



ICMR BULLETIN

Vol. 25, No. 11

November, 1995

STUDIES ON THE NATURE AND UTILIZATION OF CARBOHYDRATES CONTAINED IN PULSES

Pulses and *dhals* have always been important ingredients in Indian traditional diets. Inclusion of pulses ensures adequate dietary protein intake among populations in the developing countries. Studies reported hitherto generally considered protein content or its quality in pulses for their supplementary effect on cereal proteins. Some information on the presence of antinutritional factors such as trypsin inhibitors¹ and non-reducing sugars² in pulses is available.

In the developing countries most of the dietary calories are derived from carbohydrates of cereals, pulses and tubers. The carbohydrate content reported for cereals ranges from 68-78 per cent, tubers 33-35 per cent and pulses 57-60 per cent but these values were obtained by difference after accounting for protein, fat, fibre and minerals³. There is a popular belief that pulses are less digestible and that their consumption leads to flatulence. There is, however, little information on the nature of these carbohydrates and efficiency with which they are utilized. Studies carried out at the National Institute of Nutrition (NIN), Hyderabad, on the nature and digestibility of carbohydrates in the four commonly consumed pulses^{4,5} viz. Bengal gram, green gram, red gram and black gram have provided scientific data on relative merits of these pulses with regard to their carbohydrates.

In vitro Studies on Carbohydrate Digestibility

Raw and cooked pulses in the form of homogenous slurries were subjected to *in vitro* digestion with α -amylase. This enzyme hydrolyses starch to yield maltose by splitting

1-4 linkages of the polysaccharide. The pulses studied showed distinct differences in their *in vitro* digestibility. Carbohydrates of green gram were hydrolyzed more rapidly as compared to those of other pulses viz. red gram, black gram and Bengal gram (Fig.1). Cooking improved the rate of α -amylolysis (digestion with α -amylase) of all pulses. However, green gram still maintained its superiority over other pulses in terms of rapid digestion of its carbohydrates.

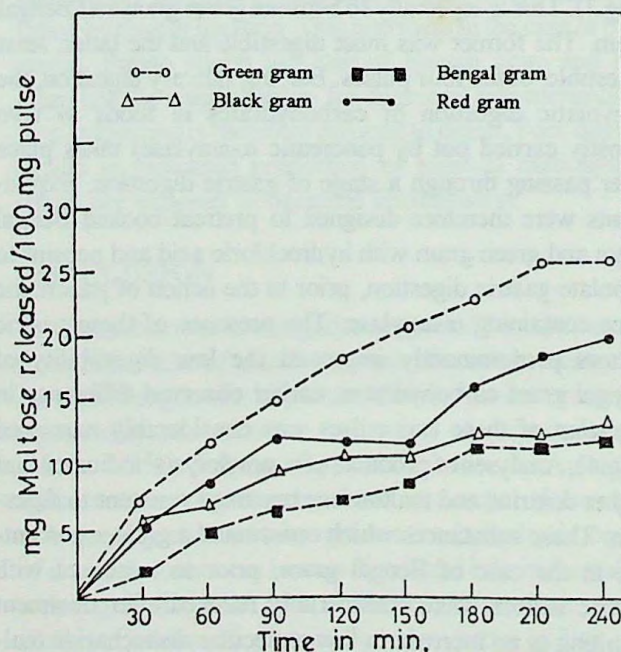


Fig.1. α -amylolysis of raw pulses

Even the isolated raw starches from these pulses showed similar differences (Fig. 2). Cooked starches were, however, easily hydrolyzed by α -amylase almost at the same rate.

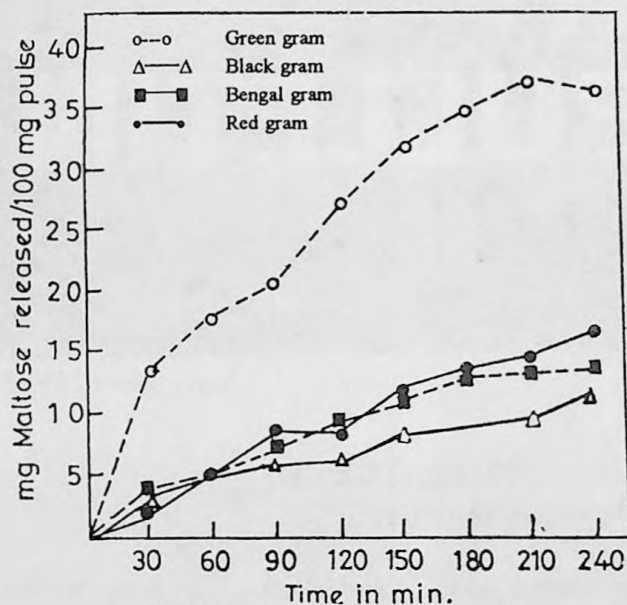


Fig. 2. α -amylolysis of raw starches

Role of Gastric Factors

The manner of distribution of starches in pulses in relation to other components in their native form is important. This could perhaps be a contributing factor for the observed differences in their digestibility after cooking (Fig. 3). This is especially so between green gram and Bengal gram. The former was most digestible and the latter, least digestible, of the four pulses. Barring salivary digestion, the enzymatic digestion of carbohydrates in foods *in vivo* (mostly carried out by pancreatic α -amylase) takes place after passing through a stage of gastric digestion. Experiments were therefore designed to pretreat cooked Bengal gram and green gram with hydrochloric acid and pepsin⁶ to simulate gastric digestion, prior to the action of pancreatic juice containing α -amylase. The presence of these gastric factors predominantly improved the low digestibility of Bengal gram carbohydrates; earlier observed difference in digestion of these two pulses was considerably narrowed (Fig. 4). Analyses of products of α -amylolysis⁷ indicated that higher dextrans and maltotriose remained resistant to digestion. These substances which constituted a greater percentage in the case of Bengal gram, prior to treatment with gastric factors, were considerably reduced after treatment resulting in an increase in low molecular disaccharide maltose. These experiments clearly indicate the influence of

gastric factors such as HCl and pepsin on the digestion of carbohydrates.

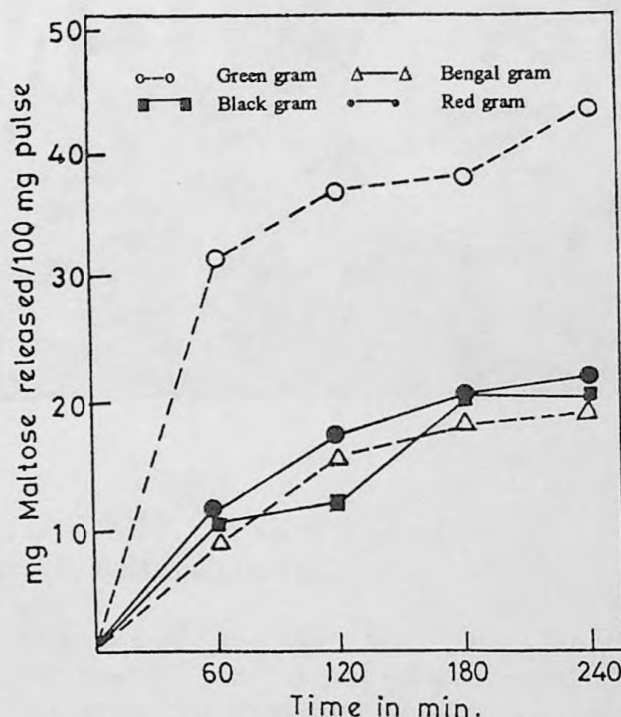


Fig. 3. Effect of cooking on α -amylolysis of pulses.

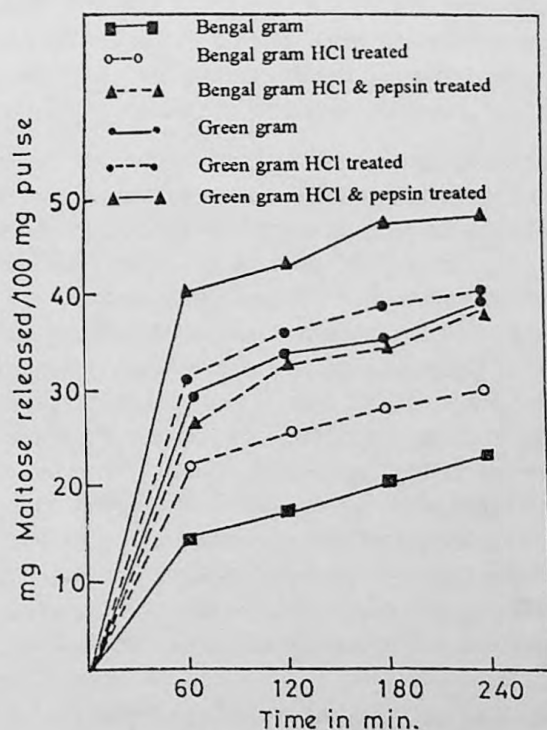


Fig. 4. Effect of HCl and pepsin on α -amylolysis of Bengal gram and green gram

Utilization of Carbohydrates of Green Gram and Bengal Gram *In vivo* in Children

Studies were undertaken to determine the efficacy of utilization of carbohydrates of green gram and Bengal gram *in vivo* in children. Subjects aged 3 to 4 years (using crossover design) were given cooked homogenous slurry from Bengal gram and green gram and the carbohydrate tolerance test was performed. The per cent increase in blood sugar level (peak value) over fasting level in children fed green gram was significantly higher compared to that observed on feeding Bengal gram (Table I). Further, in six of the eight children examined, peak blood glucose level was attained at 30 min in the case of green gram. With Bengal gram, in 4 of the 8 children, glucose peak occurred at 60 min. These studies indicate poorer utilization of carbohydrates of Bengal gram for energy purposes.

Table I. Blood glucose in children fed Bengal gram and green gram.

Subject	Bengal gram	Green gram
1.	14.46	16.67
2.	17.28	53.40†
3.	15.38	30.77
4.	25.00†	39.30
5.	22.84†	31.58
6.	4.55	18.60
7.	15.38†	25.63†
8.	13.22†	13.22
Mean	16.01	28.65
± SE	2.201	± 4.689*

† Peak level was reached later than 30 min. after pulse meal.

Values are the percentage increase over fasting levels.

* $P < 0.05$

Nature of the Starch Component in Pulses

Percentage of linear chain fraction of starch (amylose) from these pulses was determined⁸ to explain the difference in the rates of α -amylolysis of isolated starches using the standard potentiometric titration procedure. It was evident that linear fraction of starch in easily digestible cereals like rice constituted to the extent of 20 per cent whereas it varied from 35 to 46 per cent in the case of pulses. Amongst the four pulses studied, the better digestible starches from green gram and red gram had 35 and 38 per cent amylose

respectively. As against this, black gram and Bengal gram showed amylose values like 44 to 45 per cent respectively.

Apart from the amount of amylose present in starch, its chain length in terms of total glucose residues also is of importance. This latter characteristic of starch seems to influence its digestion. Degree of polymerization of amylose moiety isolated from these pulses indicated that Bengal gram and black gram had chain length 3-6 times higher compared to green gram (Table II).

Table II. Amylose and chain length (degree of polymerisation) of amylose.

Source	Amylose (% linear fraction)	Degree of Polymerisation (No. of glucose residues/amylose unit)
Bengal gram	45.81	1667
Green gram	35.01	667
Red gram	38.01	540
Black gram	43.86	4000

Consumption of pulses is also known to cause flatulence. Non-reducing sugars, such as, raffinose, stachyose and verbascose, present in the pulses were implicated in the production of flatulence⁹. Concentration of these non-reducing sugars could not be considered as the sole contributory factor for higher flatulence seen with Bengal gram. Poorer digestibility of carbohydrates of Bengal gram compared to other pulses, is the primary cause for flatulence. Lower digestibility of starches can lead to their bacterial fermentation by the gut bacteria. This is evident in the case of potato starch. Potato starch like that of Bengal gram and black gram has also higher value for degree of polymerisation of its amylose and is therefore difficult to digest. Poor digestion results in increased proportion of residual carbohydrates which are exposed to bacterial fermentation.

CONCLUSION

Data from the investigations reported here indicate that the composition of starch in terms of amylose content and its chain length are important factors in determining the digestibility and effective utilization of carbohydrates in pulses. These findings support the view that qualitative differences among starchy foods are major determinants affecting digestion and absorption of carbohydrates, because of starch dominance in human diets¹⁰ and help in formulating weaning foods based on specific pulses to ensure not only adequate intake of protein but also better utility of its carbohydrates as sources of energy. Detailed studies have

brought out the superior quality of carbohydrates in green gram. Going by the chemical nature of the carbohydrates, red gram also appears to be equally promising. These investigations also provide valuable information for formulating pulse-based weaning foods. For infants who suffer from poor gastric digestion, formulations based on green gram could be a good choice.

References:

1. Sohonie, K. and Bhandarkar, A.P. Trypsin inhibitors in Indian foodstuffs. Part II. Inhibitors in pulses. *J Sci Ind Res (India)* 14C: 100, 1955.
2. Nigam, V.N. and Giri, K.V. Sugars in pulses. *Can J Biochem Physiol* 39: 1847, 1961.
3. Gopalan, C. Ramasastri, B.V., and Balasubramaniam, S.C. *Nutritive value of Indian Foods*. Revised and updated by B.S. Narsinga Rao, Y.G. Deosthale and K.C. Pant. National Institute of Nutrition (ICMR), Hyderabad, 1989, p.47.
4. Srinivasa Rao, P. Studies on the digestibility of carbohydrates in pulses. *Indian J Med Res* 57: 2151, 1969.
5. Srinivasa Rao, P. Nature of carbohydrates in pulses. *J Agr Fd Chem* 24: 948, 1976.
6. Oser, B.L. In: *Hawk's Physiological Chemistry*. 14th ed. Ed. B.L. Oser. Academic Press, New York, 1965, p.47.
7. Williams, K.T., and Arthur, B. The chromatographic examination of sugars in wheat flour. *Cereal Chem* 28: 416, 1951.
8. Schoch, T.J. Iodimetric determination of amylose. *Methods Carbohydr Chem* 4: 157, 1964.
9. Murphy, E.L. Proceedings of the 6th Research Conference on Dry Beans. Los Angeles, California. *USDA Report WUEDD*, 1963, p.30.
10. Bjorck, I., Grandtelt, Y., Liljeberg, H., Tovar J. and Asp, N.G. Food properties affecting the digestion and absorption of carbohydrates. *Am J Clin Nutr* 59: 6998, 1994.

This write-up has been contributed by Dr. P. Srinivasa Rao, Dy. Director, National Institute of Nutrition, Hyderabad.

ABSTRACTS

Some Research Projects Completed Recently

Functional value of nerve decompression in leprosy patients.

The nerves of 34 patients of leprosy with nerve involvement ranging from 22 days to 7 years were subjected to nerve decompression to assess its benefit in terms of symptomatic relief and improvement in functions/sensitivity of the affected part (foot and hand). Due to difficulties in evaluation of nerve damage and improvement, children below 10 years of age were excluded from the study. Twenty five nerves were subjected to nerve decompression alone under local anaesthesia, while the other 25 nerves were treated with intralesional corticosteroid injection intraoperatively, followed by 2 injections at weekly intervals postoperatively. Postoperative recovery of function was assessed at the end of 6 weeks. Sweat prints of the affected part i.e palm/foot were taken preoperatively and 6 weeks postoperatively to assess the enhancement of sweat secretion.

Neurological involvement was observed more often in the tuberculoid leprosy patients (88.23%) and least in the lepromatous patients (5.9%). Loss of sweat secretion and nerve thickening was seen in all patients. Nerve pain and

tenderness were seen (in 84% and 94% patients respectively) in the majority.

Improvement in nerve function was observed in most of the nerves subjected to nerve decompression. The nerves subjected to intralesional steroid injection had better improvement in nerve function. Deterioration or no change in nerve function was observed in nerves with a long duration of nerve involvement and presence of nerve abscesses. Lesser the duration of nerve involvement better was the recovery following either nerve decompression alone or when combined with intralesional steroids. The best results were obtained when nerve involvement was of less than 6 months duration. Marked relief in pain was observed in all nerves subjected to nerve decompression. Enhancement in sweat secretion from the preoperative status was noticed in both the groups which was more marked in patients given steroids. However, the amount of sweat secretion did not reach normal level in either group during the study.

V.K. Sringesh
N.C. Padhi
Department of Surgery
M.K.C.G. Medical College
Berhampur.

Immunocytochemical localization and biochemical estimation of peptide hormone binding capacity of breast tissue.

The study was carried out to examine immunohistochemically detectable prolactin (PRL), follicular stimulating hormone (FSH) and leutinising hormone (LH) binding sites in various breast lesions using a highly sensitive modified dinitrophenyl hapten sandwich staining procedure and biochemically estimating PRL binding in particulate membrane preparations of breast tissue.

One hundred and seven formalin fixed paraffin embedded breast tissue sections were immunostained for localisation of prolactin binding sites in benign and malignant breast lesions. Of these, 35 and 28 sections were also stained for FSH and LH binding sites respectively. Eighty two per cent of breast carcinoma gave an intracellular positive reaction in tissue sections for prolactin binding sites, but the positivity was 72 per cent in fine needle aspiration smears.

In an attempt to biochemically quantitate prolactin receptors, both purified and crude plasma membranes of tissues from benign and malignant lesions, were prepared. Breast carcinoma showed more consistent staining as compared to benign breast lesions. Also, prolactin receptors could be located biochemically in malignant breast tissue

membrane preparations. Prolactin binding sites were present in greater proportion in peri or post menopausal breast cancer patients.

It is thus concluded that the more consistent immunostaining in breast carcinoma as compared to benign breast tissues as well as presence of PRL receptor in crude membrane of breast-carcinoma tissue suggest the role of PRL in mammary tumourigenesis. The results of immunocytochemistry on FNAC smears were comparable with that of histologic sections. FNAC being economical, quick and a nonoperative procedure, could be more easily used for study of hormone binding sites in breast lesions.

Sandeep Kumar
Department of Surgery
Maulana Azad Medical College
New Delhi

Publications:

1. Agarwal, P.K. Tandon, S., Agarwal, A.K. and Kumar, S. Highly specific sites of prolactin binding in benign and malignant breast tissue. *Indian J Expt Biol* 27: 1035, 1989.
2. Tandon, S., Agarwal, P.K., Mishra, L., Goel, A. and Kumar, S. Immunocytochemical detection of prolactin binding sites in fine needle aspiration smears of breast tissue lesions. *Indian J Med Res* 98: 161, 1993.

ICMR NEWS

The IX meeting of the Directors of the ICMR Institutes/Centres located in different parts of India was held at New Delhi on October 29 and 30, 1995.

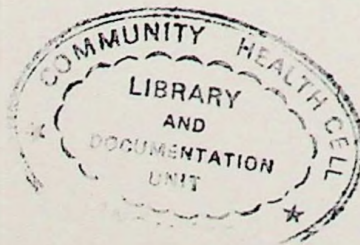
Meetings:

An Expert Group Meeting on Training Modules for the Modified Project on Integrated Delivery of Reproductive Health Care Services at the District Level, was held at New Delhi (October 18, 1995).

Participation of ICMR Scientists in Scientific Events:

Dr. S. Radhakrishna, Director, Institute for Research in Medical Statistics, Madras, served as a Short-term WHO Consultant on Tuberculosis in Phillipines for one month (w.e.f. October 11, 1995).

Dr. G.V. Satyavati, Director-General, ICMR, chaired the Concluding Session of the Seminar on Policy Implications and Action Plan Based on National Family Health Survey at New Delhi (October 21, 1995). She also delivered the Inaugural Address of the Symposium on U.N. Brahmachari and Perspective of Kala-azar Research at Calcutta (November 3, 1995).



ICMR AIDED SYMPOSIA/SEMINARS/WORKSHOPS/COURSES/CONFERENCES

Symposium/Seminar/Workshop/ Course/Conference	Date & Place	Contact Address
XXVI Annual Conference of the Endocrine Society of India.	December 1-3, 1995; (at Ahmedabad)	Dr. J.M. Bhatavdekar, Organising Secretary, ESICON-1995, Division of Molecular Endocrinology, The Gujarat Cancer Society, Ahmedabad.
International Symposium on Radiomodifiers in Human Health.	December 28-31, 1995; (at Manipal)	Prof. P. Uma Devi, Convenor, ISRHH, Department of Radiobiology, Kasturba Medical College, Manipal.

COUNCIL'S TRAINING PROGRAMMES

Reproductive Biology

At the Institute for Research in Reproduction, Bombay:

- Training Course on Techniques in Immunology, Cell Biology and Molecular Biology (November 5-25, 1995).
- Training Course on Techniques in Neuroendocrine Research (February 6-10, 1996).

Nutrition

At the National Institute of Nutrition, Hyderabad:

- Annual Training Course in Nutrition (December 1, 1995 - February 28, 1996).

Occupational Health

At the National Institute of Occupational Health, Ahmedabad:

- Orientation Course on Occupational Health for Industrial Medical Officers (November 13-24, 1995).
- Training Course on Air Pollution Monitoring and Risk Assessment (December 13-19, 1995).

Laboratory Animal Technology

At the Laboratory Animal Information Services Centre, National Institute of Nutrition, Hyderabad:

- Training Course for Laboratory Animal Supervisors (September 4 - November 30, 1995).

ICMR PUBLICATIONS

	Price (Rs.)
Nutritive Value of Indian Foods (1985), by C. Gopalan, B.V. Ramasastri and S.C. Balasubramaniam, Revised and Updated (1989), by B.S. Narasinga Rao, K.C. Pant and Y.G. Decsthale (Reprinted 1995)	25.00
Growth & Physical Development of Indian Infants and Children (1972, Reprinted 1989)	10.00

Studies on Weaning & Supplementary Foods (1974, Reprinted 1986)	6.00
Studies on Pre-School Children (1974, Reprinted 1984)	6.00
A Manual of Nutrition (Second Edition 1974, Reprinted 1992)	4.50
Low Cost Nutritious Supplements (Second Edition 1975, Reprinted 1994)	4.00
Menus for Low Cost Balanced Diets and School Lunch Programmes Suitable for South India (Third Edition 1977, Reprinted 1991)	4.50
Menus for Low Cost Balanced Diets and School Lunch Programmes Suitable for North India (Second Edition 1977, Reprinted 1994)	4.50
Some Common Indian Recipes and their Nutritive Value (Fourth Edition 1977, Reprinted 1991) by Swaran Pasricha & L.M. Rebello	10.00
Nutrition for Mother & Child (Third Edition 1978, Reprinted 1991) by P.S. Venkatachalam & L.M. Rebello	9.00
Japanese Encephalitis in India (Revised Edition 1980)	5.00
Some Therapeutic Diets (Fourth Edition 1988, Reprinted 1995) by Swaran Pasricha	4.50
Nutrient Requirements & Recommended Dietary Allowances for Indians (1990, Reprinted 1994)	14.00
Fruits (1983, Reprinted 1992) by Indira Gopalan & M. Mohan Ram	7.00
Count What You Eat (1989, Reprinted 1991) by Swaran Pasricha	9.00
Diet & Diabetes (Second Edition 1993) by T.C. Raghuram, Swaran Pasricha & R.D. Sharma	18.00
Dietary Tips for the Elderly (1992, by Swaran Pasricha & B.V.S. Thimmayamma	3.50
Diet and Heart Disease (1994) by Ghafoorunissa and Kamala Krishnaswamy	26.00
*Depressive Disease (1986) by A. Venkoba Rao	58.00
**Medicinal Plants of India Vol.2 (1987)	136.00
**The Anophelines of India (Revised Edition 1984) by T. Ramachandra Rao	150.00

*10 per cent discount allowed to individuals.

**25 per cent discount allowed to individuals.

Unpriced Publications (for limited distribution)

Proceedings of the Indo-UK Workshop on Leishmaniasis (1983)
Collaborative Study on Blindness, 1971-74 (1987)

Endomyocardial Fibrosis in India (1983)

Epidmiological Survey of Endemic Goitre and Endemic Cretinism (1989)

Illegal Abortion in Rural Areas (1989)

Collaborative Study on Phenomenology and Natural History of Acute Psychosis (1989)

Melatonin (1991) by S. Parvathi Devi

Field Supplementation Trial in Pregnant Women with 60 mg, 120 mg and 180 mg of iron with 500 µg of Folic Acid (1992).

These publications are available on prepayment of cost by cheque, bank draft or postal order (bank and postal charges will be extra) in favour of the Director-General, Indian Council of Medical Research, New Delhi. Money orders are not acceptable. All correspondence in this regard should be addressed to the Chief, Division of Publication and Information, Indian Council of Medical Research, Post Box No.4911, Ansari Nagar, New Delhi-110029 (India).

EDITORIAL BOARD

Dr. G.V. Satyavati	 Chairperson
Dr. Badri N. Saxena	 Member
Dr. N. Medappa	 Editor

Printed and Published by Shri J.N. Mathur for the Indian Council of Medical Research, New Delhi
at the ICMR Offset Press, New Delhi-110029

R.N. 21813/71