

Chromosomal Biotypes of *Carica papaya* Linn.

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Introduction

Carica papaya Linn. (Caricaceae) is a very popular fruit, commonly cultivated and more or less naturalized in India, where it was introduced as early as 1598 (Schery 1952). The fruit is usually consumed fresh but may be made into juice, pickles, preserves, jellies or sherbets or may be served cooked like cucurbits. It is the source of the digestive enzyme papain, which finds some commercial use as a meat tenderizing sauce (Schery 1952). It has got many medicinal uses: Milky juice of unripe fruits is used as a cosmetic to remove freckles and other blemishes from the skin. Ripe fruit is used as stomachic, carminative and diuretic, and seeds as vermifuge, emmenagogue and for quenching thirst. Carpaine, carposide and papain are the chief constituents (vide Chopra, Nayar and Chopra 1959).

Several distinct varieties of *Carica papaya* Linn. have been mentioned (Richharia 1957, Sen 1939), which vary in shape and size of fruits, height of plants, etc. This dioecious species shows different sex types e.g. pure male, pure female, hermaphrodite with occasional fertile flowers on long peduncles and hermaphrodite with larger fertile flowers on short peduncles (Kulkarni 1924, Burns 1920).

Researches in the field of cytogenetics of this species though not many in records (Asana and Sutaria 1929, Eichhorn 1937, Kumar and Abraham 1942, Hofmeyer 1945) have not been left untouched. None of these workers have been able to determine any sex determining factor in the karyological constitution of the species.

A reinvestigation on the possibility of the existence of the heteromorphic pair of chromosomes, as a sex determining mechanism with modern improved techniques of cytological studies has been thought desirable.

There are three known factors contributing to the genetical changes leading to the evolution of the varieties: numerical change of chromosomes, structural change of chromosomes by deletion, translocation, etc. and point mutation. In order to find out how far the first two factors have played in bringing about these genetical changes, this detailed study of the karyotype has been taken up.

Materials and method

Five different pure strains of *Carica papaya* Linn. were collected from a commercial Nursery of Calcutta. The varieties are: 1) Bangalore 2) Honey Dew, 3) Ranchi-mammoth, 4) Ceylon and 5) Washington. These varieties differ in morphological characters e.g. size and shape of fruits, stature of plants, etc.

Seeds were germinated in separate pots in a mixture of clay, sand and sawdust. For smearing root tips, several techniques involving prefixation with oxiquinoline (Sharma and Ghosh 1950), aesculin (Sharma and Sarkar 1955) and para-dichlorobenzene (Sharma and Mookerjee 1955) for varying periods were tried. These were followed by fixing and hydrolysing by heating in a mixture of 2% aceto-orcein solution and normal hydrochloric acid (9:1) for about 3 seconds and finally smearing with 1% aceto-orcein solution. The best result was however obtained by prefixing with aesculin for one hour.

Plates were studied under oil immersion lens and five distinct metaphase plates for each variety were drawn with camera lucida on a drawing board at a magnification of 2000.

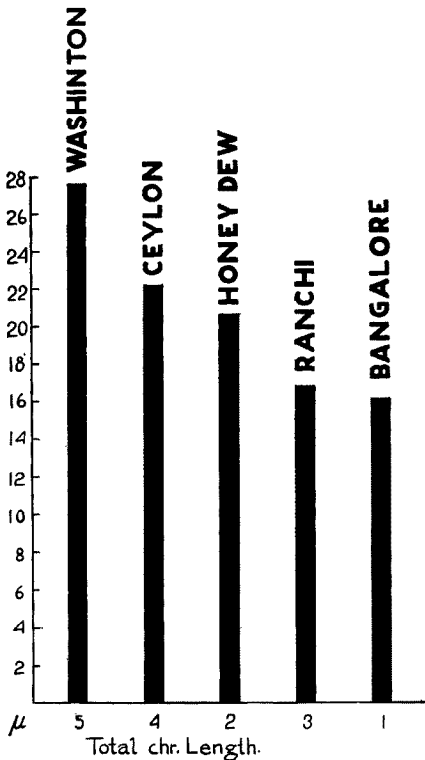


Fig. 1. Histogram showing total haploid chromosome length of the different varieties of *C. papaya*.

Observations

The chromosome number is constantly eighteen in all varieties. Though the varieties belong to the same species, they differ in details of chromosome structure. Of course, as is naturally expected, there are similarities in the complements of different varieties. The chromosomes are generally small with slight difference in length. Primary constrictions are generally median or submedian. Number of secondary constrictions varies from six to twelve.

The range of length of chromosomes in different varieties is 1.00μ to 4.23μ approximately. Total chromosome length is different in different varieties (vide Histogram in Fig. 1). The variety "Washington" possesses the longest chromosomes, "Bangalore" the smallest. Table 1 will indicate these features:

On the basis of the relative length and the positions of primary and secondary constrictions, the chromosomes of this species may be classified

Table 1.

Variety	Total chromosome length (haploid), μ	Primary constrictions (position)	No. of secondary const. chromosome
1. Bangalore	16.25	median, submedian and subterminal	6
2. Honey Dew	20.50	median and submedian	8
3. Ranchi	16.87	median and submedian	8
4. Ceylon	22.25	median and submedian	10
5. Washington	27.75	median or submedian	6

into the following types (Fig. 2) :

Type A (3.00 to 3.50 μ approx.): A type with three constrictions forming four segments, one longer than the other three differing slightly in length.

Type A' (2.25 to 3.00 μ approx.): A type with three constrictions forming four parts, one SAT, the longer three being almost equal in length.

Type B (2.50 to 3.00 μ approx.): A type with two constrictions forming three almost equal segments.

Type C (2.25 to 3.00 μ approx.): A type with two constrictions forming three segments, one longer than the other two, slightly differing in length.

Type D (2.50 μ approx.): A type with closely situated two constrictions forming three segments, the middle one being markedly smaller than the other two.

Type E (2.50 to 4.25 μ approx.): A type with two constrictions forming three segments one SAT and the longer two almost equal.

Type E' (3.00 μ approx.): A type similar to E, differing in the middle segment being longest.

Type F (2.25 to 3.50 μ approx.): A type with a median primary constriction.

Type F' (2.50 μ approx.): Similar to type F, differing by the slight difference in length of the two arms.

Type G (1.5 to 3.00 μ approx.): A type with a submedian primary constriction.

Type H (1.00 to 1.50 μ approx.): A chromosome type similar to F but very short.

On the basis of the above description of chromosome types, the detailed karyotype of each variety has been described below. The measurements, lengths of arms and positions of primary constriction have been shown in Tables 2-6. (Abbreviations in tables: m=median primary, sm=submedian primary, sup=super-numerary secondary constriction, sec=secondary constriction).

1) "Bangalore": Chromosome pairs of this variety show slight size difference which is more pronounced than in other varieties (Figs. 3 and 4).

Chromosome length ranges from 1.25 to 3.25 μ . Chromosomes are represented by six types, of which three (A, C and E) involving three pairs bear secondary constrictions. Type A is with supernumerary constrictions. Relative lengths and the nature of constrictions are shown in Table 2.



Fig. 2-12. Somatic plates and idiograms of *C. papaya*, given respectively. 2, diagram showing different types of chromosomes found in the present study. 3 and 4, Bangalore; 5 and 6, Honey Dew; 7 and 8, Ranchi; 9 and 10, Ceylon; 11 and 12, Washington.

2) "Honey Dew":

Chromosome length ranges from 1.50 to 3.00 μ (Table 3 and Figs. 5 and 6). Chromosomes are represented by six types of which three (A, B and E) involving four pairs bear secondary constrictions. Type A' is with supernumerary constrictions.

3) "Ranchi": Chromosome length ranges from 1.00 to 2.50 μ (Table 4 and Figs. 7 and 8). Chromosomes are represented by six types, of which three (A', C and E) involving four pairs bear secondary constrictions. The type A' is with supernumerary constrictions.

4) "Ceylon": Chromosome length ranges from 1.50 to 3.25 μ (Table 5 and Figs. 9 and 10). Chromosomes are represented by seven types, of which A, E', C and D involving five pairs bear secondary constrictions. The type A is with supernumerary constrictions.

5) "Washington":

Chromosome length ranges from 2.25 to 4.25 μ (Table 6 and Figs. 11 and 12).

Chromosomes are represented by four types of which one (E) involving three pairs bears secondary constrictions. No supernumerary constriction has been detected.

Table 2. "Bangalore"

Chromosome pairs	Type	Mean length μ	Relative length	Constrictions
1	A	3.25	100	sm (sup)
2	C	2.75	84.62	sm (sec)
3	E	1.75	54.15	sm (sec)
4	F	1.75	54.15	m
5	F	1.50	46.15	m
6	G	1.50	46.15	sm
7	H	1.25	38.46	m
8	H	1.25	38.46	m
9	H	1.25	38.46	m

Table 3. "Honey Dew"

Chromosome pairs	Types	Mean length μ	Relative length	Constrictions
1	A	3.00	100	sm (sup)
2	B	2.75	91.66	sm (sec)
3	E	2.75	91.66	sm (sec)
4	G	2.25	75.00	sm
5	E	2.25	75.00	sm
6	G	2.00	66.66	sm
7	F	2.00	66.66	m
8	F	2.00	66.66	m
9	H	1.50	50.00	m

Table 4. "Ranchi"

Chromosome pairs	Types	Mean length μ	Relative length	Constrictions
1	A'	2.50	100	sm (sup)
2	C	2.50	100	m (sec)
3	E	2.37	94.80	sm (sec)
4	C	2.25	90.00	m (sec)
5	F	2.00	80.00	m
6	F	1.50	60.00	m
7	G	1.52	60.00	sm
8	H	1.25	50.00	m
9	H	1.00	40.00	m

Table 5. "Ceylon"

Chromosome pairs	Types	Mean length μ	Relative length	Constrictions
1	A	3.25	100	sm (sup)
2	E'	3.00	92.30	sm (sec)
3	C	3.00	92.30	m, sm (sec)
4	D	2.50	76.92	m, sm (sec)
5	C	2.50	76.92	m, sm (sec)
6	F	2.25	69.23	m
7	F	2.25	69.23	m
8	G	2.00	61.33	sm
9	H	1.50	46.13	m

Table 6. "Washington"

Chromosome pairs	Types	Mean length μ	Relative length	Constriction
1	E	4.25	100	sm (sec)
2	E	4.00	94.11	sm, m (sec)
3	E	3.25	76.47	sm (sec)
4	F	3.25	67.47	m
5	G	3.00	70.59	sm
6	F'	2.75	64.70	m
7	F	2.75	64.70	m
8	F	2.25	52.94	m
9	F'	2.25	52.94	m

Discussion

Chromosome structure, varieties and sexes

The purpose of the present cytological study was to obtain detailed information on the somatic chromosomes of the different common Indian varieties of *Caria papaya*, which had not yet been studied previously in detail.

All the five varieties examined critically have eighteen chromosomes, agreeing with the previous observations (Asana and Sutaria 1929, Eichhorn 1937, Kumar and Abraham 1942). It is evident that the five varieties are cytologically stable. A glance at the karyotype of different varieties indicates their homogeneity. All the varieties have median to submedian primary constrictions. Most of the varieties have considerably high number of chromosomes with secondary constriction, generally including one pair with a supernumerary constriction. Chromosomes of all the varieties are in general short. Size difference among the chromosomes of a variety is not pronounced.

In spite of this homogeneity, the varieties have distinctive features. "Bangalore" possess the shortest chromosome length having secondary constrictions in three pairs one being with supernumerary constriction. The varieties "Honey Dew" and "Ranchi" possess secondary constrictions in eight chromosomes (involving one pair with supernumerary constrictions). "Ceylon" has secondary constrictions in five pairs (one with supernumerary). "Washington" having the longest chromosomes, bears three pairs of secondary constrictions. No supernumerary constriction has been noticed. Chromosome types are different in different varieties, which are as follows :

"Bangalore" : 2A, 2C, 2E, 4F, 2G, 6H

"Honey Dew" : 2A, 2B, 4E, 4F, 4G, 2H

"Ranchi" : 2A, 4C, 2E, 4F, 2G, 4H

"Ceylon" : 2A, 4C, 2D, 2E', 4F, 2G, 2H

"Washington" : 6E, 6F, 4F', 2G.

If chromosomes are arranged from the longest to the shortest types in the

varieties, each of the varieties will represent different sequence. "Bangalore"—A, C, E, F, F, G, H, H, H. "Honey Dew"—A, B, E, G, E, G, F, F, H. "Ranchi"—A', C, E, C, F, F, G, H, H. "Ceylon"—A, E', C, D, C, F, F, G, H. "Washington"—E, E, E, F, G, F', F, F, F'.

In all the varieties, chromosome types are found in regular pairs. No heteromorphic pair or a single unpaired chromosome or any extra chromatin body could be recognized in any somatic cell of any variety studied. Therefore, no chromosomal basis of sexes and inter-sexes could be found. The sex determining factors are probably related to some cytoplasmic micromolecular bodies, undetectable by ordinary cytological techniques.

Role of structural change of chromosomes

Variation in structure of chromosomes which involves difference 1) in position of primary constrictions, 2) in position of secondary constrictions, 3) in the morphology of the chromosomes bearing supernumerary constrictions, 4) in number of chromosomes having secondary constriction and 5) in total chromosome length, indicates clearly that structural change of chromosomes has played an important role in the evolution of the varieties. Such structural changes are generally brought about by translocation, inversion, deletion, etc. Chromosomes changed in this way may gradually be rendered homozygous by continued selection and intensive cultivation.

Status of evolution of varieties

From the details of chromosome morphology, it appears that almost all the varieties of *Carica papaya* have reached quite an advanced position in their history of evolution. Presence of many chromosome pairs with secondary and supernumerary constrictions is a clear indication of advancement. It is very difficult to ascertain which of these varieties is more advanced than others, and which is the most primitive among them.

From the chromosome length only, the variety "Washington", possessing the longest total chromosome length, appears to be most primitive. Its primitiveness is further supported by the absence of supernumerary constriction, found in other varieties, and generally median to nearly median primary constriction. The number of chromosome bearing secondary constriction is also highest in this variety. The variety "Bangalore", having the shortest total chromosome length seems to be more advanced than others. It possesses chromosomes bearing supernumerary constriction and median to nearly submedian primary constriction. Of course, the number of secondary constrictions in this variety is lower than that in "Honey Dew", "Ranchi" and "Ceylon". Though generally the high number of secondary constriction is regarded as an advanced character, the possibility of reduction of secondarily constriction through deletion cannot be precluded. A glance of the Tables 2 to 6 will show that in comparison with other varieties the relative lengths of chromosomes of "Bangalore" represent some abrupt change in the second

and third pairs. This size difference is also an indication of advanced position. The other varieties such as "Honey Dew", "Ranchi" and "Ceylon" are intermediate between "Washington" and "Bangalore" in their total chromosome length and the median to submedian primary constriction. Number of secondary constriction is almost the same in these three varieties. Within these three varieties again "Ceylon", with the longest chromosomes, is probably least evolved, while "Ranchi", with the shortest chromosomes, is the most evolved variety.

Summary

Five horticultural forms of *Carica papaya* growing in India have been studied. Karyotypes of them represent homogeneity. Slight structural difference in chromosomes of different varieties is noticed, which proves the role of structural alteration of chromosomes on the evolution of the forms. No heteromorphic pair, or unpaired chromosome or any chromatin body, suggesting chromosomal basis of sex difference in the species, could be recognized.

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