shown by inhibitory effect on edema formation in rat hind paw induced by carageenin injection as shown in Table 8. On the basis of these results, a bathing agent from Oolong tea extract is developed and its use in atopic dermatitis have been investigated. Recent report shows that bathing in hot Oolong tea extract (5 gm of Oolong tea extract powder in 200 lt.

Table 7: Inhibitory Effect of Orally Administrated Tea Extract for PCA (Passive Cutaneous Anaplaxies) Induced in Back Skin of Rat Induced by Antibody and Antigen Reaction

Element	Dose (mg/kg)	Determination of Extracted Dye (μg)	Inhibition Ratio (%)
Water	0	8.26 ± 1.35	
Green Tea Extract	150	2.66 ± 0.31*	67.8
Oolong Tea Extract	150	3.74 ± 0.97*	54.7
Black Tea Extract	150	3.76 ± 1.00*	54.5
Tranilast	150	3.99 ± 0.92*	51.7

*: t test, $p<0.05$, compared with control (water).
Tranilast : Anti-allergy reagent.

Table 8: Effect of Soaking Treatment in Oolong Tea Extract Solution Bath on Carrageenin-induced Edema

Induced Edema Ratio (%), ratio of increasing volumes by cargreenin injection to initial volume of hind paw (Inhibition Ratio(%) compared with Water Soaking)					
Concentration of Ollong Tea Extract in Soaking Bath (ppm)	Period after Cargeenin Injection (hr) 1	2	3	4	5
0(water)	48.0± 6.8	55.9 ± 9.2	65.6 ± 7.3	56.6 ± 4.7	49.0 ± 6.8
25	31.3 ± 2.1	37.2 ± 3.4	45.9 ± 4.0	43.0 ± 5.1	38.2 ± 4.5
50	28.5 ± 4.4	39.6 ± 7.1	33.4 ± 7.7*	23.3 ± 5.5* (49)	21.3 ± 5.2** (57)
75	27.4 ± 4.1	25.3 ± 4.3	22.4 ± 4.8	19.3 ± 3.8** (65)	17.7 ± 6.2** (64)

* ** Studen's t test $p<0.05$, $p<0.01$, compared with water soaking at same period.

Table 9: Antibacterial Activity against Food Poisoning and Diarrhogenic Bacterial (S. Toad & T. Simamura; 1990)

Bacteria	Green Tea	Black Tea
Staphylococcus aureus 209 P	+++	+++
aureus ATCC 25923	++	+++
epidermidis ATCC 1228	+++	+++
salmonella typi	+	++
typhimurium TSA 2121	+	++
entertidis 37-350	-	++
Shigella flexneri 2a	-	+
Dysenteriae	++-	-
Enteroinvasive Escherichia coli (EIEC) EI-4 0124:H	-	-
Enteropathogenic *Escherichia coli* (EPEC)EP-01 0111	-	-
Enterotoxic *Escherichia coli* (ETEC) F 86352-1	-	-
Vivrio cholerae 0-1, V86 El Tor	++	+
cholerae 0-1, 569B classical	+	+
cholerae non 0-1	++	++
parahaemolyticus	+	+
fluvialis CDC 9554-78	-	-
mimicus ATCC 33653	++	++
Plesimonas shigelloides 83-640	+	+
Aeromonas sobria TAE - 217	-	++
Hydrophila TAE - 219	-	-
Yersinia enterocolitica Te - 14	+	-
Pseudomonas aeruginoas	-	-
Enterobacter cloacae ATCC 23355	-	-

+++, ++, +: Degree of inhibition -: no inhibition

of hot water, around 40°C) depresses the swelling, inflammation and itch of skin of patients from atopic dermatitis.

Also the cleaning of skin surface by warm green tea extract (3 gm of green tea extract powder in 200 lt. of warm water) shows good result on curing of diaper dermatitis in newborn.

4.4 Sterilization Effect

Catechins have effective sterilization effect for food poisioning and diarrhogenic bacteria as shown in Table 9. Specially, catechins show high sterilising effect for species of *Staphylococcus aureus*, enteroinvasive *Escherichia coli*, and *Vivrio cholerae*, etc. Catechins have inhibitory effect in the multiplication of viruses. It is well known that the multiplication of A & B type influenza viruses are effectively inhibited by rinsing out mouth with low concentration of epigallocatechin gallate (1μ gm) of black tea extract (Nakagawa, 1990).

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