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Flavor of Black Tea

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Black tea is the world's most popular beverage. One of the principal reason for such high acceptability is due to its mild and exquisite aroma.

The quantity of constituents which contribute to tea flavor is so small as around 0.017% in black tea, and consists of more than eighty components. [1)~6)]

It has been too difficult to study such a complicated minor components but recently the use of gas chromatography permits the rapid and detailed investigation of tea aroma.

Changes in Aroma constituents during the manufacture of black tea

The manufacturing process of black tea consists of four steps, ie. withering, rolling, fermentaition and firing. During withering the moisture content is reduced from 77% to 68% under normal circumstances. By rolling process, as soon as the green leaf begin to be damaged in the roller fermention starts. After rolling process, the tea leaves are transferred into the fermentation room to complete fermentation. Then the leaf is fired to stop fermentation and to dry. During these processing, considerable change of flavor occurs and the typical flavor of black tea is produced.

In our laboratory, changes in aroma constituents during these four steps has been investigated by means of gas chromatography [7)]

Teble 1. Change in the amount of individual component during withering, fermentation and firing

Component	During Withering	During Fermentation	During Firing
iso-Butanol	≒	≒	−
n-Butanol	≒	≒	+
1-Penten-3-ol	≒	++	−
iso-Amyl alcohol	+	+	−−
n-Amyl alcohol	≒	+	−
cis-2-Pentenol	−−	+++	−−−
n-Hexyl alcohol	++	+	−−−
cis-3-Hexenol	−	+	−−−
trans-2-Hexenol	+	−	−
Linalool oxide Ⅰ (trans, furanoid)	≒	+	−
Linalool oxide Ⅱ (cis, furanoid)	+	+	−−−

Linalool	−−	−	−−−
Linalool oxide Ⅲ (trans, pyranold)	−	+	−
Linalool oxide Ⅳ (cis, pyranoid)	−	+	−
Nerol	+++	−−−	−
Geraniol	−−−	−	−−
Benzyl alcohol	−−−	++	−
Phenylethanol	−−−	+	++
n-Butyraldehyde	÷	÷	−
iso-Valeraldehyde	÷	÷	+
n-Valeraldehyde	+	÷	−
Capronaldehyde	+	+	−
n-Heptanal	+	+	−
trans-2-Hexenal	+	++	−−
trans-2-Octenal	+	+	−
Benzaldehyde	+	++	−−
Phenylacetaldehyde	+	+	+
cis-Jasmone	÷	+	−
Acetic acid	−−−	+	+++
Propionic acid	−−	+	++
iso-Butyric acid	−	+	++
n-Butyric acid	+	+	+
iso-Valeric acid	+	+	−
n-Valeric acid	÷	+	+
iso-Caproic acid	÷	÷	÷
n-Caproic acid	+	++	+
cis-3-Hexenoic acid	+	++	−−−
trans-2-Hexenoic acid	+++	−	−
Caprylic acid	−	+	+
Salicylic acid	+	+++	−−−
Unknown phenolic cpd. (1)	+	÷	−
Methyl salicylate	−	+	−−−
Unknown phenolic cpd. (2)	+	+	−
Phenol	−	+	÷
o-Cresol	+	÷	−
m-Cresol	−	−	−
Unknown phenolic cpd. (3)			+

Note: ÷ No significant change.
Decrease − significant amount, −− Moderate, −−− Extremely.
Increase + significant amount, ++ Moderate, +++ Extremely.

The results were summerized in Table 1. Looking through Table 1, it could be said that during withering, hexyl alcohol, nerol, *trans*-2-hexenonic acid, *trans*-2-hexenol, linalool oxide (*cis*, furanoid), *n*-valeraldehyde, capronaldehyde, *n*-heptanal, *trans*-2-hexenal, *trans*-2-octenal, benzaldehyde, phenylacetaldehyde, *n*-butyric, isovaleric, *n*-caproic, *cis*-3-hexenoic, salicylic acids and *o*-cresol increased, especially the former three greatly increased, while *cis*-2-pentenol, linalool, geraniol, benzyl alcohol, phenylethanol and acetic acid diminished markedly. In the process of fermentation almost all constituents increased, especially, 1-penten-3-ol, *cis*-2-pentenol, benzyl alcohol, *trans*-2-hexenal, benzaldehyde, *n*-caproic, *cis*-3-hexenoic and salicylic acids were remarkable.

On firing, most alcohols, carbonyl and phenolic compounds decreased remarkably whereas acetic, propionic and isobutyric acids greatly increased.

Comparison of aroma of various kinds of black tea [8]

Commercial black tea is characterized with the variety of tea leaves and the place of production.

Ceylon and India are two famous tea producing countries in the world, In our laboratory, the following black teas were used for comparison of tea aroma during the last two years.

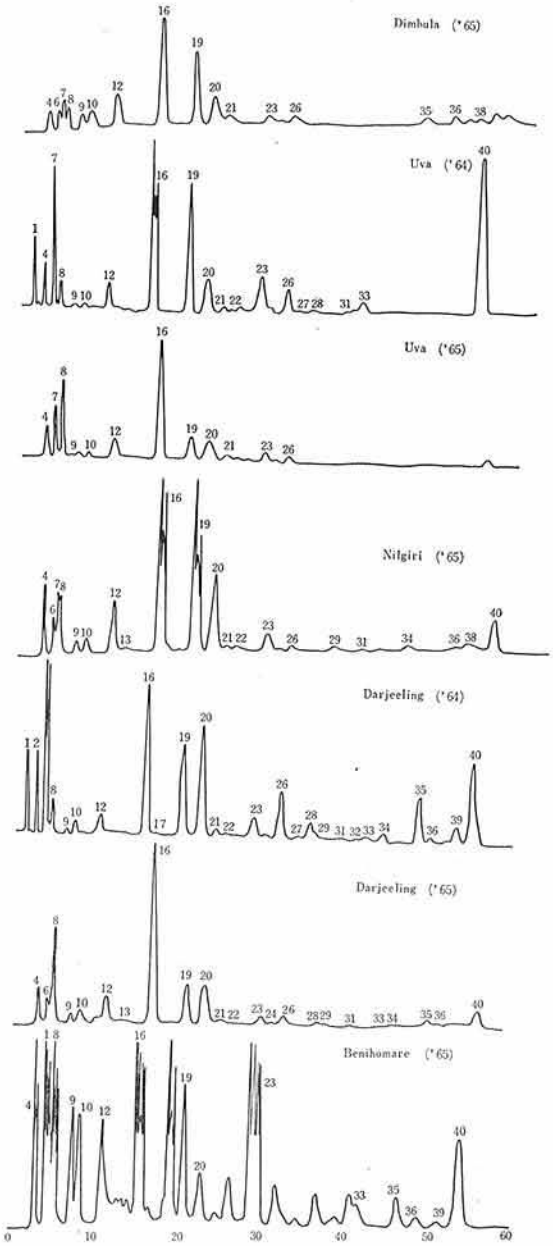

Fig. 1 Comparison of carpoxylic fraction (Me-ester)

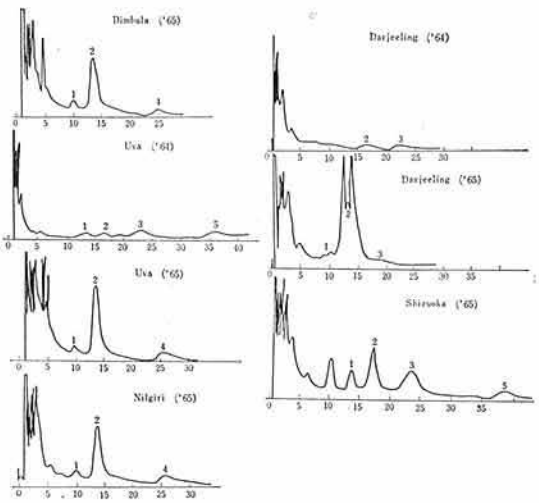

Fig 2. Comparison of Phenolic Fraction

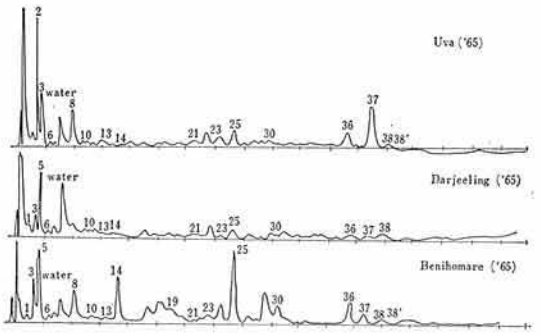

Fig. 3 Comparison of carbonyl fraction

	[place of production]	[var. of tea leaf]
Ceylon	Dimbula	var. assamica
	Uva	var. assamica
India	Nilgiri	var. assamica
	Darjeeling	var. sinensis
Japan	Shizuoka	Benihomare (hybrid of var. assamica and var. sinensis)

The aroma concentrates were prepared from black teas and separated into carboxylic, phenolic, carbonyl, and carbonyl-free neutral fractions. [4], [5],

Each fraction was examined by gas chromatography. The conditions of gas chromatography were all the same as discribed in the references No. 3, 4 and 5.

Figs. 1, 2 and 3 are the chromatograms of carboxylic, phenolic and carbonyl fractions respectively. The chromatogram of carbonyl-free neutral fraction(consists of mostly alcohols) closely resembles to that of original aroma concentrate from Dimbula ('65) and Uva ('65) as shown in Fig. 4. This means that the main part of aroma concentrate is alcoholic fraction.

Table 2, 3 and 4 are the lists of peak assignment and quantitative data referred to Figs. 1, 2 and 3.

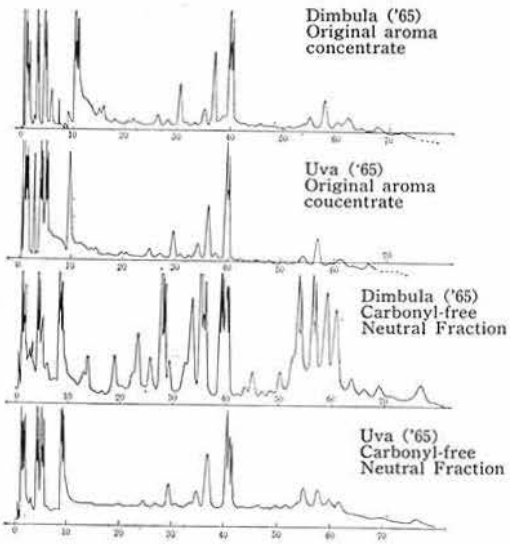

Fig. 4 Comparison of Carbonly-free Neutra Fraction and Original Aroma Concentrate from Dimbula and Uva.

Table 2. Comparison of carboxylic fraction (wt. %)

Peak No.	Acid	Dimbula	Uva (High grown)	Uva	Nilgiri	Darjeeling		Shizuoka
		'65	'64	'65	'65	'64	'64	'65
4	Acetic	29.5	28.0	37.7	26.2	32.4	36.1	31.3
7	Propionic	5.9	9.8	9.0	3.9	13.6	—	13.5
8	iso-Butyric	5.0	2.6	15.0	3.7	2.6	14.9	12.5
9	n-Butyric	3.1	0.5	0.4	14.9	0.6	1.7	2.6
10	iso-Valeric	4.6	0.8	1.2	2.4	2.2	3.5	3.8
12	n-Valeric	6.8	2.5	5.2	3.9	16.5	5.3	3.3
16	n-Caproic	21.0	22.5	21.1	7.4	9.3	22.1	21.4
19	cis-3-Hexenoic	13.3	13.5	3.6	4.7	7.0	5.4	1.5
20	trance-2-Hexenoic	9.7	5.3	5.5	7.9	9.7	7.9	2.2
22	n-Octanoic	0.1	2.1	0.7	1.9	1.5	1.3	6.3
33	n-Decanoic	0.5	1.2	—	—	0.5	—	0.4
34	Benzoic	—	—	—	1.3	0.7	0.6	—
40	Salicylic	—	11.3	0.6	1.8	3.7	1.3	1.3

Table 3. Comparison of phenolic fraction (peak area %)

Peak No.	Phenolic Compound	Dimbula	Uva		Nilgiri	Darjeeling		Shizuoka
		'65	'64	'65	'65	'64	'65	'65
1	Unknown	17.5	11.3	16.9	19.8	—	8.8	16.5
2	Methyl salicylate	61.4	15.6	67.0	49.3	53.7	82.0	31.3
3	Phenol	—	32.7	—	—	46.3	9.2	33.8
4	m-Cresol	21.1	—	16.2	30.9	—	—	—
5	Unknown	—	40.4	—	—	—	—	18.5

Table 4. Comparison of Carbonyl fractions (peak arae %)

Peak No.	Carbonyl compound	Uva '64	Darjeeling '64	Shizuoka '64
1	iso-Butyraldehyde Methylethyl ketone	16.24	2.82	0.78
3	n-Butyraldehyde	9.25	3.85	0.75
5	iso-Valeraldehyde	1.12	16.66	7.97
6	n-Valeraldehyde	1.31	1.02	0.87
7	Unknown	—	3.85	1.80
8	Capronaldehyde	11.9	8.22	5.54
9 ~ 12	Unknown	4.57	7.49	3.78
13	Heptanal	2.82	1.02	1.30
14	trans-2-Hexenal	1.00	1.50	9.37
15 ~ 20	Unknown	7.95	7.53	19.50
21	2-Octenal	3.76	1.18	2.83
22 ~ 24	Unknown	13.32	9.57	6.13
25	Benzaldehyde	6.96	7.01	17.80
26 ~ 29	Unknown	8.13	7.99	7.85
30	Phenylacetaldehyde	3.94	0.60	5.90
31 ~ 38	Unknown	7.64	19.57	7.58
	Sum of area of Unknown peaks	58.97	56.12	46.64

Fig. 5 shows the carbonyl-free neutral fractions of six kinds of black tea other than Dimbula ('65) and Uva ('65). After calculating each peak area percentage, it was found that the sum of linalool and its oxides (tentatively named as "Linalool Value") has some correlationship to the type of black tea.

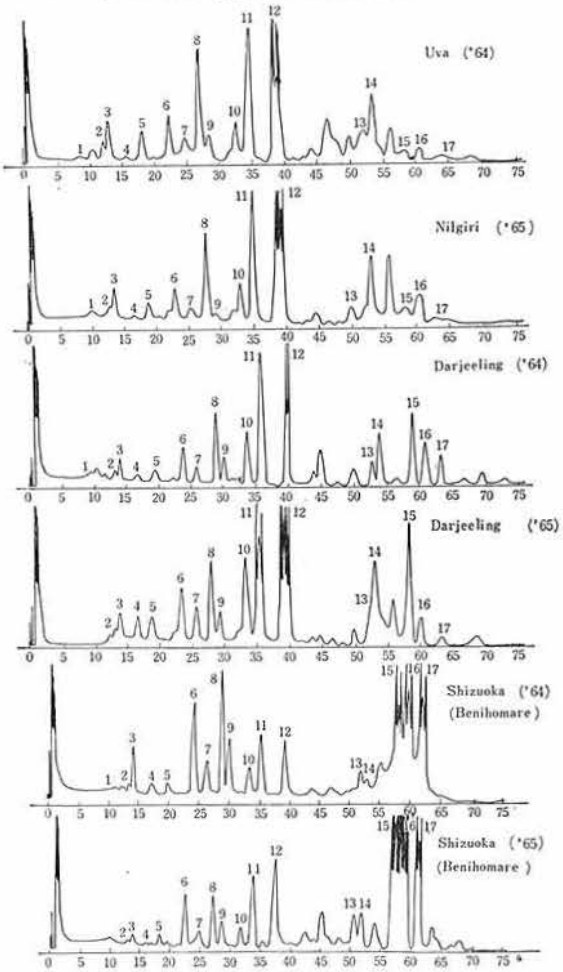

Fig 5. Comparison of carbonyl-free neutral fractions

Table 5. Comparison of alcohols in the essential oil from eight kinds of black tea (wt, proportion)

Peak No.		Dimbula '65	Uva '64	Uva '65	Nilgiri '65	Darjeeling '64	Darjeeling '65	Shizuoka '64	Shizuoka '65
1	iso-Butanol	trace	0.8	trace	trace	trace	trace	0.4	trace
2	n-Butanol	0.5	1.2	0.5	1.2	1.5	0.4	0.8	trace
3	1-Penten-3-ol	1.1	2.5	0.8	2.7	0.8	1.6	1.8	0.2
4	iso-Amyl alcohol	0.1	0.5	trace	1.3	1.9	1.6	1.1	trace
5	n-Amyl alcohol	0.9	1.5	0.7	2.3	0.6	1.8	0.7	trace
6	cis-2-Pentenol	2.0	3.4	1.8	3.5	4.0	3.0	4.6	1.8
7	n-Hexanol	0.1	2.2	1.5	2.3	1.8	1.8	1.8	0.4
8	cis-3-Hexenol	11.4	13.1	8.9	11.6	11.1	6.8	9.4	3.1
9	trans-2-Hexenol	1.4	3.4	2.6	2.7	4.4	2.6	4.3	1.4

10	Linalool oxide I	67.3	5.3	67.2	4.5	72.6	6.2	66.1	4.6	48.4	7.2	65.4	7.0	11.7	2.1	11.5	1.2
11	Linalool oxide II		13.9		12.6		16.7		12.9		15.7		16.4		3.8		3.0
12	Linalool		42.8		42.8		41.9		41.7		17.5		34.7		3.1		3.5
13	Linalool oxide III		0.9		1.9		1.6		1.4		2.7		7.3		1.5		2.0
14	Linalool oxide IV		4.4		5.4		6.2		5.5		5.4				1.2		1.8
15	Nerol (Me. salicylate)*		—		—		—		—		—		—		—		—
16	Geraniol		5.6		1.1		5.3		2.2		10.3		9.6		14.3		37.5
17	Benzyl alcohol		5.7		1.5		4.7		3.7		7.9		2.8		18.3		21.5
18	Phenylethyl alcohol		2.1		1.4		0.9		0.4		7.1		2.5		29.9		22.7

(Note.) *Methyl salicylate came into neutral fraction.

In comparing the chromatograms of the original aroma concentrates from thirteen kinds of black tea, it was found that "Linalool Value" has similar relation to the type of black tea as mentioned above. Furthermore the ratio of total area of peaks which appear before linalool to that after linalool in the chromatogram seemed to have some relation with the variety of black tea as shown in Table 6.

Table 6. Comparison of "Linalool Value" and peak area ratio of befor to after linalool.

Black Tea	Sum of Linalool and Linalool oxides (Peak area % in the Aroma Concentrate)	Sum of area of peaks before Linalool / Sum of area of peaks after Linalool
Dimbula '65	47.4	0.9
Uva '64 (high grown)	43.0	0.4
Uva '65	59.3	0.7
Nilgiri '65	47.2	0.8
Darjeeling '64 (highest grade)	52.7	0.5 (0.46)
Darjeelng '65	54.5	0.4
* Peru (low grade)	35.1	1.0
* Taiwan (Shan form)	23.7	0.9
* Taiwan	23.8	0.7
Shizuoka '64	9.7	0.08
Shizuoka '65 (Benihomare)	17.9	0.1
* Shizuoka '63	8.5	0.07
* Shizuoka '63 (Benifuji)	8.5	0.07

Note (*) Condition of chromatography was isothermal.

To compare the top note of black tea aroma, head space gas analyses were carried out on black tea of Dimbula, Uva, Nilgiri, Darjeeling and Shizuoka. Fig. 6 shows these aroma patterns and Table 7 is the list of peak identification (tentative) and peak area percentage. It is difficult to characterize the chromatogram with the relation to the type of black tea. Further investigation by means of cryogenic method is now in progress.

Table 7. Comparison of head space gas composition.

Peak No.		Dimbula '65	Uva '65	Nilgiri '65	Darjeeling '65	Benihomare '65
		%	%	%	%	%
1	Unknown	14.8	13.1	17.3	15.7	9.1
2	Unknown	—	—	6.9	—	—

3	Acetaldehyde	7.3	6.4	9.6	15.7	13.1
4	Dimethylsulfide Propanal	14.7	21.6	11.4	11.7	8.1
5	iso-Butanal, Acetone	20.6	19.0	17.3	18.3	29.3
6	Methyl acetate	—	—	—	2.5	—
7	Methylethylketone, Methanol	1.0	2.4	2.4	—	1.8
8	n-Butanal	—	—	—	26.9	—
9	iso-Pentanal	26.2	20.7	20.3	—	27.2
10	iso-Propanol, Etanol	3.4	4.0	4.1	—	—
11	Diacetyl	—	—	—	2.2	—
12	n-Pentanal	2.3	2.8	2.7	1.7	1.8
13	n-Propyl alcohol	3.1	2.7	1.9	—	1.1
14	Unknown	—	—	—	1.5	—
15	Unknown	—	—	—	0.9	—
16	Unknown	0.9	0.8	—	—	0.8
17	Unknown	—	—	0.9	—	—
18	iso-Butyl alcohol	—	—	—	0.9	—
19	n-Hexanal	2.8	4.2	3.0	0.6	1.8
20	n-Butyl alcohol	—	—	—	1.1	0.5
21	1-Penten-3-ol	1.1	1.2	1.3	—	1.0
22	Unknown	—	—	—	0.3	—
23	n-Heptanal	0.5	0.3	—	—	—
24	trans-2-Hexenal	—	—	0.5	—	0.3
25	iso-Amyl alcohol	1.0	1.1	0.7	—	0.5
26	n-Amyl alcohol	0.6	0.5	0.6	0.1	0.4
Sum of the peak area		210.5	226.4	103.4	216.95	225.3

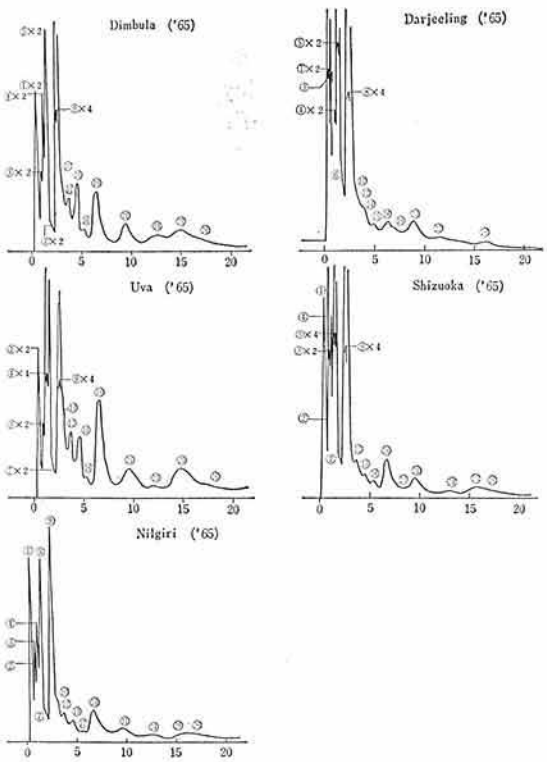

Fig. 6 Comparison of head space gas of five types of black tea.

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A Basic System of Farm Accounting for Family Farm

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Introduction

Farm business in the developed economy is usually concerned with purchasing materials and services, operating agricultural production and selling the produce from the farm. Main interest of the farmer is in obtaining more net cash income with desirable level of his farming effort. It will be possible to discribe economic activity on the farm by means of systematic record of transaction for market. As the result, financial situation of the farm at a given time and economic activity on the farm during a period of time can be summarized without difficulty in sophisticated forms called a balance sheet and a profit and loss statement.

In the developing economy on the other hand economic activity itself is usually very simple. Farm accounting, however, is not so easy. For a farmer subsistance is a large part of his economy and market transaction is only a part. Consequently, record of transaction for market does not tell even an outline of farming. Production, consumption and also primitive capital formation should be regarded as the total economic activity of the farm. For accounting it materials and services produced, consumed and worked on the farm have to be evaluated by money term and recorded with each amount of them. Of course this method of accounting farm economy presents some difficulties. It, however, might help to rationalize farm living in developing economy.

In this brief paper I will present a very sipmle farm accounting method called "self-accounting system" which has been developed at College of Agriculture, Kyoto University and it played a substaintial role in the improvement of farming and farm life and helped administrators and policy makers on their survey and analysis of financial situation of the farm and farmer's economy. At present it is still an adequate accounting system for many family farms in Japan, even though advanced system of farm accounting is necessary for farming and living under more developed economic and social status.

Outlines of the self-accounting system for family farm

1) Unit (Entity)

The unit for the farm accounting system is the farming and living economy of a farmer as a whole. It includes economic activity on production in the farm, consumption of the farm products by the farmers and direct capital formation in the unit. Business and household account of the unit are not separated.

Farm living is accounted by two actions: purchase of materials, services and other payment for living, and delivery of the farm products for self-consumption by the farm