Public Health Implications of Pesticide Residues in Meat

Vijay J. Jadhav*[1] and Vikas S. Waskar[2]

1 College of Veterinary Sciences, CCS Haryana Agricultural University,
Hisar- 125004, Hayrana. India. * Corresponding author email: vetviju@gmail.com
2 College of Veterinary and Animal Sciences, Udgir, Dist-Latur 413 517. vikaswaskar@gmail.com

Abstract

Use of pesticides in India began in 1948 when DDT was imported for malaria control and BHC for locust control. Since then various synthetic pesticides are used for protection of crops and public health. The persistence nature of some of these pesticides led to their accumulation in animal tissues and subsequently causes human dietary exposure to these pesticides through consumption of animal products viz. meat, milk, eggs and seafoods. Scientific evidence suggest that even such low dose but long term exposure can cause serious health hazards to human health and environment as well. The reports on occurrence of pesticides residues in animal products manufactured in India are fragmentary, but provide confirmation to the fact Indian consumers do get dietary exposure to these pesticides. The role of Insecticide Act and Prevention of Food Adulteration Act enforced in India for judicious pesticide use and safety of consumers of animal products is discussed.

Keywords: Pesticide, Public Health, Pesticide residue, Meat, Animal Products, Environment pollution.

Introduction

India, after independence, has to meet with most difficult challenge of overcoming the problem of long-standing food crisis owing to rapidly growing population. For attaining self-sufficiency in food grain production, Government of India played a pivotal role on the agricultural front by providing overall leadership and co-ordination as well as by providing a significant part of the financing for agricultural programs. India's agricultural growth strategy, after independence, was mainly evolved after second Five-Year Plan. India's economic development during fourth to sixth five year plan is identified predominantly as the Green Revolution. Many modern agricultural implements, new varieties of generic seeds and financial assistance were made available to farmers that increased the yield of food crops such as wheat, rice and corn, as well as commercial crops like cotton, tea, tobacco, and coffee. This intensive agriculture with judicious use of inputs like fertilizers, new seed varieties and water etc. was successful in meeting the goals of self-sufficiency in food-grain production and adequate buffer stocks by the end of the 1970s with imports being negligible.

Intensive agricultural production, however, was not sufficient to meet the requirement for the swelling population of India mainly due to production losses during growing, harvesting and storage. Nearly 60,000 species of invertebrate pests and plant diseases in the field and storage, and 8000 species of weeds compete with man to incur a loss of 40 per cent of the production (Oerke et al., 1994). Although several eco-friendly technologies viz, integrated pest management system, use of neem based insecticides and other biopesticides are available for pest management, farmers rely mostly on the chemical pesticides because of their easy availability, immediate and spectacular effect (Little, 1996). In addition, these pesticide chemicals have contributed a lot to the betterment of human health through the control of vectors of dreaded diseases like malaria, typhus etc. (Bindra and Kalra, 1973).

The positive side of the use of pesticides include enhancement of economic potential in terms of increased production of food and fiber as well as prevention of vector-borne diseases, whereas on the negative front this resulted in serious health implications to man and his environment in the form of variety of known and unknown toxic symptoms. Therefore, the thrust of this discussion will be to review the causes for occurrence of pesticide residues, health hazards associated with dietary exposure of pesticides, Indian scenario for pesticide residues in meat and prevention and control strategies for occurrence of pesticide residues in animal products.

Causes and concerns of pesticide residues

The principal sources of pesticide residues in crops, food animals, soil, water and almost all food commodities are given below (Mukherjee and Gopal, 1996):

1. Carry-over from insecticide application to soil or to growing crops
2. Leaching of pesticides (herbicides) or insecticides into ground water
3. Drift of the pesticides from adjacent field
4. Translocation of soil applied pesticide into growing crops
5. Disposal of pesticides in streams, rivers and lakes
6. Effluents of pesticide industry in rivers and streams, and into soil which may be translocated in crops.

Pesticides along with certain environmental chemicals are known to cause endocrine disruption by mimicking or antagonising natural hormones in the body and it has been postulated that their long-term, low-dose exposure are increasingly linked to human health effects such as immunosuppression, hormone disruption, diminished intelligence, reproductive abnormalities and cancer (Crisp et al., 1998 and Hurley et al., 1998). A cytogenitic study conducted by Rita and coworkers (1987) on males associated with the spraying of pesticides in grape garden revealed a significant increase in chromatid breaks and gaps in chromosomes in the peripheral blood cells. However, the potential toxicity of residues still remained a matter of controversy. Although it is believed that adipose tissue acts as a protective reservoir, Dale et al. (1962) reported that p,p'-DDT residues in the adipose tissue can be mobilized during starvation, reach tissues such as brain and produce symptoms of neurotoxicity. Similarly, To-Figueras et al. (1988) compared kinetics of Hexachlorobenzene (HCB) and p,p'-DDE in rats before, during and after partial starvation and noted that food restriction produced a drastic mobilization of the residues stored in the adipose tissue resulting in symptoms of neurotoxicity. Furthermore, the redistribution was reversible and did not result in loss/excretion of the residues leading to their re-accumulation in the adipose tissue.

Majority of the pesticides used for agricultural and domestic pest control purpose degrade rapidly in the environment, a few are trans-located from soil to plant tissues and then to animals where they have specific affinity for adipose tissue and ultimately lead to contamination of the livestock products (Peshin et al., 2002). Since livestock food constitutes significant part of human diet and human beings are placed at the top of most food chains, it is not surprising that high levels of these compounds have been found in human adipose tissue and milk fat (Kanja et al., 1986 and Jensen, 1983). Most of these pesticides are eliminated from the mammalian system more or less rapidly. To facilitate the clearance of such poorly excretable lipophilic pesticides, most organisms have a battery of enzymes that are specialized for the conversion of lipophilic materials to hydrophilic metabolites which can readily be eliminated by excretion in body wastes. The rate of elimination is a major factor governing the severity and duration of any toxic effects that may occur. Some products of pesticide metabolism are more toxic than the parent compound and are responsible for many of the undesirable toxic effects, both chronic and acute (Hollingworth et al., 1995).

Public awareness

The hazards involved in the use of pesticides were first highlighted to the public in the famous book, 'Silent Spring' by Rachel Carson in 1962, though many a scientists may question the content of this book saying that she drew incorrect conclusions from unrelated facts and made implications based on possibilities. In all fairness, the book had been most effective in influencing the public concern about the pesticides not only in USA but also in many other countries (Kashyap and Gupta, 1973). In India, the first report of poisoning due to pesticide was from Kerala in 1958, where over 100 people died after consuming wheat flour contaminated with parathion. This prompted the special committee on Harmful effects of pesticides constituted by Indian Council of Agricultural Research to focus further attention on the problem of pesticide residues in foods (Wadhwani and Lall, 1972).

Now a days common peoples especially belonging to urban population are well versed with impact of pesticide residues in food. Recent reports on the analysis of bottled water, colas and other soft drinks carried out by the Center for Science and Environment, New Delhi revealed very high content of pesticide residues (Anonymous 2003 a, b and c) which in turn led to a major issue in nationwide media. It is important to note in this context that, the issue of risk from pesticide residues in food has put both government (politicians, international agencies and a host of expert committees) and the public in the dilemma. On the one hand, scientific community having knowledge and information on the hazard and the exposure, failed to present the significance of pesticide residues to the public in a rational way. The media on the other hand, quoted the selected publication containing limited information with biasness accompanied by exaggerated and scary headlines. Governments by their reluctance to explain

Table-1: Mean concentration of DDT and HCH (mcg/g wet wt) in meat collected from various locations in India.

Year	Location	DDT	HCH	References
1975-1976	Calcutta	1.5	1.2	Mukharjee et al. 1980
1979	Delhi	1.0	NA	Sharma et al., 1979
1979	Bombay	NA	0.6	Banerjee, 1979
1980-1981	Punjab	0.25	0.19	Singh and Chawla, 1988
1981-1983	Uttar Pradesh	0.24	0.20	Kaphalia et al., 1985
1989	Various states	0.1	0.48	Kannan et al., 1992

the lack of risk clearly and the media by their thirst for "braking news" are responsible for making the public to misunderstand the real significance of the risk from pesticide residues in food.

Pesticide residues in meat, poultry and fish: Indian scenario

Animal husbandry constitutes backbone of Indian farming, where animals are used as source of draft power as well as food in the form of milk, meat and eggs. India accommodates a huge livestock as 98 million buffaloes, 185 million cattle, 120 million goats, 62.5 million sheep, 14.3 million pigs and 430 million chickens (FAO. 2005). In 2002, the meat production of India was 5,561 thousand tones including 285 thousand tones of meat exported to various countries and rest 5,277 thousand tones was consumed locally (FAO, 2007). In the fiscal year 2005-06, India exported buffalo meat, sheep/goat meat and poultry products of Rs. 2629.56 crores, 80.37 crores and 167.58 crores, respectively (APEDA, 2007). These facts and figures underline the importance of meat and poultry in the trade.

However, the issue of chemical quality of these products is not well studied in India. In contrast to food grains, very little information is available on the contamination of meat and meat products, probably because of their lesser significance in Indian diet, which is predominantly vegetarian. Animal origin foodstuffs (meat, eggs and fish) accounts for only <5% of the total daily consumption. Studies on meat contamination in the 1970s indicated relatively low residues, at <1 mcg/g of DDT and HCH (Table 1), compared to agricultural products (Kalra and Chawla, 1985). Poultry eggs from Punjab, Bombay, Uttar Pradesh and Delhi contained < 1 mcg/g of both DDT and HCH and rarely exceeded the MRL. Similarly, goat, sheep buffalo, pig, chicken and fish tissue contained <1mcg/g of DDT and HCH. Among several meat products, greatest contamination was observed in chicken muscle followed by goat and beef collected in Lucknow, India (Kaphalia and Seth, 1981). In contrast, recent studies indicate that contamination of chicken, mutton and pork was greater than that of agricultural products, although residues were <1mcg/g (Kannan and coworkers 1992). Organochlorines in fish and prawns from various locations in India were least among different foodstuffs (Kannan and coworkers, 1995). However fish collected in River Yamuna in Delhi, which received discharges from a DDT factory, contained DDT at a mean concentration of 56 mcg/g (Agarwal et al., 1986). Similarly, fish from rural ponds that received agricultural runoff contained DDT and HCH at mean concentration of 7 and 6.3 mcg/g, respectively (Dua et al. 1996). This may imply localized contamination of aquatic products including fish. The occurrence pattern of organochlorine pesticide residues in adipose tissue, liver and kidney samples of goats, sheep and oxen collected from the local slaughterhouse in Bangalore, India were studied by Nath et al. (1998). DDT was in higher concentration in most of the tissues analyzed. The mean concentrations (mcg/g) of HCH, HCH, p,p'-DDE and DDT residues were 0.021, 0.057, 0.056 and 0.17 in adipose tissue; 0.006, 0.013, 0.005 and 0.110 in liver and 0.002, 0.004, 0.001 and 0.003 in kidney tissue respectively. Endosulphan was not detected in any of the sample. Recently, Aulakh et al. (2005) investigated occurrence of organochlorine pesticide residues in chicken muscle at a poultry farm in Punjab and found mean concentration of HCH, DDT, endosulfan sulfate and heptachlor epoxide residues to be 0.11, 0.24, 0.10 and 0.07 mcg/g respectively but none of the muscle samples exceeded maximum residue limits (MRL) for these organochlorine pesticides.

Prevention and control of pesticide residues in food

The Government of India has taken steps to ensure the safe use of pesticides. The Insecticide Act, promulgated in 1968 and enforced on 1st August, 1971 envisages to regulate the import, manufacture, sale, transport, distribution, and use of insecticides, with a

Table-2: PFA Maximum Residue Limits for pesticide residues in meat and poultry.

Sr. No.	Name of insecticide	Tolerance (ppm or mg/kg)
1.	Aldrin, dieldrin	0.20
2.	DDT	7.00
3.	Fenitrothion	0.03
4.	Lindane	2.00
5.	Chlorfenvinphos	0.20
6.	Chlorpyriphos	0.10
7.	2,4D	0.05
8.	Ethion	0.20
9.	Monocrotophos	0.02
10.	Trichlorfon	0.10
11.	Carbendazim	0.10
12.	Benomyl	0.10
13.	Carbofuran	0.10
14.	Cypermethrin	0.20
15.	Edifenphos	0.02
16.	Fenthion	2.00
17.	Fenvelerate	1.00
18.	Phenthoate	0.05
19.	Pirimiphos-methyl	0.05

view to prevent risks to human beings or animals, and for matters connected therewith. As on 28/12/2006, a total of 201 pesticides are registered under section 9(3) of this act. Thirty-eight pesticide/pesticide formulations have been banned for use to date and another 10 have been under restricted use. It was desirable as a prerequisite to the enforcement of Insecticide Act, to evaluate the magnitude of pesticide pollution in the country and related health hazards to ensure their safe use for the benefit of the society. ICMR's National Institute of Occupational Health (NIOH), Ahmedabad, and several other national laboratories, farm universities and other R & D organizations have been engaged in toxicological evaluation of pesticides, synthesis of safer molecules and evaluation of environmental contamination due to pesticides.

The control of risks from the use of pesticides for the protection of crops from pests and diseases is normally achieved nationally through the widely used pesticide registration procedures which identify and authorize the maximum registered use of pesticide which will satisfy the need for elaborative and reliable crop protection and at the same time, offer minimum risk to users and leave only resides in food and the environment that are toxicologically acceptable. Also statutory maximum residue levels for pesticides on agricultural commodities and in foods of animal origin have been defined in most countries including India to guarantee the consumer's safety and regulate the presence of pesticide residues in the environment. In India, the maximum residue limits for meat and poultry are provided for only 19 pesticides as per the Prevention of Food Adulteration Act and Rules as on 1.10.2004 (Table 2). The determination of pesticide residues is a requirement to support the enforcement of legislation, ensure trading compliance, conduct monitoring residue programmes in the dietary components and in the environmental samples, and to study their mode of action and movement within the environment (Fong et al., 1999). In India, work on monitoring of pesticide residues in various food commodities viz. fruits, vegetables, meat, eggs and seafoods has been recently initiated at National level by Indian council of Agricultural Research, New Delhi through their centers located in different parts of the country (Gupta, 2004).

Conclusions

Public concerns about the adverse environmental and human health impacts of pesticide residues led to strict regulations on their use in India two decades ago. Nevertheless, DDT and several other organochlorine pesticides are still being used for agriculture and public health programmes in India. As a consequence Indian consumers are exposed to greater dietary levels of these pesticides. The available information regarding pesticide residues in meat, poultry and fish products in India is very limited. Therefore the design and implementation of appropriate epidemiological studies and their integration with monitoring of samples from foods of animal origin as well as environmental samples would be a major step in assessing the risk of pesticide residues in meat and controlling or eliminating them. With the continued globalization of trade in animal food products and the concomitant risk that the food contamination through point-source pollution may be widely distributed, identification of sources and their control should be matters of international concern, research and action.

To sum up, based on our limited knowledge with indirect and/or inferential information, the domain of pesticides illustrates certain ambiguity of a situation in which people are undergoing life-long exposure. Therefore, there is every reason to develop health education packages based on knowledge aptitude and practices and to disseminate it within the community for minimizing human exposure to pesticides.

References

1. Agarwal, H.C., P. K. Mittal, K. B. Menon and M.K.K. Pillai (1986) DDT residues in the River Yamuna in Delhi, India. *Water Air Soil Pollut* 28: 89-104.
2. Anonymous (2003a). Pesticides in bottled water. The Times of India, New Delhi. 5th February.
3. Anonymous (2003b). Chew this: pesticides hit people, not pests. The Times of India, New Delhi. 16th April.
4. Anonymous (2003c). Colas fizz with pesticides. The Times of India, New Delhi 6th August.
5. APEDA (2007) Export statistics of meat and meat products from India. Agricultural and Processed Foods Export Development Authority, Downloaded from http://www.apeda.com on 5.5.2007.
6. Aulakh, R. S., et.al. (2005) Organochlorine pesticide residues in poultry feed, chicken muscle and eggs at a poultry farm in Punjab, *India. J. Sci. Food Agric*. 86: 741-744.
7. Banerji, S. A. (1979). Organochlorine pesticide residues. *Scavenger* 9: 2-7.
8. Bindra, O. S. and R. L. Kalra (1973) A review of work done in India on pesticide residues. In: Proceedings of the symposium on, "Progress and problems in pesticide residue analysis". Ludhiana. 18-19 November 1973. Pp 1-44.
9. Carson, R. (1962) Silent Spring. Houghton Mifflin, New York, USA.
10. Crisp, T. M.,et.al.(1998) Environmental endocrine disruption: An effects assessment and analysis. *Environ. Health. Perspect.* 106: 11.
11. Dale, W. E., B. Thomas, B. Gaines and W. J. Hayes (1962) Storage and excretion of DDT in starved rats. *Toxicol. Appl. Pharmacol.* 4: 89-106.
12. Dua, V. K., et.al.(1996) HCH and DDT contamination of rural ponds of India. *Bull Environ Contam Toxicol* 57: 568-574.
13. FAO (2005) FAO statistics on livestock population in India. Downloaded from http://faostat.fao.org on 5.8.2006.
14. FAO (2007) FAO statistics for production and consumption of meat in India. Downloaded from http://faostat.fao.org on 9.5.2007.
15. Figueras, J. T., J. Gomez-Catalan, M. Rodamilans and J. Corbella (1988) Mobilization of stored hexachlorbenzene and p, p'-dichlorodiphenyl- dichloroethylene during partial starvation in rats. *Toxicol. Lett.* 42: 79-86.
16. Fong, W. G, et.al. (1999) Pesticide residues in foods. Methods, techniques and regulations. New York: John Wiley & Sons. pp 339.
17. Gupta, P. K. (2004). Pesticide exposure: Indian scene. *Toxicology* 198: 83-90.
18. Hollingworth, R. M., et.al. (1995) Detection and significance of active metabolites of agrochemicals and related xenobiotics in animals. *Pure Appl. Chem*. 67: 1487-1532.
19. Hurley, P. M., R. N. Hill and R. J. Whiting (1998) Mode of carcinogenic action of pesticides inducing thyroid follicular cell tumors in rodents. *Environ. Health. Perspect*. 106: 437.
20. Jensen, A. A. (1983) Chemical contaminants in human milk. Res. Rev. 89: 1-128.
21. Kalra, R. L. and R. P. Chawla (1985). Pesticidal contamination in foods in the year 2000 AD. *Proc. Indian Natl Sci. Acad.* B52: 188-204.
22. Kanja, L. W., et.al. (1986) Organochlorine pesticides in human milk from different areas of Kenya 1983-1985. *J. Toxicol. Environ. Health.* 19: 449-404.
23. Kannan, K., S. Tanabe and R. Tatsukawa (1995). Geographical distribution and accumulation features of organochlorine residues in fish in tropical Asia and Ocenia. *Environ Sci and Technol* 29: 2673-2683.
24. Kannan, K., et.al. (1992b) Persistent organochlorine residues in foodstuffs from India and their implications on human dietary exposure. *J. Agric. Food. Chem*. 40: 518-524.
25. Kaphalia, B. S. and T. D. Seth (1981) DDT and BHC residues in some body tissues of goats, buffalo and chickens from Lucknow, India. *Pestic. Monit. J.* 15: 103-106.
26. Kaphalia, B. S., F. S. Siddiqui and T. D. Seth, (1982) Contamination levels in different food items and dietary intake of organochlorine pesticide residues in India. *Ind. J. Med. Res.* 81: 71-78.
27. Kasyap, S. K. and S. K. Gupta (1973) Review of pesticide toxicology in India. In: Proceedings of the symposium on, "Progress and problems in pesticide residue analysis". Ludhiana. 18-19 November 1973. Pp 1-44.
28. Little, D. L. (1996) Bracing the future. *Farm. Chem*. 10: 30-31.
29. Mukharji, I. and M. Gopal (1996) Chromatographic techniques in the analysis of organochlorine pesticide residues. *J. Chromatogra*. A, 754: 33-42.
30. Mukherjee, D., B. R. Roy, J. Chakraborty and B. N. Ghosh (1980) Pesticide residues in human food in Calcutta. *Ind. J. med Res.* 72-577-582.
31. Nath, S. B., V. Unnikrishnan, V. Gayathri, P. S. Chitra, C. N. Preeja and M. K. R. Murthy (1998) Organochlorine pesticide residues in animal tissues and their excretion through milk. *J. Food Sci. Technol*. 35: 547-548.
32. Nisha A. R.(2008) Antibiotic residues - A Global Health Hazard. *Veterinary World* 1(12): 375-377.
33. Oerke, E. C., H. W. Dehne, F. Schonbeck and A. Weber (1994) Crop production and protection- Estimated losses in major food and cash crops. Elsevier publications.
34. Peshin, S. S., S. B. Lall and S. K. Gupta (2002) Potential food contaminants and associated food risks. *Acta. Pharmacol. Sin.* 23: 193-202.
35. Rita, P., P. P. Reddy and S.V. Reddy (1987) Monitoring of workers occupationally exposed to pesticides in grape gardens of Andhra Pradesh. *Environ. Res*. 44: 1.
36. Sharma, R. C., M. Bhaskaran and N. K. Bhide (1979) A simplified chemical method of DDT estimation in the body fat. *Ind. J. Exp. Biol.* 17: 1367-1370.
37. Singh, P. P. and R. P. Chawla (1988). Insecticide residues in total diet samples in Punjab, India. *Sci. total Environ.* 76: 139-146.
38. Wadhawani, A. M. and I. J. Lall (1972) Harmful effects of pesticides. Report of the special committee of ICAR. Indian Council of Agricultural Research, New Delhi, pp 44.