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RECENT DEVELOPMENTS IN TAIWAN TEA RESEARCH

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Abstract

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Taiwan Tea Experiment Station. which was established in 1903. is the only tea research organization on the island with four branch stations. The function of the station is to: (A) Carry out breeding experiments, improvement of cultivation techniques (including soils & fertilizers, tea plant protection) and farm management. (B) Study new methods of tea processing, tea chemistry and quality. (C) Introduce tea machinery and establish the mechanical farming and irrigation system. (D) Conduct extension service of techniques for tea growers and manufacturers. Main research achievements in recent years are as follows:

1. The six newly bred tea varieties, TTES No. 12, 13, 14, 15, 16, and 17, were registered and released to growers. These new varieties are suitable for manufacture of semi-fermented (Paochong and Oolong) tea with superior characteristics of fine qualities of the made tea and high yields of fresh leaves.

2. Nutrient culture of tea cuttings in tubes with medium of vermiculite, peat moss and sand mixture have been carried out successfully with rapid growth and high percentage of rooting. The nutrient culture of tea cuttings has more advantages than traditional soil culture of tea cuttings, the former is expected to be the most economical and popular method for the tea nursery in the future.

3. Field tests on the four synthetic sex pheromone of tea tortrix moths and smaller tea tortrixs showed effective, especially *Adoxophyes* sp. (Japanese product), in attracting the male moths of the tea tortrixs. Since the synthetic sex pheromone attracts the males for at least two months, sex pheromone usage in large scale is proposed for controlling tea tortrixs.

4. The relationship between chemical components and quality of Oolong tea has been studied. Caffeine and amino acids contents showed a higher positive linear correlation with the Oolong tea quality, whereas catechins, soluble solids, total nitrogen and theobromine showed a higher curvilinear correlation with the quality. Stepwise multiple regression techniques were used to select the best multiple regression equation. The following equation with R^2 : 0.992 and F-value; 24.85 was obtained for predicting Oolong tea quality.

$$Y = 389.92 + 141.26\ TN - 115.01\ \log^2 TN + 8.98\ \log CA + 1.13\ \log Cat - 555.65\ \log SS - 178.49\ \log^2 SS - 5.57\ \log AA - 0.93\ \log^2 AA$$

Note. TN, Total nitrogen; TB_1 Theobromine; CA Caffeine: Cat. Catechins; SS, Soluble solids; AA, Amino acids.

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The area of tea planted and harvested in Taiwan now is 28,784 ha and 26,531 ha respectively with annual production of 24,365 m.t. of made tea including green tea, black tea and partially fermented (Taiwan) tea. The taste of Taiwan tea, such as Oolong and Paochong, is well like by consumers both domestic and abroad.

Taiwan Tea Experiment Station, which was established in 1903, is the only tea research organization on the island with four substations. The function of the station is to: (1) Carry out breeding experiments, improvement of cultivation techniques and farm management. (2) Study new methods of tea processing and tea chemistry and quality. (3) Introduce tea machinery and establish, mechanical farming and irrigation systems. (4) Conduct extension service of techniques for tea growers and manufacturers. Current research in tea breeding, tea cuttings, sex pheromones of tea tortrix moths and chemical components of Oolong tea are as follows.

1. The Breeding of the Six New Tea Varieties.

The two new varieties of TTES No. 12 and No. 13 were officially registered in 1981. These varieties were selected from 229 F_1 hybrids and 1 clone of line segregation. They had been investigated for local adaptability at several tea planting districts in the central and northwest parts of Taiwan before they were registered. The yields of green leaves of the two new varieties were higher than the local varieties of Chin-hsin-ta Pan and Chin-hsin Oolong. The quality of Paochong tea and Oolong tea, which were manufactured from these two new varieties, were better than those of the local varieties especially in taste and flavour.

Another four new varieties of TTES No. 14, 15, 16, and 17 were officially registered and released in 1983. These new varieties were selected from 1433 hybrids, which were crossed in 1960, after investigation of nursery selection, productivity and quality tests and local adaptability. These four new varieties were more resistant to drought than Chin-hsin Oolong, which is a leading variety for Paochong tea processing in Taiwan. TTES No. 14 and 15 have the finest and most stable qualities for Paochong tea and Oolong tea processing. TTES No. 16 and 17 have the characteristics of early plucking, vigorous growth and high yield. The agronomic characteristics of these new varieties and the check varieties are summarized in the following tables.

Table 1. Origin of F_1 hybrids of new tea varieties

New varieties	Female parent x Male parent
TTES No. 12	Tainon No. 8 x Ying-chih-hung Hsin
TTES No. 13	Ying-chih-hung Hsin x Tainon No. 8
TTES No. 14	Tainon No. 983 x Pei-mao Hou
TTES No. 15	Tainon No. 983 x Pei-mao Hou
TTES No. 16	Tainon No. 335 x Tainon No. 1958
TTES No. 17	Tainon No. 335 x Tainon No. 1958

Table 2. Yields and nitrogen and catechin contents of new tea varieties and cultivars

Varieties	Yield of green leaves by hand Plucking kg/ha	Date of 1st plucking	Total nitrogen % DW	Total catechins % DW
TTES No. 12	5,063	Feb. 9	3.95	12.98
TTES No. 13	3,925	Feb. 10	3.94	12.43
Chin-hsin-ta Pan	3,519	Feb. 15	3.52	13.19
Chin-hsin Oolong	3,185	Feb. 28	3.44	12.04
TTES No. 5	3,102	Feb. 1	3.67	12.30
TTES No. 14	2,569	Mar. 6	4.21	19.23
TTES No. 15	2,911	Mar. 4	3.75	18.90
TTES No. 16	3,876	Feb. 19	4.15	18.69
TTES No. 17	4,352	Feb. 24	4.24	22.65
Chin-hsin-ta Pan	1,440	Feb. 28	3.90	16.07
Chin-hsin-gung Tayy	1,989	Feb. 20	4.55	17.13
Pei-mao Hou	1,164	Mar. 6	3.92	16.92
Chin-hsin Oolong	-	-	3.99	14.58

Table 3. Sensory testing scores for Pouchong tea qualities of new tea varieties and cultivars

Varieties	Item					
	Appearance made tea (20)**	Colour made tea (20)**	Colour liquor (20)**	Flavour & taste (30)**	Infused leaves (10)**	Total score (100)
TTES No. 12	15.0	15.6	15.9	22.8*	7.4	76.7*
TTES No. 13	15.0	15.3	15.8	22.5*	7.2	75.8
Chin-hsin-ta Pan	15.2	15.5	16.0	21.2	7.3	75.2
Chin-hsin Oolong	16.6	15.5	15.9	22.2*	7.4	77.6*
TTES No. 5	15.0	15.5	15.8	21.6	7.5	75.4
TTES No. 14	15.1	15.2	15.8	22.8*	7.1	76.0*
TTES No. 15	15.6	15.6	15.3	21.3	7.2	75.0
TTES No. 16	15.3	15.8	15.5	22.3*	7.4	76.3*
TTES No. 17	15.2	15.2	15.8	21.9	7.3	75.4
Chin-hsin-ta Pan	15.4	16.2	15.8	21.5	7.6	76.5*
Chin-hsin-gung Tayy	15.3	15.8	15.6	21.3	7.5	75.5
Pei-mao Hou	15.7	15.9	15.8	21.7	7.4	76.5*
Chin-hsin Oolong	15.6	15.7	16.0	22.4*	7.5	77.2*

Note. *Scores of high grade Pouchong tea.

**Maximum scores of each item of tea qualities.

Table 4. Sensory testing scores for Oolong tea qualities of new tea varieties and cultivars

Varieties	Item					
	Appearance made tea (20)**	Colour made tea (20)**	Colour liquor (20)**	Flavour & taste (30)**	Infused leaves (10)**	Total score (100)
TTES No. 12	15.8	15.9	12.8	22.5	7.4	74.4
TTES No. 13	15.5	15.8	12.0	21.5	7.3	72.1
Chin-hsin-ta Pan	15.5	15.7	13.0	21.5	7.2	72.9
Chin-hsin Oolong	15.2	15.3	13.8	21.9	7.2	73.4
TTES No. 5	15.5	15.7	12.0	22.0	7.2	72.4
TTES No. 14	17.0*	16.9	16.2	23.3*	8.4	81.8*
TTES No. 15	17.4*	17.2*	15.5	23.1*	8.6	81.8*
TTES No. 16	16.7	16.6	14.7	22.5	8.1	78.6
TTES No. 17	17.1*	17.0*	15.4	22.4	8.3	80.2*
Chin-hsin-ta Pan	16.5	16.4	15.1	22.6	8.1	78.7
Chin-hsin-gung Tayy	16.1	15.9	15.4	22.1	8.0	77.5
Pei-mao Hou	17.3*	17.2*	14.5	23.4*	8.3	80.7*
Chin-hsin Oolong	15.5	15.5	14.2	22.4	7.4	75.0

Note. *Scores of high grade Oolong tea.

**Maximum scores of each item of tea qualities.

2. Nutrient Culture of Tea Cuttings in Dibbling Tubes.

The traditional soil culture of tea cuttings has been used mainly for years to propagate tea plantlets in Taiwan. It has some disadvantages, such as renewal of nursery soil (sick soil problem), soil diseases, weed control, lower percentage of rooting, longer time of growing plantlets etc. The nutrient culture of tea cuttings in dibbling tubes can overcome these defects found in traditional soil culture of tea cuttings. The different formula of media filling the dibbling tubes for planting tea cuttings and methods of nutrient application have been studied.

Effects of different medium compositions using soil, sand, peat moss and vermiculite etc., on the growth of tea cuttings (var. TTES No. 12) were investigated. Black plastic tubes with a size of 18 cm (length) x 4 cm (diameter of opening) were used to hold culture of tea cuttings. The experimental result showed that soil sterilization with chloropicrin or pasteurization is necessary for the growth of tea cuttings in tube culture. Sterilized soil or sand mixed with peat moss or vermiculite are suitable media for the tube culture of tea cuttings as shown in Table 5.

Studies of the application of nutrient solution are now underway. Dr. Hewitt's Long Ashton Standard Solution, University of Bristol. U. K. is used for the tube culture. An ammonium salt (NH_4NO_3) is used in the nutrient solution due to tea plant's preference for ammonium as nitrogen source. Proper concentrations of nutrient solution and the time of its application to the tube culture are going to be determined.

3. The use of Synthetic Sex Pheromone for the control of Tea Tortrix Moths and Smaller Tea Totrixs.

The synthetic sex pheromone, labled As(f-3), *Adoxophyes* sp., *Homona magnanima* and *Homona coffearia* from Japan are set in the field to attract the male moths of the tea tortrixs. The former one is set with 4 traps and the latter three are set with 2 traps respectively. The number of male moths attracted by each of these four synthetic sex pheromones are 470, 159, 266 and 0 respectively from Oct. 1, 1981 till Jan. 29, 1982 (Table 6).

Table 5. Effects of the medium compositions on the growth of tea cuttings in tube culture.

Treatment orig. No.	Medium Composition	Shoot Length cm	Shoot No. of leaves	Shoot Weight g	Root Length cm	Root Weight g
CK	Nursery bed	10.8^{def}	7.3^{ab}	0.93^{def}	6.8^{bcd}	2.89^{de}
F-8	Non-sterilized soil	9.2^{ef}	4.0^{efg}	0.51^{f}	3.1^{d}	1.63^{e}
F-9	Sterilized soil	11.2^{def}	5.3^{cdef}	0.86^{ef}	5.7^{d}	3.80^{cde}
F-6	Non-sterilized soil + peat moss	8.9^{ef}	3.5^{fg}	0.54^{f}	6.5^{cd}	3.39^{de}
F-15	Sterilized soil + peat moss	16.9^{a}	7.8^{a}	1.56^{ab}	11.4^{a}	10.04^{ab}
F-5	Non-sterilized soil + vermiculite	8.8^{f}	3.3^{g}	0.45^{f}	3.5^{d}	2.46^{de}
F-10	Sterilized soil + vermiculite	16.4^{ab}	8.4^{a}	1.69^{a}	12.1^{a}	8.30^{abc}
F-12	Sand sterilized by chloropicrin + peat moss + vermic.	15.9^{ab}	7.6^{a}	1.45^{abcd}	12.5^{a}	9.45^{ab}
F-16	Sand sterlized by pasteurization + peat moss + vermic.	15.5^{abc}	8.1^{a}	1.50^{abc}	11.8^{a}	10.51^{a}

Note. The result in the table are selected fiom the data of the 17 treatments with statistical analysis. Figures followed by the same letter within each column are not significantly different at 1% level according to Duncan's multiple range test.

Table 6. Number of male moths of the target insect attracted by synthetic sex pheromone.

Sex \ Time / Pheromone	Oct.1-Oct.13	Oct.14-Oct.31	Nov.1-Nov.13	Nov.14-Nov.30	Dec.1-Dec.14	Dec.15-Dec.31	Jan.1-Jan.14	Jan.15-Jan.29	Total
As (f-3) (4 traps)	26	98	38	23	38	83	106	58	470
Adoxophyes sp. (2 traps)		22*	27	33	11	29	21	16	159
Homona magnanima (2 traps)		58*	40	20	8	46	70	24	266
H. coffearia (2 traps)		0*	0	0	0	0	0	0	0

Note. *The test was begun on Oct. 24, 1981.

The density of the smaller tea tortrix moth and the tea tortrix moth is high from May to September according to our previous records of light traps. So, according to our data, the effect of synthetic sex pheromone is very good. The number of smaller tea tortrix was 213 and 728 attracted by 4 sticky traps labled As(f-3) and *Adoxophyes* sp. in the 2nd year (Table 7). Since the synthetic sex pheromone is attractive to the males at least for two months, its future usage in large scale is proposed.

Table 7. Number of male moth of *Adoxophyes fasciata* attracted by two synthetic sex pheromones.

Sex \ Time / Pheromone	May 11-May 14	May 15-May 31	June 1-June 15	June 16-June 29	July 1-July 19	Total
As (f-3)	16	68	77	29	23	213
Adoxphyes sp.	27	156	208	165	172	278

4. The Relationship between Chemical Components and Quality of Oolong Tea.

Oolong tea is produced in summer by half-fermentation. Although its way of manufacturing was learned from Fukien, Taiwan tea manufacturers have made great improvement after careful research and development. Before 1881, Oolong tea was the only kind of tea produced in Taiwan and it was first exported into international market gaining a good reputation for Taiwan tea. Oolong tea has following qualities. (1) Cup: A bright golden colour of amber. (2) Aroma: Delicate fragrance like the aroma of a ripe pear or apple. (3) Taste: Oolong tastes fragrant mild, pure, sweet and long lasting. This is the most special feature of Oolong. (4) Appearance: The finest Oolong has plenty of white tips in brownish leaves and looks beautiful. Oolong tea of very high quality, which is produced from affected (damaged) leaves by grass hoppers (insects), is called "Pwong-Fueong tea" by local name. But unfortunately, all merits of Oolong tea in colour, aroma, taste and appearance have been forgotten by the tea drinkers of the present generation and Paochung tea has replaced Oolong tea as the chiefly consumed tea, in Taiwan.

The relationship between chemical components and quality of Oolong tea was studied. Nineteen different grade of tea samples were collected directly from the factories in those Oolong tea producing area for a correlation study. Scores of the tea qualities were recorded by sensory tasting and chemical analyses of soluble solids, total nitrogen, theobromine, caffeine, catechins and amino acids were conducted. The relationships between each chemical component and scores of sensory tasting were statistically analyzed.

The results of correlation analysis (Table 8 and 9) showed that: (A) The higher caffeine content the bigher scores of sensory tasting (quality of the tea) was seen in the linear correlation analysis of Table 8. After applying Stevens law transformation, the correlation coefficient of amino acid content with scores of sensory tasting was significantly increased. (B) The higher correlation coefficients of total nitrogen, theobromine, catechins and soluble solids contents with scores of sensory tasting were obtained in curvilinear correlation analysis of Table 9. It indicates that if these components are excessive or lacking, the result is unfavourable to quality of Oolong tea. After applying Stevens law transformation, the correlation coefficients of total nitrogen, theobromine contents with scores of sensory tasting were significantly increased.

Table 8. Correlation coefficients of linear relations between chemical components and scores of sensory tasting of Oolong tea.

Chemical components	Correlation coefficient (r)		
	r	r(w)	r(s)
Total nitrogen	0.556	0.581	0.685
Theobromine	0.734	0.729	0.893
Caffeine	*0.910*	0.888	0.893
Catechins	0.709	0.685	0.688
Soluble solids	0.624	0.752	0.400
Amino acid	0.241	0.256	*0.725*

Note. r: Correlation coefficient of original data.

r(w): Correlation coefficient after applying Weber-Fechner law transformation with log form of chemical components data.

r(s): Correlation coefficient after applying Stevens law transformation with log form of both chemical components and scores of sensory tasting data.

Stepwise regression technique was used to select the best multiple regression equation. The linear or curvilinear correlation relationships among six chemical components and scores of quality tasting were selected for fitting the model of the prediction of Oolong tea quality. After testing all the postulated equations, the following three (i, ii and iii) regression equations, which have higher correlation coefficients of 0.992, 0.994 and 0.996 respectively, were obtained for using in the prediction of the quality of Oolong tea.

(i) $Y = 391.61 + 140.74 \log TN - 115.25 \log^2 TN + 9.51 \log CA - 557.94 \log SS - 179.88 \log^2 SS - 6.33 \log AA$. $R^2 = 0.984$, $F = 26.43$

(ii) $Y = 72.22 + 326.85 \log TN - 269.99 \log^2 TN + 16.94 \log CA - 40.28 \log Cat - 20.52 \log^2 Cat - 13.11 \log AA - 1.21 \log SS - 0.161$

log 1/TB.

R^2 = 0.988, F = 13.86.

(iii) Y = 389.92 + 141.26 TN – 115.01 $\log^2$ TN + 8.98 log CA + 1.13 log Cat – 555.65 log SS – 178.49 $\log^2$ SS – 5.57 log AA – 0.93 $\log^2$ AA

R^2 = 0.992, F = 24.85.

Note. TN, Total nitrogen; TB, Theobromine: CA Caffeine; Cat, Catechins; SS, Soluble solids; AA, Amino Acids.

Table 9. Correlation coefficients of curvilinear relations between chemical components and scores of sensory tasting of Oolong tea.

Chemical components	Correlation coefficient (r)		
	r	r(w)	r(s)
Total nitrogen	0.717	0.710	*0.796*
Theobromihe	0.750	0,730	*0.934*
Caffeine	0.344	0.844	0.894
Catechins	*0.726*	0.472	0.606
Soluble solids	*0.768*	0.757	0.695
Amino acids	0.351	0.310	0.390

Note: r, r(w), r(s); Same as those indicated in Table 8.

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臺灣茶業研究最近之發展

邱　再　發

摘　要

臺灣省茶葉改良場是本省唯一茶葉研究機構，成立於 1903 年，擁有四個分場，其功能爲(1)進行育種試驗，改進栽培技術（包括土壤肥料、茶樹保護）和茶園管理。(2)研究製茶新技術，茶葉化學成份和品質之關係。(3)引進茶葉機械及建立茶園機械化和灌溉系統。(4)茶農及製茶業者之技術指導與推廣服務。近年來主要研究成果如下：

1 已命名的六個茶樹新品種臺茶 12 號、13 號、14 號、15 號、16 號及 17 號已供應推廣茶農種植，這些新品種均適合半發酵（包種及烏龍）茶之製造且具有質量均優之雙重特點。

2 茶條扦插於含蛭石、泥炭、砂之混合物培養基之穴植管並做營養液栽培時，茶苗生長十分成功，其生長快速，發根率及成活率高。這種穴植管扦插苗之營養液栽培法優點多，可代替傳統的土壤扦插法將來可能成爲最經濟及最普遍的茶樹育苗方法。

3 四種性費洛蒙合成劑之茶捲葉蛾及茶姬捲葉蛾田間誘蟲試驗顯示對誘捕雄蛾有效，尤其 *Adoxophyes* sp.（日本產品）之效果佳。因爲性費洛蒙合成劑田間誘捕雄蛾效果至少維持二個月，所以建議性費洛蒙的大規使用做爲茶捲葉蛾之防治。

4. 烏龍茶的品質與化學成份之關係研究結果顯示，咖啡因（CA）及胺基酸（AA）含量與烏龍茶品質有顯著的直線正相關，而兒茶素（Cat），可溶分（SS），總氮（TN）及可可鹼（TB）與品質有顯著的二次曲線相關。利用逐步多重回歸分析選擇如下最佳多重回歸方程式，可用以預估烏龍茶之品質，其中 R^2 爲 0.992 及 F 值爲 24.85 。

$$Y = 389.92 + 141.26\ TN - 115.01\ \log^2 TN + 8.96\ \log CA + 1.13\ \log Cat - 555.65\ \log SS - 178.49\ \log^2 SS - 5.57\ \log AA - 0.93\ \log^2 AA$$

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1. 臺灣省茶業改良場場長。