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Research Article

FOOD CONTAMINATION CAUSED BY TEXTILES IN HOMES AND THEIR POSSIBLE REMEDY: AN ANALYSIS

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ABSTRACT

Health and hygiene are the primary requirements for human beings to live comfortably and work with maximum efficiency. A fabric in kitchen has become important all over the world and a considerable usage is going in this direction. The fabrics in kitchen mainly used to keep the place clean where we cook our food and consume them later. The usage of fabric in kitchen is to free kitchen wears from wetness, which makes them easily get contaminated and pave way for spoiling the food. The kitchen fabric contamination takes place by accumulation of bacteria, fungi and other parasites. Studies conducted on kitchen fabric by researches from other countries clearly show that those fabrics in kitchen provide suitable environment for growth of bacteria and harbors various bacteria namely Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae, Streptococcus faecalis, Staphylococcus epidermis, Bacillus cereus, Bacillus subtilis, Salmonella species, Shigella species, Clostridium perfringens, Pseudomonas aeruginosa, Proteus vulgaris, Enterobacter cloacae, Listeria species and Campylobacter jejuni. A suitable and safe finish is needed to protect the cloth from bacteria and at the same time also make the cloth to serve its purpose without contamination.

Keywords: Health and hygiene, comfortably, contamination, environment, bacteria.

INTRODUCTION

Increasing global competition in textile has created many challenges for textile researchers and industrialists. The rapid growth in home textiles and their end uses has generated many opportunities for the application of innovative finishes. Hygiene has acquired importance in recent years, consumer looking for solution to bacterial problem and contamination and unique benefits provided by antibacterial finish.

The kitchen fabrics are used for the various applications, they used for the purpose of cleaning, ornamentation, wiping, and presentation. The kitchen fabric contamination takes place by accumulation of bacteria, fungi and other parasites. Here in this paper, it is discussed on reasons/causes for bacterial attack, health issues on their attack, etc.

LITERATURE REVIEW

Kitchen Fabric

The term kitchen fabric includes some of the textile materials that are used in the kitchen during food preparation. There are certain types of towels used in kitchen for various purposes and their names are: 1. Dish towels, 2. Tea towels, 3. Hand towels, 4. Counter or bar map towels.

Towels Available in the Market

Five unique sorts of towels are monetarily accessible in the market.

1. Waffle weave towels - Waffle weave towels are generally produced using cotton and are of the retentive sort. They are otherwise called honeycomb and are essentially utilized for drying substantial things like pots and dish. Aside from that, it can likewise be utilized as hand towels.
2. Terrycloth towels - Kitchen towels produced using terrycloth have high engrossing force. They are cotton-based and have circles. They are normally utilized as hand towels, counter or bar clean towels and dish towels.
3. Jacquard towels - Jacquard towels are made of either cotton or semi material (mix of 45% cotton and 55% cloth). They are build up free and are fundamentally utilized with the end goal of drying crystal. The towel displays various alternatives, as far as shading and examples.
4. Flour sack towels - Flour sack towels produced using cotton are build up free, assimilate well and fill different needs. They can be utilized to dry dish sets, bread wicker bin, cover rising batter, clean silver and tidy surfaces.
5. Flat weave towels - Flat weave towels are made of 100% cotton and are of retentive sort. It is essentially utilized for drying dishes. Notwithstanding, when collapsed on itself, it can fill the need of a hot cushion, utilized for holding hot pot handles or covers and moving them.

Market Trend in India

In the market two varieties of fabrics are used for production of kitchen towels. The first variety is 100% cotton fabric and another variety is made up of 55% linen and 45% cotton materials. Nearly more than 150+ companies are involved in the

production and exporting of kitchen fabrics. Some of the companies are manufacturing and exporting around 5 lakhs pieces/month.

Contamination of Kitchen Fabrics

When a kitchen fabric is used to dry the washed utensils, cups and pans the fabric absorbs moisture. When this fabric is left unnoticed, the wetness of the fabric acts as a breeding ground for various bacteria to develop on them. The bacteria along with foul smell become inconvenient for handlers to reuse the towel. The four important reasons for the growth of bacteria are food, moisture, warmth and time.

1. **Food:** The food nourishments in which pathogens to get a increase by multiplication are due to nutritious food substances. These covers meat, poultry, fish (especially shellfish), cooked rice and pasta, diary items and eggs and furthermore any food matters which contain these as components in food. Examples are meat pies, sandwiches, gravy, plates of mixed greens and so forth.
2. **Moisture:** Most food substances normally contain adequate dampness to give microbes the water they require so as to develop.
3. **Warmth/Temperature:** Microorganisms have shifting necessities as far as the scope of temperatures in which they develop. Those which they develop at low temperatures (for the most part beneath 20°C) are called psychrophiles and at high temperatures (over 45°C) are thermophiles. Some deteriorate microorganisms fall into these classifications. Most pathogens, favor growth in warmness and they are known as mesophiles. They develop at temperatures in the vicinity between 5°C to 63°C, generally termed as the development or "critical" zone and have an ideal temperature for growth around 37°C.
4. **Time:** At perfect conditions (i.e, in damp substances at 37°C) microorganisms such as bacteria can develop and increase by isolating into two, at regular intervals for every 20 minutes. At end of 6 hours, one bacterial cell could wind up noticeably into 131,072 microscopic organisms.

Emanation of Diseases from Kitchen Fabric

The usage of kitchen fabric may lead to diseases because of the two aspects namely,

1. Wetness causing growth of bacteria and
2. Inefficient cleaning methods.

Wetness Causing Growth of Bacteria

Most of the published articles emphasise that due to wetness bacteria accumulate on fabrics. The various bacteria which develop when fabric is in wet condition are listed below:

Wiping cloths are frequently contaminated with *Escherichia coli* and these may be important reservoirs of bacteria for contamination of the hands of catering staff[1]. The frequent contamination of dishcloths with large numbers of organisms including enterobacteria suggests that these items may act not only as reservoirs but also as supporter of contamination in the kitchen. Table 1 shows different types of sampled fabrics (such as dishcloths, tea towels) containing extent of colony forming units.

Table 1 Colony forming intensity of each type of kitchen cloth

Number of colonies	No. of samples showing the presence of bacteria out of examined samples expressed in %		
	Dish Cloth (186)	Hand Towel & Tea Towel (317)	Cleaning cloth (38)
450 or more	13.4	0	26.3
100 or more	47.3	13.6	55.2
20 or more	77.9	68.5	73.6
1 or more	97.8	98.8	100

(Figures within the brackets indicate number of homes sampled)

Based upon the number of colonies in each fabric it can be said that higher the number of colonies more the chances for contamination.

Table 2 shows the % of chances for the sampled kitchen fabrics to harbor different types of bacteria.

Table 2 Presence of various types of bacteria in kitchen cloth

Type of Bacteria	No. of samples showing the presence of bacteria out of examined samples is expressed in %		
	Dish Cloth (186)	Hand Towel & Tea Towel (317)	Cleaning cloth (38)
Escherichia coli	13.5	1.9	10.5
Klebsiella pneumonia	7.6	1.6	5.3
Salmonella spp.	0	0	0
Klebsiella spp.	2.2	0	2.6
Pseudomoniae aeruginosa	0.5	0.3	0
Other *pseudonmonas*	4.9	2.2	5.2
Pseudomonas spp.	21.1	16.7	15.7
Bacillus cereus	0	2.2	0
Staphylococcus aureus	3.2	3.8	2.6
Streptococci	1.1	1.6	0

(Figures within the brackets indicate number of homes sampled)

When bacteria contaminated fabrics (such as hand towels, dish cloths) were used on other surfaces it may result in cross contamination[2]. Wet areas such as sponges, dishcloths continually appear to act as a reservoir that harbour and encourages the growth of potential pathogens[2, 3].

The pathogens such as *Pseudomonas aeruginosa, Klebsiella pneumonia, Bacillus spp., Diphtheroids, Enterobacter cloacae* and *Staphylococcus epidermidis* survive on surfaces for hours or days, depending on the species. It was also stated that wiping of surfaces (physical removal) tends to transfer and spread microorganisms from one surface to the other surface[4]. The

sampled kitchen aprons, hand towels harbor *coliforms*, *Staphylococcus* and *Pseudomonas* with poor quality index of 56% and 46%. A common practice is to dry hands after washing with aprons and these could then probably serve as sources of bacteria for further contamination[5].

Highest counts (i.e. > 450 cfu's per area sampled) were associated with cloths used for wiping surfaces and/or drying equipment (dish cloths, sponges and tea towels). Gram-positive cocci were predominant in cloths[6]. Dishcloths had been used in household kitchens for 5 days or more and were never dried out during sampling time. There were usually enough nutrients remaining in dishcloths and sponges to support the growth of most bacteria and harbor high microbial counts. The extent of growth of bacteria on dish cloths wetted with 20ml of sterile water is shown in table 3[6].

Table 3 Comparison of bacterial growth in dish cloths

Dish cloth	*Aerobic plate count (APC)*	*Coliforms*	*E.coli*	*Staphylococcus*	*Salmonella*	*B.cereus*
	(cfu/ml)					
1	500	<10	<10	<10	Negative	30
2	3,300,000	1,800	<10	<10	Negative	<10
3	1,600	<10	<10	<10	Negative	<10
4	300,000	50	<10	<10	Negative	<10
5	25,000,000	100,000	<10	5,000	Negative	1,10,000
6	26,000,000	14,000	<10	60,000	Negative	1,10,000

Multi-use cloths (dishcloths, non-woven cloths, sponge cloths and tea towels) can cause contamination to the hands. Figure 1 shows the susceptibility of multi-use cloths to harbor high number of bacteria (on average more than a billion per cloth and were called as class 4 contaminations) after only one day's normal use in a domestic kitchen. These numbers increased further after usage to a maximum level averaging more than 10 billion per cloth. The presence of such large numbers of bacteria in multi-use kitchen cloths is undesirable and not conducive to good hygiene. Despite considerable variation in use, cleaning, drying and replacement, a wide range of different bacteria readily and rapidly establish themselves in the fabric[7].

A study conducted using 132 dish cloths revealed that a number of cloths were heavily contaminated with *E. coli* and *Clostridium perfringens*. Overall 74% of the cloths were contaminated with one of these bacteria. *E. coli* was isolated from 74 cloths (56%) and of' these 25 contained more than 10 cfu. Fourteen cloths contaminated with *Str. faecalis* and four of these contained more than 10cfu. C*lostridium perfringens* was isolated after enrichment from 52 cloths (40%) [7].

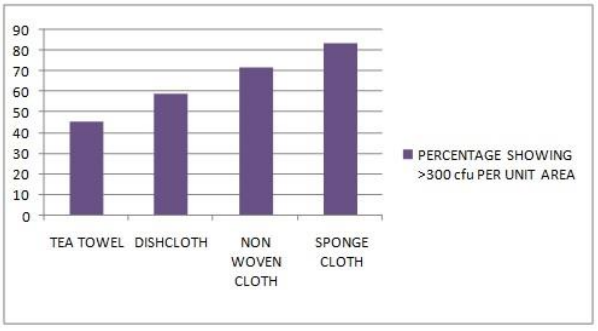

Figure 1 Bacterial count on kitchen cloths after one day use in a domestic kitchen

Towels provide an ideal environment for bacteria to grow and harbour. Wet towels can harbour potentially harmful organisms and become breeding grounds for bacteria[9, 10]. The use of towels in a kitchen has resulted in spread of bacteria to hand, equipment, crockery and cutlery. Harmful organisms not only survive, but also continue to grow in contaminated towels which remain damp. *E. coli, P.vulgaris, Klebseilla* spp. and *Shigella* spp. are the bacteria that were most frequently isolated from the restaurants[10].

Listeria spp were isolated at all sampling sites of dish cloths (37%). In about 80% of the positive dish cloths pathogen was present in numbers greater than103 cfu/object[9].

The presence of bacteria in sponges⁄ dishcloths showed greater transfer of bacteria onto food preparation surfaces. Out of 99 samples tested on sponges/dish cloth for *coliforms* and *E.coli* in 2 different regions, 67 samples showed positive for presence of bacteria. The highest concentrations of bacteria were found on sponges⁄dishcloths[11]. It was reported that typically sponges⁄ dishcloths carry a largest load of total *coliforms* and *faecal coliforms*[12].

From the above studies it is evident that wetness support bacterial growth which is responsible for the contamination of kitchen fabrics.

Inefficient Cleaning Methods

The cleaning methods such as washing with detergents and dishwasher and boiling with water are the ones which we perform in our day to day life to clean the stained fabric. The facts that they are not reducing the bacteria upto the mark are illustrated by the following literatures.

Sponge Wipes/Dishcloths harbor a lot of pathogens, for example, Escherichia coli, Salmonella, Klebsiella pneumoniae, and Enterobacter cloacae which spread all through the kitchen when they are reused. When Sponges/dishcloths utilized are cleaned for sufficient times, the spread of pathogens from wipes to different surfaces might be enormously lessened. Figure 2 shows the effectiveness of various cleaning methods with respect to reduction in bacterial content. The dishwasher had a mean percent reduction of 57.3%, meaning that it had the lowest bacterial concentrations after treatment[13].

All the methods employed have bacterial reduction on fabric but none prone to 100% Bacterial reduction is illustrated in table 4 [8].

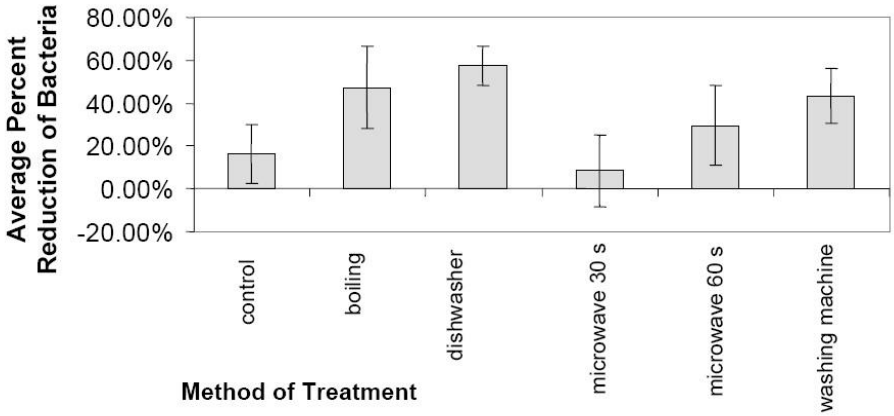

Figure 2 Method of treatments

Table 4 reveals that wiping cloth showing a positive sign of bacteria on it even after cleaning. For example, in boiling method, out of 29 bacteria affected towels tested, still 6 cloths shows the presence of bacteria after boiling. The last column in the table shows the total wiping cloth still show the presence of bacteria and expressed in %.

The table 4 clearly shows that though all cloths were cleaned daily, none of the methods appeared to be satisfactory.

From the above it can be stated that either wetness causing growth of bacteria or inefficient cleaning methods may be one of the factors for causing the diseases.

Table 4 Comparison of cleaning methods used on bacteria contaminated wiping cloths

Method	a/b				Factor 'a' is expressed in %
	A	B	C	D	
None	0/0	1/1	0/0	1/1	100
Wash in Detergent	3/10	5/12	3/18	9/32	28
Boiling	6/29	2/7	5/11	3/8	29
Soak in disinfectant	1/6	2/9	3/11	3/12	24
Wash in detergent then soak in disinfectant	4/21	0/8	2/7	3/12	19
Soak in combined agent	0/0	1/3	0/1	0/2	17
Laundered	0/0	0/1	0/0	1/2	33

Bacteria in wiping cloths include E.coli, Staphylococcus and Streptococcus faecalis.
A, B, C, D - Groups of sampled houses
a - Number of wiping cloths showing positive for the presence of bacteria after employing corresponding method
b - Total number of sampled wiping cloths contaminated with bacteria.

Diseases Emanating by Bacteria

Various cross contamination diseases are caused because of the usage of contaminated fabrics (towels) in kitchen. Articles which stress on this statement are listed below:

Bacteria that were commonly found in kitchen fabrics include *Pseudomonas aeruginosa*, *Klebsiella pneumonia, Bacillus Species* and *Staphylococcus epidermis*. These can cause diseases such as urinary tract infections, respiratory tract infections, bone and joint infections, gastrointestinal infections, Pneumonia and wound infections. Bacillus species such as *B.Cereus* can cause food poisoning[4]. Various review states that more chance of food contamination by continuous usage of various kitchen fabrics. Diseases included are nausea, vomiting, abdominal cramps, fever and diarrhoea.

Ongoing Research Studies

Researchers investigated 120 kitchens in north-east England. Research Specialist from the organization discovered 56% of fabric materials tested were not in acceptable quality, conveying fecal microscopic organisms and hazardous bugs, for example, Listeria. Dishcloths might be a decent approach to expel food sustenance from surfaces, however food tend to hold tight to some of it, even when flushed with water to a short time, making them the perfect reproducing ground for a wide range of microscopic organisms. HPA team took a total of 133 cloths, and found that 86 carried *faecal* bacteria, 21 carried *E. coli*, six were host to *Staphylococcus aureus*, and five carried *Listeria.* The *S. aureus* and *Listeria* definitely fell into the "potentially harmful" category. The strain of *Listeria* found on three of the cloths considered particularly dangerous in vulnerable groups such as the elderly and very young. Although the cloth was disinfected with bleach or other disinfectants, soaking does not remove the food on which the bacteria grow [14].

Another research in Washington reveals that cross contamination in kitchens is the process where the bacteria is pushed around with contaminated kitchen towels and wiping cloths into kitchen utensils. Wiping cloths, towels, and sponges can harbor many bacteria capable of causing illness. In a study conducted at the University of Arizona, researchers found more disease-causing bacteria in kitchens. The study conducted by microbiologist from the institute documented bacteria like *Escherichia coli* (coliforms bacteria) were present in sponges, dish towels. They studied for the presence of bacteria in 325 sponges from home kitchens. They found a large number of

E.coli, Salmonella, Pseudomonas, and *staphylococcus* on sample. With some sponges, even a couple of drops of liquid from the sponges contained up to 10 million colony forming units of disease causing bacteria [15].
These studies bring out the fact that different types of bacteria harbor in kitchen fabrics and their harmness in kitchen foods.

Various Bacteria in Kitchen

There are various types of bacteria in kitchen scenario and these can cause many dreadful diseases which are listed in section 2.6. These disease causing bacteria are divided into three types namely,

- Food borne bacteria
- Water borne bacteria and
- Oil borne bacteria.

Food borne Bacteria

There is different nourishment borne microorganisms' exhibit in kitchens. Sustenance borne ailments are caused by eating nourishment or drinking refreshments debased with microbes, parasites, or infections. Sustenance borne sicknesses can cause manifestations that range from a steamed stomach to more genuine side effects, including the runs, fever, retching, stomach issues, and lack of hydration. Most Food borne contaminations are undiscovered and unreported, however the Centers for Disease Control and Prevention appraises that consistently around 76 million individuals in the United States turn out to be sick from pathogens, or sickness causing substances, in sustenance. Of these people, about 5,000 die [16]. Some of the common bacteria in kitchen which causes diseases are given below [17].

1. *Bacillus cereus*
2. *Escherichia coli*
3. *Listeria monocytogenes*
4. *Shigella spp.*
5. *Staphylococcus aureus*
6. *Streptococcus*
7. *Campylobacter jejuni*
8. *Clostridium perfringens* and
9. *Salmonella spp.*

The various food items that are responsible for these bacteria are soft cheese, vegetables, cooked meat, raw meat, milk, egg, unpasteurized milk, potato (starchy food), oil, vinegar, high salt foods, high protein foods, sauces etc.

Water borne Bacteria

Waterborne bacteria cause a wide range of diseases including acute dehydrating diarrhea (cholera), prolonged febrile illness with abdominal symptoms (typhoid fever), acute bloody diarrhea (dysentery), and chronic diarrhea (Brainerd diarrhea). Common bacteria causing waterborne diseases are given below[18].

1. *Vibrio cholerae*
2. *Campylobacter*
3. *Salmonella*
4. *Shigella* and
5. *Escherichia coli (E. coli).*

Most common diseases caused in kitchen are due to selected type of water borne bacteria namely *E.coli, Salmonella spp. and Clostridium botulinum.*

Oil borne Bacteria

In kitchen more chances are there for oil borne bacteria and cause diseases. Some of the oil borne bacteria are,

1. *Salmonella typhimurium* and
2. *Listeria monocytogens.*

From the above three classes of bacteria it can be inferred that most common food borne, waterborne and oil borne bacteria that predominantly present in kitchen may include *Pseudomoniae aeruginosa, Klebsiella pneumonia, Staphylococcus epidermis, Bacillus cereus, Staphylococcus aureus, Streptococcus faecalis, Escherichia coli, Salmonella and Clostridium perfringens.*

Antibacterial Finish

There is an analysis made in recent years to discover possible bacteria in Indian kitchens[19].Microorganisms can be discovered wherever in the earth. Any sort of completing that devastates microscopic organisms or stifles their development or their capacity to repeat is called as antibacterial wrap up. The complete hinders the bacterial assault on the material by negative impact on the essentialness of the microscopic organisms.

Importance of antibacterial finishes

There are numerous reasons indicating the importance of antibacterial finishes for fabric. Some of the cited points are as follows. Bacteria both pathogenic and odour causing, interact with fibres in several phases including the initial adherence, subsequent growth and damage to the fibres and dissemination from them [20]. Cotton textiles in contact with the human body offer an ideal environment for microbial growth. Obnoxious smell from the inner garment, spread of diseases, staining and degradation of textiles are some of the detrimental effects of bad microbes [21]. Cotton fabrics are highly popular with people for their excellent properties such as regeneration, bio-degradation, softness and hygroscopic property. Along with their properties, cotton fabrics also provide an excellent environment for microorganisms to grow because of their large surface area and ability to retain moisture [22]. Contamination of food products by microbial growth can cause potential health hazards to human beings. In recent years, much emphasis has been put on the safety aspects of food, because mass contamination is caused by food spoilage microorganisms [23]. Due to its porous structure and hydrophilic nature cotton materials are preferred to be used in kitchen Textile articles made from cotton have an ability to keep moisture, oxygen and nutrients which offer an ideal medium to accommodate microbes. Microbial growth, especially bacteria, in textile materials can result in the deterioration of their properties, developing foul smells, causing skin irritation and leading to cross infections [23]. Cloths used for wiping surfaces are frequently heavily contaminated with bacteria. Such cloths readily transfer bacteria from one surface to another surface[1]. Concluding the facts mentioned above, it can be said that the fabric with moisture has a greater chance of microbial attack, particularly in food preparing environment.

Antibacterial finishes on textile materials

Textile materials need antimicrobial completions to stay away from diseases, control invasion and shield the material item from crumbling. Remembering the security parts of sound way of life and cleanliness prompts a scope of material items. Both engineered antimicrobial operators, for example, triclosan, metal and their salts, organo-metallics, phenols, quaternary ammonium mixes and regular specialists, for example, neem removes,

common colors, chitosan, tulsi leaf extricates, Aloe Vera separates, tea tree oil are promptly accessible in the market as antimicrobial specialists for characteristic and manufactured material materials. These characteristic natural antibacterial concentrates can be utilized as finishing specialists in the free-state or as microcapsules to improve the solidness and controlled arrival of the concentrates[25-27].

Killing Mechanism of Bacteria

Generally there are two broad finishes to kill the bacteria/inhibit the growth of bacteria. The former is called bactericide while the later is called bacteriostatic. The pictorial representation of the mechanism is illustrated in figure 3. When a product has a negative influence on the microorganism, it is generally termed as an antimicrobial. When the bacteria are killed, the suffix cide is used and when only the growth is stopped the suffix static used.

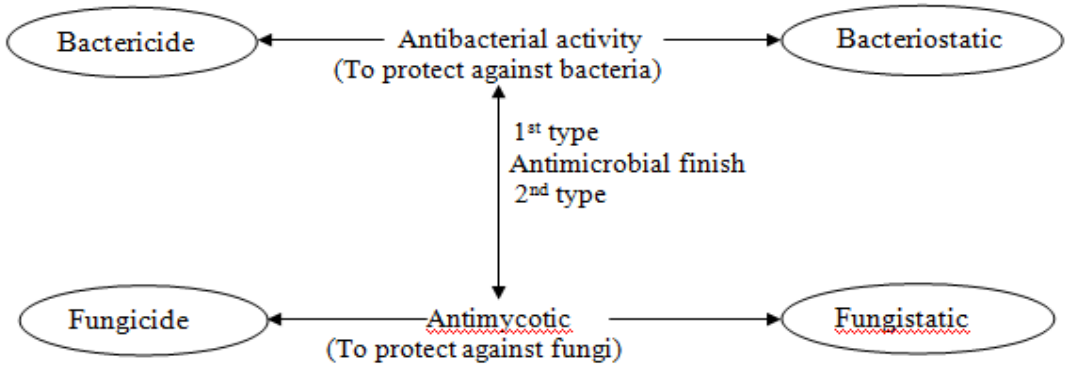

Figure 3 Mechanism of antimicrobial finish

Antimicrobial agents act in various ways. The main modes of actions are,

- Protein coagulation,
- Disruption of cell membrane resulting in exposure, damage or loss of the contents,
- Removal of free sulphydryl bunches needed for the working of enzymes and Substrate competition (A compound resembling the substrate of the enzymes/catalysts occupies or deludes the catalyst essential for the digestion of the cell and causes cell death).

Microorganisms contain a semi-permeable cell wall, which keeps up the integrity of cell substance. Bactericidal agents cause the break of this cell layer and harm the cells. Bacteriostatic agents just keep the protection of multiplication of microscopic organisms, which might be alive. Method of activity is by surpassing the synthesis of cell wall, modification of cytoplasmic membrane permeability, adjustment of the physical and chemical condition of proteins and nucleic acids, hindrance of catalyst activity and restraint of protein and nucleic acid synthesis.

In recent day's antibacterial kitchen clothes development have been attempted with possible bacteria and the natural agents can be claimed to suppress bacteria[28].

The mechanism of "antimicrobial activity" is not only for controlling the growth of bacteria but also involves protection from fungi [29]. The mechanisms with which these antimicrobial agents work when they are applied in fabric materials are classified as Leaching type antimicrobial agents and another one named as Bound type antimicrobial agents. These components are outlined underneath:

Leaching type Antimicrobial Agents

Most by far antimicrobial products work by leaching i.e, moving from the surface on which they are applied and entering the microorganism, harming it, and upsetting the existence process of it or causing a lethal mutation. The dosage of antimicrobial agent utilized is critical for efficiency. In case too little of the compound is applied, at that point the microorganism is not controlled and can adjust for survival. Notwithstanding, if a lot of is there on fabric then it can hurt other living things as well.

Bound type Antimicrobial Agents

Another set of antimicrobial with a totally unique method of activity is one that molecularly bonds to the fabric material. This agents makes the substrate surface antimicrobial active and works by rupturing the cell membrane of the microorganism when it comes to direct contact[29].

Types of Agents

Generally the antimicrobial agents used for finishing of textile fabrics to protect it from bacteria are divided into two types. They are

1. Natural antimicrobial agents and
2. Synthetic antimicrobial agents.

Various antimicrobial agents used are mainly for odour controlling environment and these agents control those odour types of bacteria.

Natural Antimicrobial Agents

A review of the various articles that mention about the efficiency of natural agents in controlling odour type bacteria are given bellow,

The methanolic extract of prickly chaff (Achyranthes aspera Linn.) leaves was applied to develop microbial resistant cotton fabric using citric acid as cross-linking agent. The antimicrobial activity of the finished fabric against bacteria that normally exists in the textile environment like *Staphylococcus aureus and Escherichia coli* was analysed. The treated sample showed higher bacterial reduction percentage of about 92.84 and 50.25 against *S.aureus and E.coli*. It was concluded that Prickly chaff leaf extracts have antimicrobial character due to the presence of a chemical substance called 'betaine', identified using high performance liquid chromatography (HPLC) technique [26, 27].

Herbal extracts from Ocimum sanctum (tulsi leaf) and skin of Punica granatum (pomegranate) have been connected to cotton texture by the technique for coordinate application, smaller scale exemplification and pitch cross-connecting. The two herbals were dried under sunshade to decrease the dampness content in the scope of 10-11% and pulverized into little pieces and separated with methanol. Bacterial decrease of Staphylococcus aureus and Klebsiella pneumonia were observed to be more noteworthy than 90% for Tulsi Leaf and more noteworthy than 85% for Pomegranate extricate. Both tulsi leaf and pomegranate skin separate treated textures indicated impressive zone of restraint to Gram positive and Gram negative microorganisms[21].

Quercus infectoria (QI) separate indicated great action at 12% focus hindering the microbial development by 45-60%. Microbial development restraint expanded to 70-90% when alum and copper sulfate were utilized as mordants. The mordants hold 100% action upto 5 launderings. The QI remove utilized were tried against Escherichia coli and Bacillus subtilis which cause cross contaminations in healing centers and unsavory scents in materials[30].

Extracts of neem and Mexican daisy were applied by direct application and microencapsulation to cotton fabric to protect from *staphylococcus aureus and Escherichia coli*. Microencapsulated herbal extracts showed very good resistance for microbes even after 15 washes. The herbs were dried at a temperature range of 37º-40ºC and moisture content was reduced to less than 14% and then powdered. The powdered plant material was extracted using methanol to separate the alkaloids[25].

The chitosan used to impart good antimicrobial property to the cotton fabric with the aid of citric acid as cross linking agent. *S.aureus* was used for antimicrobial testing since they were responsible for body odour and skin diseases. The finish showed 98.27% bacterial reduction against *S.aureus* and activity of 79% even after 3 wash cycles[30].

Neem extract was applied to cotton fabric with the aid of citric acid for imparting antimicrobial activity against *S.aureus and E.coli* bacteria (Thilagavathi et al 2007). Cotton fabric was treated with methanol extracted *Aloe Vera* (*Aloe barbadensis Mill*) at various concentrations. The aloe gel treated fabrics exhibited antimicrobial activity against the *Staphylococcus aureus*. The wash durability of the treated sample was found to be retaining 98% of its efficiency even after 50 washes[31].

These are some of the available literatures about application of natural agents to textiles and their antibacterial activity against selected bacteria such as *E.coli, S.aureus*. There are other natural agents that controls various bacteria, but they are not applied to textiles, are summarized below.

Analysis of antibacterial activity of *Pistacia,* and *Anthemis pungens* showed that they are active against *E. coli, B. subtilis* and *S. aureus.* Another plant Lichens have showed antibacterial activity against *Bacillus, Pseudomonas, E.coli, Streptococcus, Staphylococcus, Enterococcus and Mycobacterium*[32].

Antimicrobial activity of *Mikania triangularis* was tested against five genera of bacteria namely *Bacillus cereus, E. coli, P. aeruginosa, S. aureus* and *S. epidermidis*. It showed a very good antibacterial activity of 70% against all bacteria[33].

Methanol extracts of *W.somnifera* showed good antibacterial activity against *Proteus mirabilis* at a concentration of 50 mg/ml, *E.coli* and *P.aeruginosa* at a concentration of 60 mg/ml, *K.pnemoniae* at a concentration of 80 mg/ml, *S.aureus* and *Streptococcus pyogenes* at a concentration of 100 mg/ml was analysed[34].

The antimicrobial screening of the nut oil of *S. anacardium* was performed against Gram positive-*Bacillus subtilis* and *Staphylococcus aureus*, Gram negative-*Proteus vulgaris* and *Escherichia coli* is illustrated in table 5.

The study was conducted using the essential oil extracted from nut oil of *S. anacardium* at 1:2 dilution in dimethyl sulphoxide. The results showed that this agent

Table 5 Antimicrobial activity of nut oil of *Semecarpus anacardium*

Tested microorganism	Diameter of inhibition zone (mm)
Bacillus subtilis	9.3±0.22
Staphylococcus aureus	12±0.05
Proteus vulgaris	7±0.06
Escherichia coli	8±0.00
Candida albicans	9.3±0.20

It has good antibacterial activity against the bacteria given in the table 5. In particular it shows a remarkable inhibitory effect against *S. aureus*, a gram positive bacterium which is known to play significant role in skin diseases.

All the above four articles in general stress on extraction of oil from plant leaves and their antimicrobial efficiency against different bacteria/pathogens. It not only involves odour causing bacteria (E.coli, S.aureus) but also other food borne bacteria like *Proteus spp, Klebsiella spp*. etc. that cause cross infection diseases.

Synthetic Antimicrobial Agents

There are various papers discussing the different synthetic agents used as antibacterial agents on textile materials. The extracts from these articles are given below:

Cotton was treated with nano-silver colloid by an impregnation procedure to furnsih the cotton fabric with antibacterial properties. The results exhibited that the silver-treated cotton surface showed 99.01% bacterial decline of Staphylococcus aureus and 99.26% bacterial decreasing of Escherichia coli. The antimicrobial efficiency of the silver-treated cotton surface was kept up at over 98.77% diminishment level even resulting to being exhibited to 20 consecutive home washing conditions against both Staphylococcus aureus and Escherichia coli. Amino ended hyper expanded polymer (HBP-NH2) fills in as a folio to present and settle the silver nanoparticles to the cotton surface in the midst of the finishing process[22].

While another paper reveals that, nano silver on cotton fabric showed antibacterial activity of 99.91% against *E. coli* and 99.31% against *S. aureus* at a concentration of 80 ppm[35].

The antimicrobial property of silver and copper nanoparticles was explored utilizing Escherichia coli (four strains), Bacillus subtilis and Staphylococcus aureus (three strains). The examination demonstrated that silver and copper nanoparticles have incredible action against E. coli, B. subtilis and S. aureus. Both E. coli and S. aureus delineate higher affectability to the silver nanoparticles contrasted with the copper nanoparticles, the distinction was less movement for S. aureus contrasted with E. coli. Also, all the S. aureus strains showed indistinguishable affectability to silver and copper nanoparticles[36].

The 100% cotton fabric treated with ZnO nanoparticles showed significant antibacterial activity against *S. aureus.* Fabric treated with ZnO nanoparticles showed higher antibacterial activity when compared with ZnO bulk treated fabrics. The significant antimicrobial activity was actively retained in the ZnO nanoparticles treated fabrics upto 10 washes with bacteria reduction of around 70% [37].

While another paper on nano-ZnO uncovers that, the nano-ZnO impregnated cotton textures demonstrated phenomenal antibacterial action against two agent microorganisms, Staphylococcus aureus (Gram positive) and Klebsiella pneumoniae (Gram negative). Nano-ZnO covering with 1.63% take-up of ZnO demonstrated brilliant antibacterial movement (decrease > 99.9%). The finding was that Gram-positive microbes were more helpless to ZnO [38].

Bacteria such as *E.coli* and *S.aureus* were controlled and reduced by triclosan treated cotton fabric. The treated fabric showed antibacterial activity of 93% against *S.aureus* and 92.6% against *E.coli*. Triclosan was more effective against Gram-positive bacteria. If treatment is carried out on Hydrogen peroxide bleached cotton fabric the bacterial reduction improved to 100% against S.aureus and 95.2% against E.coli [39].

Metallic salt treatment on cellulosic fabrics and their antibacterial activity against three kinds of bacteria namely, gram-positive bacteria *Staphylococcus aureus (S. aureus),* gram-negative bacteria *Klebsiella pneumoniae (K. pneumoniae)* and methicillin resistant *Staphylococcus aureus* (MRS) were analysed[42]. It is reported that the antibacterial activity of these fabrics was retained even after ten washing cycles. While another paper on metallic salts reveal that, antibacterial activity of the cotton fabric treated with quaternary ammonium salt was assessed against both *Escherichia coli and Staphylococcus aureus* bacteria (reduction > 92% [40]. The studies conducted on antibacterial finish using natural and synthetic agents reveal that they are mostly focused on bacteria such as *E.coli, Klebsiella pneumoniae* and *S.aureus* especially for products which find application in Medical Textiles Health care, Hygiene textiles and Infection control.

Importance of Antimcrobial Finishes For Kitchen Fabrics[43]

There are various necessities for textile fabrics to give protection against bacteria. Some of them are listed below:

1. To reduce odour from perspiration, stains and other soil on textile materials.
2. To reduce the risk of cross infection being carried by feet from ward to ward in hospital.
3. To control spread of disease and danger of infection following injury.
4. To control the deterioration of textiles particularly fabrics made from natural fibre caused by mildew [41].

When kitchen fabrics are taken into consideration, imparting antibacterial finish becomes essential since growth of bacteria on them can cause diseases like,

- Vomiting, nausea to child and
- Urinary tract infection to adults.

CONCLUSION

Collection of literature on kitchen fabrics reveals that all the studies made in the past for the presence of bacteria on them were only from other countries. No such attempts were made in the past in India and hence information pertaining to presence of various bacteria on fabrics used in Indian kitchen environment is not available. The work carried out leaves a gap in terms of analyzing the Indian Kitchen Environments for such microorganisms and their potential way of generation and their health issues. The above situation brings out the fact that imparting antibacterial finish to kitchen fabrics becomes very essential and fabrics used in Indian kitchens are not an exception to this. Antibacterial kitchen textile products might have an overwhelming response since most of the current products used by end consumers are need to be hygiene and health care.

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