

Addressing safety concerns for producing high quality food packaging papers



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Abstract: Meeting relevant quality standard is basic to the production of paper. But when the paper produced is intended to be used for food packaging purposes safety concerns for its use also need to be addressed simultaneously. With respect to its safety, packaging material that prevents the contamination of food from external sources and itself not a source of contamination is considered suitable for food packaging applications.

Even though paper is considered a suitable packaging material due to its biodegradability and cost effectiveness, there are certain limitations associated with the use of paper for food packaging applications. Due to its inherent nature, presence of chemical and microbial contamination in papers cannot be ruled out. Contamination can creep in through the raw materials, equipment wears and tear or through improper storage conditions. Hence good manufacturing and hygienic handling practises need to be adopted for ensuring the purity of paper intended for packaging of food items.

This article highlights the regulatory requirements In India for papers intended for food contact along with their health hazards. The article also outlines the good manufacturing practices starting from selection of raw material to proper cleaning of equipment and good housekeeping practices for ensuring the safety of food packaging papers. The current status of few commercially available food packaging papers with respect to relevant norms is also discussed.

Keywords: Heavy metals, Food packaging, Pulp and paper, Contaminates, Health safety.

Introduction :

As long as civilisation has existed, packaging and storage of food has been integral to survival. Global food packaging industry is worth of \$800 billion in which major chunk is captured by plastic-based packaging. Packaging lies in the core of present food industry. Almost each food product is sold market in some sort of packaging. The main purpose of packaging is to protect food products from contamination, ensure safety, retain its quality and preserve its integrity. Good packaging inhibits the wastage of food products and retains the appropriate quality of food products. Packaging helps in long distance transportation of food products without much degradation in its quality. Despite of importance of packaging there arises a concern about packaging material which may itself contaminate the food product as it is in direct contact of food products[1].

Packaging materials coming in contact with eatable stuffs must not leach chemicals in food which may endanger health of human beings and became reason for unsuitable changes in composition of food stuff [2]. Proper food packaging protect food from physical damage, allow for storage, handling and shipping and protect food content against chemical and microbiological contaminants. This will ensure the food inside stays safe from damage and does not pose a threat to human health.

Eco-friendly tag attached to paper and paperboard make these useful in food packaging industry. Paper is used in two main levels in food packaging industry. In primary level food products stored in paper made container which came directly in contact with the paper. In secondary level food products are stored indirectly, mainly paperboard container for transportation purpose[3]. Packaging paper can be made of parchment paper or used as bags for food carrying. Cardboard is commonly used packaging of dry foods, foods in frozen form, liquid food and fast food. Corrugated board utilized for primary packaging of food stuff such as pizza, cake and pastry boxes and also used as secondary packaging material.

Different stages of paper formation such as pulping, bleaching, digestion and final treatments involves the use of numerous chemical that come on contact with food stuff and migrate from paper to food. One of the major safety concerns come from the use of ink on packaging papers. The ink used in printing is major reason for causing lung cancer in worker exposed to it. The carcinogenicity of ink is due to solvent extracts of carbon black. These are formed of polyaromatic hydrocarbons like benzo(a)pyrene. Naphthylamine, benzidine, benzophenone and 4-aminobiphenyl found in recycled paper which are known for bladder cancer. Benzophenone had been reported as the major endocrine disrupting chemicals in infants and pregnant women. In recycled pulp fluorinated compounds are utilized as grease barriers for package grade paper. Leach out of these fluorinated substances in food results in carcinogenic risks and decrease in the immune system of human beings [4, 5]. Because when chemical contaminants like heavy metals, PCBs and PCPs and microbiological contaminants like bacteria and fungi come in contact with the food material pose serious threat to human health. For controlling this problem various countries have different laws and recommendation for dealing this serious issue.

According to guidelines of European Union (2002/72) upper limit of overall migration from packaging paper to food stuff is 60 mg/kg. Whereas, in case of smaller paper container possessing capacity lower than 500 ml the set limit is 10 mg/dm [6, 7]. In Switzerland utilization of paper/paper board made from recycled fibre that came in direct contact of food is forbidden. Here, it becomes equally important that the packing material itself is of food-grade and not a hazard to food safety. Therefore, in India packaging paper and paper board should pass certain standards set by FSSAI (FSSAI Regulation 2018), in order to ensure that given sample of paper and paperboard is safe for food packaging.

In the light of above this article discusses the source chemical contaminants in paper and paper products along with their health hazards and maximum limit of these contaminants specified by the Food safety and standard authority of India (FSSAI). The analytical methods for the estimation of chemical contaminants in the packaging paper are also highlighted. The safety concerns of food packaging papers are also addressed by contaminants analysis of commercially available paper samples used by food industry. Some of best possible practices that paper industry should adopt to minimize the microbial and chemical contaminants in end product are also enumerated in this article.

2. Limits set for Chemical contaminants by FSSAI

Unlike other countries India has not set migration limit of contaminants. Only in plastic samples migration limit set for contaminants by FSSAI. In the recent years FSSAI: 2018 set limits for chemical contaminants. Limit for cadmium set for food grade paper is 0.5 mg/Kg of paper for both dry and wet food. For Cr⁶⁺ the limit set is 0.1 mg/Kg of paper coming in contact of food dry/wet. The quantity of Pb should not exceed from 3.0 mg/Kg of paper for food grade paper. In case of Hg the maximum limit of Hg present in food grade paper coming in direct contact of food should be 0.3 mg/Kg of paper. PCP contaminates should not exceed 0.05 mg/Kg of paper whereas for PCBs maximum limit set is 2.0 mg/Kg of paper for dry and wet food whereas, for filtration paper it should not more than 0.5 mg/Kg of paper (Table 2) (FSSAI Regulation 2018).

Table 2: Contaminate Limits in food grade paper (FSSAI Regulation 2018)

Contaminates	Paper come in contact with dry food (mg/Kg of paper)	Paper come in contact with wet food (mg/Kg of paper)	Paper for Filtration (mg/Kg of paper)
Cadmium	0.5	0.5	-
Chromium	0.1	0.1	-
Lead	3.0	3.0	-
Mercury	0.3	0.3	-
Pentachlorophenol	0.05	0.05	0.05
Poly chlorinated biphenyls	2.0	2.0	0.5

3. Sources of heavy metals in packaging paper and their impact on human health

3.1 Lead (Pb)

Lead commonly does not occurs in irrigation water from water sources such as streams, lakes and wells. Lead mainly comes from distribution lines, pumping station etc. This water used for irrigation becomes main source of lead contamination. White, red, yellow and green coloured inks which are used for printing purposes acts as source of lead in the paper. Recycled paper possessed higher

Table 1: Range of lead-induced effects in humans at different blood levels

Lead in Blood level	Adults	Children
10 µg/dL	Hypertension	Crosses placenta Impairment IQ, growth Partial inhibition of heme synthesis
20 µg/dL	Inhibition of heme synthesis Increased erythrocyte protoporphyrin	Beginning impairment of nerve conduction velocity
30 µg/dL	Systolic hypertension Impaired hearing	Impaired vitamin D metabolism
40 µg/dL	Infertility in males Renal effects Neuropathy Fatigue, headache, abd pain	Haemoglobin synthesis inhibition
50 µg/dL	Anaemia, gastro-intestinal disorder, headache, tremor	Colicky abdominal pain, neuropathy
100 µg/dL	Lethargy, seizures, encephalopathy	Encephalopathy, anemia, nephropathy, seizures

Source: Inter discip Toxicol 2015 Jun 8(2) : 55-64

amount of lead in comparison to virgin paper. Lead present in food packages material may found in the range of 2 to 10,000 ppm depends upon the print quality and colour of ink. Printed packages possessed higher amount of lead in comparison to unprinted material, however some unprinted paper may contained lead up to 58 ppm [8]. Impact of lead metal on human body with increase in accumulation dose given in table 1.

3.2 Cadmium (Cd)

In paper industry Cadmium (Cd) is commonly utilized as brighter coloured pigments in fine arts. Cd and its compounds are highly preferred for printing purposes. Cadmium can accumulate in the body of trees and plants for long time with a half-life period of 25–30 years. Utilization of such raw material in paper making lead to formation of cadmium contaminated paper. On coming contact with food stuff Cd may move from paper to edible product. On the consumption of these edible products causes irritation in stomach, abdominal cramps, nausea, vomiting and diarrhoea. Headaches and flu-like symptoms, swelling of the throat and tingling hands may also occur. Minute quantity of cadmium remains in human body after the consumption of contaminated food stuff. But regular consumption of affected food leads to kidney diseases and bones weakening. Large amount of cadmium consumption can damage liver, heart and kidney which ultimately leads to death. Children found to be had same symptoms as adults. Mothers exposed to higher level of cadmium may lead to have children with lower birth weight[9].

3.3 Chromium (Cr⁶⁺)

Chromium (VI) refers to chemical which possess the chromium in +6 oxidation state. Chromium exists as oxo species such as CrO₃ and CrO₄²⁻, which possesses oxidizing nature [10]. The main source of chromium in paper and paper board is chromium compounds utilized in preservation of wood, further from this wood chromium enters in final paper and paper products. Chromium trioxide is used in the preservation of wood in paper industry [11]. Exposure to the compounds having Cr(VI) cause different health problems such as skin irritation, ulcer, sensitization and allergies. Cr(VI) can cause genotoxicity which includes a various effects like DNA damage, gene mutation, sister chromatid exchange, chromosomal aberrations, cell transformation, and dominant lethal mutations.

3.4 Mercury (Hg)

Main source of Hg in paper is its raw material from which the paper is manufactured[12]. Higher dose of Hg cause serious health issues and is fatal to humans. Even minute traces of mercury compounds can have adverse effects on developing nervous system, harmful effects on the cardiovascular, immune and reproductive systems. Hg and its compounds affect central nervous system, human kidneys and liver, it

also cause disturbance in immune system, tremor, disturbed vision and hearing, paralysis, insomnia and emotional instability. In pregnancy, mercury compounds cross the placental barrier and can interfere with the development of the foetus and cause delays in developments during childhood[13].

3.5 Pentachlorophenol (PCPs)

Pentachlorophenol was used as biocides in various countries. It was also used as a wood preservative. Paper preparation using this wood material leads PCP infected paper which may leach out in food products on coming in direct contact with them. Pentachlorophenol possesses extreme toxicity when absorbed direct contact humans. Exposer to small amount of pentachlorophenol in humans may leads to bad impact cardio vascular system, blood cells, liver (jaundice) and on visual abilities. Neurological impact of PCPs on human health includes lethargy, tachypnea, tachycardia, delirium, and convulsions. Larger dose of PCPs in humans may resulted in inflammation in respiratory tract, anaemia, effects on the kidney and liver, immunological effects and irritation of the eyes, nose, and skin. Chronic oral exposure to pentachlorophenol in animals has resulted in effects on the liver, kidney, blood, endocrine, immune system, and CNS. Some studies also reported that women expose to PCPs may leads to spontaneous abortions, unexplained infertility, or menstrual disorders.

3.6 Polychlorinated biphenyl (PCBs)

Commercial PCBs are the mixtures of 42% of chlorine and were mainly utilized in the production of mechanical copy paper. Some coolants also contains PCBs which get mixed with water and become responsible raw material contamination. Mixture of different PCBs was utilized as solvent in the microcapsules used in carbonless copy paper. In the paper recycling process there may release of PCB-carrying ink that would attach to pulp and

ultimately enters in paper[14]. The major chunk of PCBs would reside in final paper product and that may release in to food stuff packed in same paper. In people, PCBs cause skin problems, people may cause chloracne i.e. pale, yellow skin lesions which could last for weeks to years. PCBs also affect the functioning of the liver without any traceable symptoms. Liver changers are similar to the affects that could occur due to consumption of alcoholic or smoking. Another study reported that PCBs could affect the immune, endocrine and reproductive systems in animals. Large amount of PCBs consumption leads to cancer in human beings. Birth defects in the children were also observed whose mothers exposed to PCBs[15].

4. Study on conformity of commercially available papers to FSSAI Limit of chemical contaminants

With the objective to evaluate the conformity of food packaging papers to FSSAI norms , few commercially available papers were analysed for various contaminants.

4.1 Materials and Methods

The food grade and non-food grade samples were taken directly from production site and packed in sterile polybags and stored at 4°C. Table 3 represent the detail of samples. Penta Chlorophenols (PCPs) and Poly Chlorinated Biphenyls (PCBs) were analysed on SHIMADZU GC-230AF. Hg, Pb and Cd were analysed using AAS procured from AnalytiKjena company with Model no. ZEEnit700p. Cr⁶⁺ was analysed by UV photo-spectrometer procured from PG Instruments Limited model no. T80+. IS 6615:1972 was followed for sample analysis.

5. Results and discussion

The food grade and non-food grade samples such as Pizza box (A), Cake base (B), Cake box (C), Brown Kraft paper (D), Paper plate (E), Paper cups (F), Paper bowls (G), Butter paper (H), Cup stock (I), laminated paper (J) from source 1, laminated Paper (K) from source 2, chemically bleached Paper (L) from source 1, chemically bleached Paper sample (M) from source 2, Butter paper (N) were analysed for identify the presence of PCP, PCBs, Hg, Pb, Cd and Cr⁶⁺. Table 4 and Table 5 reveals the analytical results. All samples were found to meet specified limit of metals, organic and phenolic compound traces, except sample D and Sample F. Both samples have PCP content of 13.4 and 8.9 mg/Kg and hence exceeding the limit of 0.05mg/Kg.

7. Good Manufacturing practices for quality food packaging papers

Good manufacturing practices (GMP) should be adapted by paper manufacturers and action should be taken to reduce the microbial contaminants in paper-based food packaging material during the

Table 3: Code names of different paper samples

S. No.	Sample Name	Sample Code
1	Pizza box	(A)
2	Cake base	(B)
3	Cake box	(C)
4	Brown Kraft paper	(D)
5	Paper cups	(F)
6	Paper bowls	(G)
7	Butter paper	(H)
8	Cup stock	(I)
9	Laminated paper	(J)
10	Chemically bleached Paper	(L)
11	Chemically Paper sample (Source 2)	(M)
12	Butter paper	(N)

Table 4: Analytical results of chemical contaminants in paper samples

S. No.	Sample code	Cd mg/L (mg/kg)	Pb (mg/kg)	Total Mercury Concentration (µg/L)	Total chromium +6 Concentration (µg/L)
1	A	BDL	1.45	BDL	BDL
2	B	BDL	1.6	BDL	BDL
3	C	BDL	0.85	BDL	BDL
4	D	BDL	1.35	BDL	BDL
5	F	BDL	0.15	BDL	BDL
6	G	BDL	0.05	BDL	BDL
7	H	BDL	0.01	BDL	BDL
8	I	BDL	0.45	BDL	BDL
9	J	BDL	0.05	BDL	BDL
10	L	BDL	0.01	BDL	BDL
11	M	BDL	0.05	BDL	BDL
12	N	BDL	0.01	BDL	BDL

*BDL = Below Detection Limit **Detection limit – (µg/L) :- Cd – 0.42(0.002mg/kg), Pb – 0.31, Hg – 0.7 (0.004 mg/kg)

Table 5: Analytical results of organic and phenolic contaminants in paper samples

S. No	Name of compounds	Detection limit	Sample code						
			B	C	D	F	G	H	L
1	PCB-28	0.53 mg/gm	BDL	BDL	BDL	BDL	BDL	BDL	BDL
2	PCB-52	0.68 mg/gm	BDL	BDL	BDL	BDL	BDL	BDL	BDL
3	PCB-101	0.62 mg/gm	BDL	BDL	BDL	BDL	BDL	BDL	BDL
4	PCB-118	0.31 mg/gm	BDL	BDL	BDL	BDL	BDL	BDL	BDL
5	PCB-138	0.32 mg/gm	BDL	BDL	BDL	BDL	BDL	BDL	BDL
6	PCB-153	0.45 mg/gm	BDL	BDL	BDL	BDL	BDL	BDL	BDL
7	PCB-180	0.32 mg/gm	BDL	BDL	BDL	BDL	BDL	BDL	BDL
8	PCP	1.65 µg/gm	BDL	BDL	13.4	8.9	BDL	BDL	BDL

*BDL= Below Detection Limit (0.0005 mg/kg)

manufacturing process [16]. Some best practices that enhance the quality of end product i.e. food packaging paper; manufactures should focus on best raw material having uniform formation, adequate thickness, and appropriate substance.

7.1 Selection of raw material

Proper selection of raw material used for making food packaging paper is the most important aspect because overall paper making process depends on quality of raw material. Sourcing of raw material should be done with utmost care so as to avoid contamination of trace/ heavy metal. Raw material should also be free of mineral oils and organic pollutants to reduce health hazards.

To avoid chemical contamination pulp, presence of heavy metals, PCBs and PCPs in raw material should be checked before and after making paper for food packaging purpose so that the exact concentration of these chemical contaminants can be calculated because these contaminants are hazardous to human health. Raw material should be procured from reputable provider who provide pulp/raw material which is of ECF (elemental chlorine free) and TCF (totally chlorine free) grades. Avoid the use of wood chips, timber and hemp which were sprayed with hazardous chemicals such as pentachlorophenol (PCP) or lindane. Focus should be to use feedstock which is free from pesticides. Raw material should be treated with biocides only should be used in if it is very much necessary and degradable biocides such as guanidine and isothiazolones which creates minimum contamination in raw materials.

7.2 Monitoring the process water / chemicals to avoid chemical contamination

The water containing heavy metals and traces of pesticide should not be used as irrigation source as these contaminates got absorbed by tree/plant which further can be used as raw material for paper making. Chemicals such as DTPA, as a chelant, which are biodegradable in nature and avoid the use of EDTA or NTA. White water which is use in recycling of paper should be checked for microbial load. Mills should adopt suitable biocide program to reduce microbial load in white water reuse.

7.3 Regular monitoring of process related equipment

Periodical cleaning of process equipment should be done because regular inspection of process equipment is an important factor to reduce the risk of contamination and to establish successful housekeeping program. Stringent quality monitoring during food packaging paper making process is very crucial to improve the nature of product. Faulty parts should be replaced with new parts as the wear tear in tools can also contaminate the paper being manufactured from it.

7.4 Proper handling, storage and transport of raw material and finished product

The correct handling, storage and transport of these raw materials as well as finished product are necessary to avoid microbial contaminants. Handling the product in hygienic manner and storage of paper under controlled conditions of humidity can prevent the growth on microbes.

7.5 Good housekeeping practices

Paper industries should maintain hygienic conditions through adoption of good housekeeping practices at workplace to reduce the risk of contamination. To maintain a safe and healthy workplace, good housekeeping must be a priority. Mostly we should avoid storing raw material in chest for longer

duration as it may results in microbial growth. Determination of microbial load is a vital factor if any stored material is used for making food packaging paper.

7.6 Conformity to set norms

Industries should regularly test their manufactured paper for chemical contaminants to ensure the quality of paper. The chemical contaminates should not exceeds the limit set for food packaging grade paper by FSSAI 2018 notification.

8. Conclusion

Heavy metals, PCPs and PCBs enters in packaging paper through various sources and may enter in food products on coming contact with food products which is harmful to human health. Food packaging paper should meet the FSSAI norms for contaminates. In India no recycled paper is used for making food packaging paper. In raw material water used for irrigation and pesticides are the main sources of chemical contamination. Whereas, microbial contamination occurs in manufactured paper due to long and unhygienic storage of raw material. Paper manufacturing process includes storage of raw material in open sites that increase the risk of microbial contamination which stay there even after high temperature treatment. Various agencies all over the world set a specific limit for chemical contaminant that should not exceed in packaging paper. This limit allows the testing agencies that packing paper is safe for storing the food product or not. All samples which were analyzed were found to meet specified limit of metals, organic and phenolic compound traces, except sample D and Sample F. Both samples have PCP content of 13.4 and 8.9 mg/Kg and hence exceeding the limit of 0.05mg/Kg. This paper gives a proper idea of various contaminates present in packaging paper along with their possible sources along with permissible limit set by FSSAI for these contaminants in the packaging paper. This article

also highlights the possible best practices such as selection of good quality raw material, precaution to avoid microbial contamination, measures to avoid chemical contamination and good housekeeping practices for making contaminants free and good quality food packaging paper.

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