Pesticides and Veterinary Drugs Residues in Conventional Meat: A Food Safety Issue

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Abstract: In the current scenario the most of people are well aware with health issues. Food safety is generally related with the quality of food i.e. whether the food product is standardised as according to national or international norms set by the statutory organisations. People can compromise with the nutritive values of food but not with their safety aspects. The meat and meat products carry the burden of harmful agents according to the production methods. Now-a-days the feedlot animals are being reared either through the natural farming (organic farming) or conventional farming method. Those methods produce safe and healthier meat because there is no use of harmful chemical agents' viz., pesticides, herbicides, hormones, growth promoters, veterinary drugs and etc. On the other hand, in the conventional farming, all these chemical agents are used to enhance animal growth. Several chemical agents like pesticides and veterinary drugs residues may cause harmful health implications viz., teratogenicity, carcinogenicity, hypersensitivity reactions, gut bacterial resistance, toxicity and many more health problems in human beings. It is the thrust of today to replace the conventional meat with the organic meat to check the use of harmful chemical agents for a healthy social life.

Keywords: Meat, organic farming, conventional farming, food safety.

INTRODUCTION

A very famous slogan of a biscuit manufacturing company, Britannia is "Eat Healthy Think Better" i.e. every human activity is the outcome of eating. So, to be healthy, it is necessary to take healthy food. Many countries set their own definition of healthy and unhealthy food [1]. The whole world have now paying attention for their health, even many countries have banned GM (Genetically modified) crops to reduce the safety risks of health. Among all the food related problems, food safety is a major issue to tackle out at present. Food safety is basically an approach to control the hazards to the consumers through several safety measures. The food safety issues are associated with conventional meat and their products. The veterinary drugs viz., antibiotics are used for prevention, therapy and as growth promoters in conventional livestock farming [2]. India has banned so many pesticides for manufacture, import and use, for example: Aldicarb, aldrin, Benzene Hexachloride, Dieldrin, Heptachlor, Lindane (Gamma-HCH) and etc. [3]. In the world mostly animal farming is carried out through conventional method. According to total U.S. beef sales in 2006, natural and organic beef production was only 1.1% of total beef production and remaining 98.90% is the conventional beef. The people have now become well aware for their health. In each and every country of world, there is a different statutory organisation to control the food safety issues at national level while at international level the standards are decided by the international statutory organisations like codex alimentarius commission, European Union. The per capita consumption of Total meat from 1965 (red meat and poultry meat) to 2014 is increasing annually [4]. In 1965, it was recorded as 178.4 pounds while it reached up to 202.3 pounds in 2014 while the per capita consumption in 2016 projected as 213.8 [4]. The World average meat consumption is 41.90 kg per person per year [5].

The meat consumption in India is increased from the year 2000 till the year 2009 but suddenly falls after 2009 to the 2011 (Figure **1**). It doesn't matter whether the per capita meat consumption is increasing or decreasing but the average per capita meat consumption is increasing. However, the total poultry meat consumption in India will increase from 687 million kilograms to 1,674 million kilograms till 2020 [6]. The per capita poultry meat consumption in India is increased from 0.8 kg to 2.8 kg during the year 2000 to 2012 [7]. The overall per capita meat consumption in the world is increasing (Figure **2**). The food habits of people are changing from the true vegetarian to omnivores therefore, there is a huge requirement and a moral duty or a big responsibility of the countries to provide the safe food by developing sanitize and hygienic process and technologies to the nations because of the safety of meat and meat products is very essential component of meat process industry.

In meat system the hazards can be discussed in the form of microbiological hazards and chemical hazards

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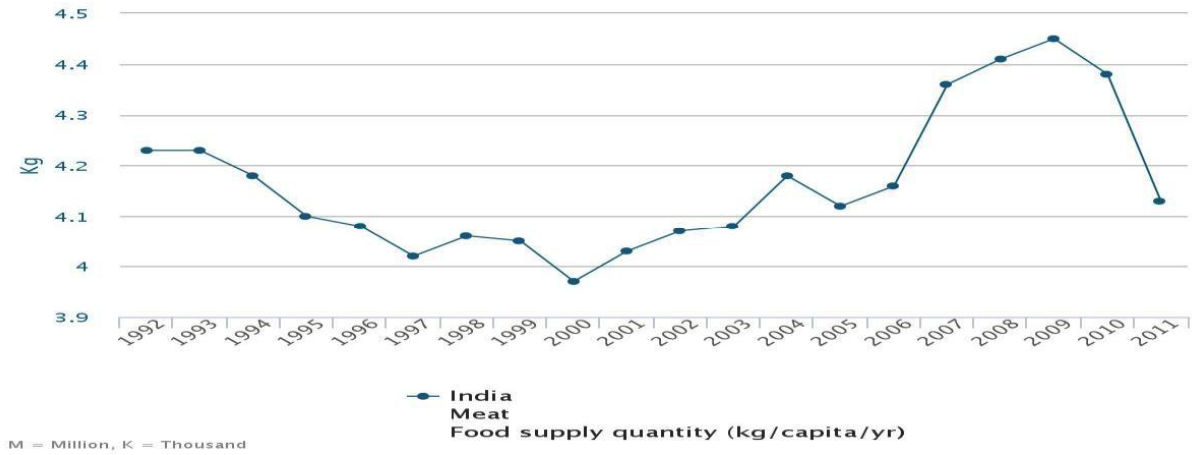


Figure 1: Statistical data of meat consumption in India by FAO-United nations.

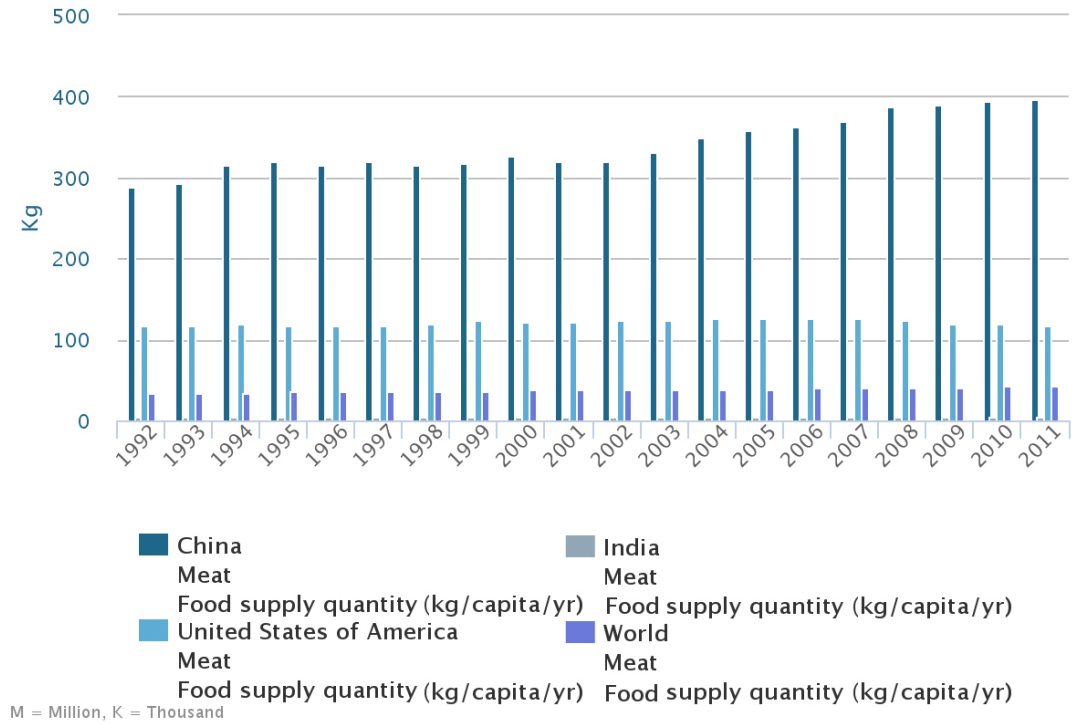


Figure 2: Comparative Data of Per Capita Meat Consumption by FAO-United Nations.

(pesticide hazards, heavy metal hazards, hazards with veterinary drugs, hazards with food additives, hazards with other chemical agents). In this text, food safety issues will be discussed in respect of pesticides hazards, veterinary drugs hazards and hazards with food additives (i.e. nitrite/nitrate) specifically in reference of meat system. The people are now becoming more and more health conscious and they can't compromise with the quality of food but nutrition value. Many categories of people groups feed specifically on meat to boost their strength i.e. athletes, wrestlers, bowlers, players of football and in many other games where a huge stamina is required because meat is the good source of protein percentage-wise and quality wise as well. So to provide a safe meat and their products to the consumers is a challenging job. To provide the momentum to the meat market and for the feel of wellness, meat process industries along with other food industries have now been implemented the hazard analysis critical control point approach (HACCP) as a preventive measures to control the food safety risks in meat and their products. To ensure the safety of meat and their products, statutory organisations viz., codex alimentarius commission, WHO/FAO has decided maximum residue limits of pesticide residues, veterinary drug residues

and standards limits of food additives. In India, to take food safety into account, the government has passed "food safety and standard act (FSSA)" in 2006 and enforced food safety and standard rules in 2011. In each and every country, the government policies play a critical role to ensure the establishment of food safety laws and policies in the country which ultimately is the starter for better food safety climate in the country which thereby reduce mortality and morbidity due to unsafe food.

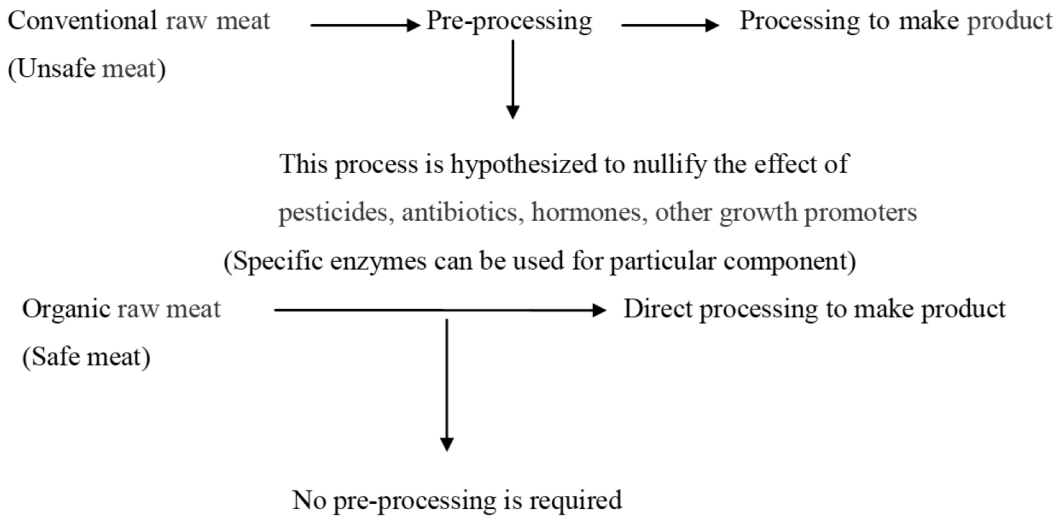
(A) Risk Associated with Conventional Meat

Several types of additives are used in processed meat products for different purposes. Sodium or potassium nitrite/nitrate provides preservative properties, and improves the taste and colour of the meat products. Nitrites produce the desired reactions much faster and are much more commonly used than nitrates. Sodium ascorbate, sodium phosphate and sodium hexa-meta phosphate are used as preservatives. Mono-sodium glutamate (MSG) used as a flavouring agent though it has been banned due to its harmful effect on human body but it is still in use in India and so many other synthetic additives are being used in meat product. The raw meat utilised for the preparation of processed meat products, is generally produced through conventional farming which allow use of antibiotics, hormones and several other chemicals to promote the growth of livestock. The raw meat is also producing through organic farming that prohibits the use of antibiotics, hormones and other growth promoters but in a very less amount. Though, there is no strong evidence to prove that organic meat is more or less safe than conventional meat in respect of microbial contamination [8, 9] or foodborne pathogens viz., *Campylobacter coli, Campylobacter jejuni, Listeria monocytogenes, Salmonella enterica and Yersinia enterocolitica* [10] and even no valid difference has been found till date in respect of flavour and nutritional quality between organic animal products and conventional animal products [11]. In this text the main focus will be on control organic farming. Though the information related to climate versus livestock system is very scarce [12] but few researchers have demonstrated that the environmental factors and outdoor grazing may play an important role to alter the quality of meat as the animal will be more prone to environmental factors that may affect the body metabolism and ultimately pose effects on muscles which can persist after slaughter [13]. A little difference among the pH value, colour and sheer force of meat has been registered irrespective of production system while a clear difference in fat profile observed i.e. organically reared animals during summer season have higher concentration of linoliec acid, omega 3 fatty acid and had a lower ratio of omega-6 to omega-3 fatty acids as compare to non-organic animals during winter [14]. To fulfil the consumer interest, either the conventional meat should go for pre-processing to nullify the effect of antibiotics; hormones etc. or the raw meat should be produced only through organic farming.

(1) Pesticides Residues

A variety of pesticides are used in crops in India and abroad. Through animal feed the pesticide residues ultimately reach in the livestock body and thereby in

A Hypothetical Flow Chart of Meat Processing



different livestock products viz., meat, milk and honey. One of the main reasons of this unwanted entry of pesticides in the livestock products is that the farmers and ranchers are not aware of pesticides hazards. Particularly in India this is the most dominating factor. A lot of work has done at different aspects of pesticides to provide the appropriate data for the research and development. Now the people have become more health conscious and they are not ready to buy such a product which is not health promising. So it is necessary to avoid this factor of pesticides by endorsing the organic production or organic farming. No doubt the government policies play an important role for the implementation of any programme that's why policy makers should make policies in respect of public interest. A study was conducted on buffalo meat in India, and the samples were reported with higher level of endosulfan as decided by the statutory organizations [15]. The beef samples were tested against organochlorines (DDT, Aldrin, Dieldrin and Lindane) in Qena, Egypt and the pesticides residue limits were found below the permissible limits [16] as decided by WHO (1989) and FAO/WHO (1987). A study was conducted in Egypt on fermented sausage to evaluate the degradation effect of meat starter on organochlorines viz., DDT and Lindane and at the end of fermentation period of 72 hrs the meat samples were found to have reduced level of DDT and Lindane pesticides [17]. The cyclodiene pesticides **(**Aldrin, α-Endosulfan, β-Endosulfan, Endosulfan sulfate and Heptachlor) residues detected in buffalo meat in Mysore (India) and was found lower than the maximum residue limits [18]. About 58.33– 64.59% and 55.93–61.60% reduction in α-Endosulfan and reduction in β-Endosulfan through pressure cooking [18]. A health risk assessment study for the detection of organochlorine pesticides was conducted on the milk butter and margarine showed that the samples were positive against organochlorine pesticides [19]. The cow and chicken meat samples were found positive against DDT pesticide. Of these, the cow meat had higher concentration of DDT then chicken meat [20]. In Taiwan, estimation of the organochlorine pesticide in meat showed 85 to 107% recovery of organochlorine in meat samples [21]. Fatty meals had high contamination of organochlorine pesticides and among them egg meal and meat samples had lowest contamination respectively [22]. A strong correlation between organochlorine and testicular cancer has been observed in Italy which is a case study of cancer patients [23]. A study was conducted in Rome (Italy) for the determination of pesticide residues in the baby foods of animal origin and no pesticide was reported in any of the baby-food samples above the prescribed maximum residue limits [24]. The residue levels of organochlorine in the cattle meat samples collected from different cities of Ethiopia were found lower residue limits as decided by the different statutory organizations [25]. In a meta-analysis of organic meat and conventional meat against organochlorine pesticides, polychlorinated biphenyls, the residue limits were found under the prescribed maximum residue limits [26].

VETERINARY DRUG RESIDUES

Veterinary drugs are used for treatment of many diseases in the livestock and sometimes with the animal feed for the sake of livestock health maintenance. Veterinary drug residues in meat is a concerning issue with respect to the safety of meat and their products. Many of veterinary drugs are continuously being used for the growth of livestock animals during conventional farming of livestock in India and abroad. Due to their several chemical reactions and their solubility in water and fat, these drugs are ultimately reach in the animal tissues viz., muscle, liver, kidney and etc. and may cause many health implications in the human beings. Though the maximum residue limits has been set by the different competent authorities like codex alimentarius commission (CAC), Food and Drug Administration (FDA), European Union and by Provision for food adulteration (PFA) in India. The maximum residue limit for the most common veterinary drugs viz., Chlortetracycline, Oxytetracycline and Tetracycline are 200, 600, and 1200 µg/kg in muscle, liver and kidney tissue of cattle, pig, sheep and poultry, respectively. After a periodic interval the maximum residue limits are used to revise and reset by the competent authorities. Day by day the maximum residue limits (MRLs) of veterinary drugs for animal product is going to increase like the maximum residue limits (MRLs) for Tetracycline has been increased from but it is necessary to remove these harmful drug residues from the livestock products. Several studies have been conducted to evaluate the concentrations of different drug residues in different livestock animal and their products. In 122 export buffalo meat samples collected to study the residue concentration of Oxytetracycline, Tetracycline and Chlortetracycline from different parts of India, only five samples had a detectable residue concentration of Oxytetracycline which was lower than the maximum residue limits set by Codex Alimentarius Commission (CAC), United States Food and Drug Administration

Table 1A: MRLs and ADI of some Common Pesticides Residues in Different Animal Tissues [41]

S.N.	Pesticides	Type of Animal Tissue	MRLs (mg/kg)	Acceptable daily intake (ADI) Mg/kg of body weight
1	Abamectin	Cattle kidney	0.05	0.002
		Cattle liver/Goat edible offal	0.1	
		Cattle/Goat meat	0.01	
2	Aldicarb	Meat from mammals excluding marine mammals	0.01	0.003
3	Aldrin and dieldrin	Meat from mammals excluding marine mammals	0.2	0.0001
		Poultry meat	0.2	
7	Buprofezin	Edible mammalian offal/mammalian meat excluding marine mammals	0.05	0-0.009
8	Bentazone	Poultry meat	0.03	0-0.09
		Poultry edible offal	0.07	
10	Carbaryl	Cattle/Goat/Pig/Sheep kidney	3	0-0.008
		Cattle/Goat/Pig/Sheep liver	1	
		Meat from mammals excluding marine mammals	0.05	
11	Carbofuran	Edible offal of Cattle/Goat/Pig/Sheep/horse	0.05	0-0.001
		Meat of Cattle/Goat/Pig/Sheep/horse	0.05	
12	Carbosulfan	Mammalian meat (excluding marine mammals), Poultry meat & edible offal	0.05	0-0.01
13	Chlorpyrifos	Cattle kidney/liver, poultry meat & edible offal, Pig edible offal, sheep edible offal	0.01	0-0.01
		Cattle meat, sheep meat	1	
		Pig meat	0.02	

Table 1B: MRLs and ADI of some Common Pesticides Residue in Different Animal Tissues [41]

S.N.	Pesticides	Type of Animal Tissue	MRLs (mg/kg)	Acceptable daily intake (ADI) Mg/kg of body weight
14	Clofentezine	Mammalian meat (excluding marine mammals) & edible offal, poultry meat & edible offal	0.05	0-0.02
15	cycloxydim	Edible mammalian offal	0.5	0-0.07
		Mammalian meat (excluding marine mammals)	0.06	
		Poultry meat	0.03	
		Poultry edible offal	0.02	
16	DDT	Mammalian meat (excluding marine mammals)	5	0.01
		Poultry meat	0.3	
17	Deltamethrin	Kidney & liver of cattle/Goat/Pig/Sheep	0.03	0.01
		Mammalian meat (excluding marine mammals)	0.5	
		Poultry meat	0.1	
		Poultry edible offal	0.02	
18	Diphenylamine	Cattle meat & kidney	0.01	0.08
		Cattle liver	0.05	

(Table 1B). Continued.

S.N.	Pesticides	Type of Animal Tissue	MRLs (mg/kg)	Acceptable daily intake (ADI) Mg/kg of body weight
19	Endosulfan	Kidney of cattle/Goat/Pig/Sheep, poultry meat & edible offal	0.03	0.006
		liver of cattle/Goat/Pig/Sheep	0.1	
		Mammalian meat (excluding marine mammals)	0.2	
20	Endrin	Poultry meat	0.1	0.0002
21	Glyphosate	Edible mammalian offal	5	0-1
		Mammalian meat (excluding marine mammals), poultry meat	0.05	
		Poultry edible offal	0.5	
22	Heptachlor	Mammalian meat (excluding marine mammals), poultry meat, poultry meat	0.2	0.0001
23	Imidacloprid	Mammalian meat (excluding marine mammals)	0.1	0-0.06
		Edible mammalian offal	0.3	
		Poultry meat	0.02	
		Poultry edible offal	0.05	
24	Lindane	Edible mammalian offal, Poultry edible offal	0.01	0.005
		Mammalian meat (excluding marine mammals)	0.1	
		Poultry meat	0.05	

(US-FDA) and European Union [27]. The samples of viz., liver, kidney, thigh muscles and breast muscles of broiler and layer meat were analysed for residues of Tetracycline, Ciprofloxacin, Enrofloxacin, Amoxicillin and showed that poultry liver had the highest level of antibiotic residue [28]. The frequency of antibiotic was in the order Tetracycline (48%)> Ciprofloxacin (44%) > Amoxicyllin (42%) > Enrofloxacin (40%) [28]. Among the cattle meat marketed in the Kilosa district, Tanzania, 71.1 % samples were found positive against Oxytetracycline while 68.3% sample were found to have higher level of Oxytetracyclin as set by statutory organisations [29]. Also liver and kidney tissue had higher level of Oxytetracycline than the muscle tissue [29]. The chicken meat samples were tested against the Tetracycline residues and only five samples were found positive against Oxtetracycline out of eighty seven chicken meat samples [30]. The residues of Tetracycline antibiotics were detected in the muscle and liver tissue samples of chicken in a study conducted in Egypt [31]. Bovine, porcine and chicken muscles were detected against the 130 veterinary drug residues in Japan and the samples were found to have the drugs concentration in the range of 1 to 10 ng/g [32]. The chicken and beef meat samples (sold in the markets of Ankara, Turkey) were screened against the Quinolone antibiotic residues and 45.70% of chicken meat samples and 60 57.70% of beef meat samples were reported positive [33]. Chicken and Swine Muscles investigated against 13 veterinary drugs (Clopidol, Sulfadiazine, Sulfathiazole, Carbadox, Sulfamerazine, Ormethoprim, Sulfamethazine, Furazolidone, Sulfamonomethoxine, Sulfamethoxazole, Ethopabate, Sulfaquinoxaline, and Sulfadimethoxine) and found that only one sample of chicken muscle was found to have higher level of Sulfaquinoxaline than the maximum residue limits based on the statutory organizations [34]. Different meat samples viz., chicken, pork and beef, were tested against veterinary drug residues and the samples were detected positive for Enrofloxacin and Sulfadiazine drug residues [35]. In Nigeria, 54.44% of the beef samples reported with the detectable limits of Oxytetracycline residue while 34.44% of the beef samples reported with the elevated level of oxytetracycline residue than MRLs based on WHO/FAO [36].

FUTURE PROSPECTS OF ORGANIC MEAT

The need is the mother of invention i.e. wherever is a thrust, the development will be there. The people have now felt that it is necessary to replace the conventional meat with organic meat due to their health concerns and they are changing their food habits from unhealthy food to healthy food. The non-vegetarian population is looking for healthy and safe meat

Table 2A: MRLs and Acceptable Daily Intake of some common Veterinary Drugs [42]

S.N.	Veterinary Drug Residue	Animal Species	Maximum Residue Limits (µg/Kg)			Acceptable Daily Intake µg/Kg Of Body Weight
			Muscle Tissue	Liver Tissue	Kidney Tissue	
1	Abamectin	Cattle	-----	100	50	0-2
2	Albendazole	Not Specified	100	5000	5000	0-50
3	Amoxicillin	Cattle/sheep/Pig	50	50	50	0-0.07
		Sheep	50	50	50	
		Pig	50	50	50	
4	Chlortetracycline /Oxytetracycline /Tetracycline	Cattle	200	600	1200	0-30
		Pig	200	600	1200	
		Poultry	200	600	1200	
		Sheep	200	600	1200	
5	Clenbuterol	Cattle	0.2	0.6	0.6	0-0.004
6	Closantel	Cattle	1000	1000	3000	0-30
		Sheep	1500	1500	5000	
7	Colistin	Cattle	150	150	200	0-7
		Sheep	150	150	200	
		Goat	150	150	200	
		Pig	150	150	200	
		Chicken	150	150	200	
		Turkey	150	150	200	
8	Dexamethasone	Cattle	1.0	2.0	1.0	0-0.015
		Pig	1.0	2.0	1.0	
9	Dihydrostreptomycin/Streptomycin	Cattle	600	600	1000	
		Chicken	600	600	1000	
		Pig	600	600	1000	
		Sheep	600	600	1000	
10	Erythromycin	Chicken	100	100	100	0-0.7
		Turkey	100	100	100	
11	Febantel/Fenbendazole/Oxfendazole	Cattle	100	500	100	0-7
		Goat	100	500	100	
		Pig	100	500	100	
		Sheep	100	500	100	

Table 2A:

S.N.	Veterinary Drug Residue	Animal Species	Maximum Residue Limits (µg/Kg)			Acceptable Daily Intake µg/Kg Of Body Weight
			Muscle Tissue	Liver Tissue	Kidney Tissue	
12	Gentamicin	Cattle	100	2000	5000	0-20
		Pig	100	2000	5000	
13	Imidocarb	Cattle	300	1500	2000	0-10
14	Isometamidium	Cattle	100	500	1000	0-100

(Table 2B). Continued.

S.N.	Veterinary Drug Residue	Animal Species	Maximum Residue Limits (µg/Kg)			Acceptable Daily Intake µg/Kg Of Body Weight
			Muscle Tissue	Liver Tissue	Kidney Tissue	
15	Neomycin	Cattle	500	500	10000	0-60
		Chicken	500	500	10000	
		Duck	500	500	10000	
		Goat	500	500	10000	
		Pig	500	500	10000	
		Sheep	500	500	10000	
		Turkey	500	500	10000	
16	Sarafloxacin	Chicken	10	80	80	0-0.3
		Turkey	10	80	80	
17	Testosterone	Cattle	UN	UN	UN	0-2
18	Progesterone	Cattle	UN	UN	UN	0-30
19	Triclabendazole	Cattle	250	850	400	0-3
		Sheep	200	300	200	
20	Tylosin	Cattle	100	100	100	0-30
		Chicken	100	100	100	
		Pig	100	100	100	
21	Triclabendazole	Cattle	250	850	400	0-3
		Sheep	200	300	200	
22	Sulfadimidine	Not specified	100	100	100	0-50
23	Spiramycin	Cattle	200	600	300	0-50
		Chicken	200	600	800	
		Pig	200	600	300	
24	Spectinomycin	Cattle	500	2000	5000	0-40
		Chicken	500	2000	5000	
		Pig	500	2000	5000	
		Sheep	500	2000	5000	

products in the market i.e. the demand is growing for organic meat products then it is a challenge for the meat scientist and technologist to fulfil their requirements. Organic meat consumption not only better for consumers but also for environment, soil and for animal welfare also. The organic food industry now is in its exponential phase. There are some developing countries which are exporting organic meat to the developed countries. The largest organic livestock sectors are found in Brazil and Argentina according to FAO [37]. Approximately 130 countries are involved in the production of certified organic products [38]. The main hurdles of organic livestock production are lack of knowledge, small farms, and problems in livestock feeding, sanitary regulations, traceability, disease, and lack of training and certification facilities [37]. So these hurdles must be overcome to accomplish or to establish the organic livestock industry India and abroad. India exports a variety of certified vegetarian organic products to the other countries. There is no statistical data on the export of organic meat in India. Organic beef production in Australia is greater than the other organic food commodity [39]. Apart from Australia, the European Union is also one of the largest producer and consumer of meat products and has a great potential for organic meat market. India overcome

Brazil in the export of beef and secured top position [40] while standing 8th in rank in the world's meat production and the largest producer of buffalo meat in the world (59% of total world buffalo meat production) [40]. It suggests that India has a potential to cash the platinum opportunity to be a leader in world organic meat production but the religious taboos are the most concerning issue in India to demotivate and deprive the research and development of meat and meat products. To nullify these issues, the Government, Bureaucrats and Policy makers will have to work together for cherishing the role of organic meat in India which will ultimately boost the country's economy and simultaneously generate the employment opportunities.

CONCLUSION

The conventional meat and meat products carry harmful residues of pesticides and veterinary drugs which may cause several health implications to the human beings. In many cases the pesticides and veterinary drugs residues in meat and meat products found lower than the maximum residue limits as decided by the national and international statutory organisations but this low level pesticide residue can also affect the human body if taken continuously for a long period. There are two ways to check the exposure of pesticides and veterinary drugs residues. One way is to check the entry of these chemical agents into meat system and the solution is the organic meat production rather than conventional meat. The other way is to nullify the effect of pesticides and veterinary drugs residues in meat system by different processes like enzyme treatment etc. as this is most familiar fact that "*prevention is better than treatment*" so the most appropriate and safe way to avoid the pesticides and veterinary drugs residues is the production of organic meat.

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