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Review Article

SPICES AS ANTIMICROBIAL AGENTS: A REVIEW

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ABSTRACT
The sources of drug are classified as plant, animal, minerals sources. The products from plants are used in many ways by human in there day today life. The best and the most important use are as food, and as spices. It does not matter which ever the civilization, what ever be the race and color of humans the main food comes from the plant. The spices are the vegetative substances used for to flavor the food. They are also used as preservative and are useful for the humans in many other ways. A spice could be dried seed, fruit, root, bark, or vegetative substance used in nutritionally insignificant quantities as a food additive for flavor, color, or as a preservative that kills harmful bacteria or prevents their growth. It may be used to flavor a dish or to hide other flavors. In the kitchen, spices are distinguished from herbs, which are leafy, green plant parts used for flavoring or as garnish. The above article is an effort to bring out the importance of some daily used spices as antimicrobial agents.
KEYWORDS: Spices, Antimicrobial agents, Ginger, Garlic, Coriander.

INTRODUCTION

Plants and there products have been used by humans in many ways, and the best use is as food and spices. Irrespective of race, civilization and culture the use of plant product as spice is prominent. Spices are the agents which provide flavor to our food. They can be roots, seeds, leaves or other part. May be used in dried form or as fresh. Either in the process of cooking or after it, to garnish or to mask the other undesired flavor. Use is the same but the application may be different. The uses of spice are not limited up to flavoring agents. They posses potent medicinal properties such as antimicrobial activity, antioxidants, anticancer, motion sickness vomiting of pregnancy, anorexia, bronchitis and rheumatic complaints, as a post-operative antiemetic. The medicinal character which is taken under review is antimicrobial activity. The antimicrobial character can be demonstrated in static or cidal manner. The main advantage of using the herbal antimicrobial drug is the side effects are reduced. The side effect such as damage of the normal intestinal flora, bone marrow depression, dysentery, local inflammation, damage to liver and kidney. The above side effects are over come to great extent by using the herbal drugs either be in the form of spices[1`].

Zingiber officinale



Figure 1: Ginger

Pharmacognosy and uses of *Zingiber officinale*

Ginger or *Zingiber officinale*, Roscoe belonging to the Family Zingiberaceae, is a Ginger produces clusters of white and pink flower buds that bloom into yellow flowers. Because of its aesthetic appeal and the adaptation of the plant to warm climates, ginger is often used as landscaping around subtropical homes. It is a perennial reed-like plant with annual leafy stems, about a meter (3 to 4 feet) tall. Traditionally, the root is gathered when the stalk withers; it is immediately scalded, or washed and scraped, to kill it and prevent sprouting.

Its roots are used as spice in cooking throughout the world. The ginger plant has a long history of cultivation known to originate in China and then spread to India, South East Asia, West Africa and the Caribbean. The main constituents are sesquiterpenoids with (-)- zingiberene as the main component. Other components include β-sesquiphellandrene bisabolene and farnesene which are also sesquiterpenoids, (β-sesquiphellandrene, cineol and citral)[2,3]. Mature ginger roots are fibrous and nearly dry. They can be cooked as an ingredient in many dishes. They can be stewed in boiling water to make ginger tea, to which honey is often added as a sweetener; sliced orange or lemon fruit may also be added. The juice of ginger roots is extremely potent and is often used as spice to flavour dishes such as seafood, mutton, snacks or stew. Powdered dry ginger roots (ginger powder) are typically used to add spiciness to ginger bread and other recipes. Ginger is also made into candy and used as flavoring for cookies, crackers and cakes as well as flavour in ginger ale-a sweet, carbonated, non-alcoholic beverage, ginger bread, ginger snaps, ginger cake and ginger biscuits [4].

Botanical classification

Kingdom	:	Plantae
Clade	:	Angiosperms
Order	:	Zingiberales
Family	:	Zingiberaceae
Genus	:	Zingiber
Species	:	*Z. officinale*

Antimicrobial potential of *Zingiber officinale*

Result of the study performed using different extract and culture sensitivity against microbes namely *colliform bacillus, staphylococcus epidermidis and streptococcus viridians* evidenced the antimicrobial activity clamed for the above herbal extract. The extract found effective were hexane and ethyl acetate. The water extract was found ineffective agnist the above microbes the inhibition of bacterial growth appeared to be dose dependent since no activiy was observed at low concentrations[5].

Effect on *Staphylococcus aureus* and *Streptococcus pyogenes*

In above study the effect of ginger and some antibiotics have been compared agnist *Staphylococcus aureus* and *Streptococcus pyogenes*. The antibiotics used for the comparison were chloramphenicol, ampicillin and tetracycline. The herbal extraction was done using solvents water and ethanol. The part of plant used for the extraction was leaves and root. Ginger leaf and root had the lowest zone of inhibition of 10 mm on *S. aureus* at 20 g/100 ml concentration of the water extract and it increased significantly as the concentration increased to 100 g/100 ml concentration which recorded the highest zone of inhibition of 30 and 32 mm of both the ginger leaf and root water extract. *S. pyogene* had the lowest zone of inhibition diameter of 18 and 19 mm on both ginger leaf and root respectively at 20 g/100 ml of water extract concentration which increased as the concentration increased with 100 g/100 ml concentration having the highest zone of inhibition of 25 and 28 mm of ginger leaf and root, respectively. The ethanol extract had significant effect ($P < 0.001$) on the zone of inhibition of *S. pyogene*. At concentration of 20 g/100 ml of the ethanol extract the lowest zone of inhibition of 20 and 21 mm (ginger leaf and ginger root, respectively) was produced. Meanwhile the highest zone of inhibition value of 30 mm (ginger leaf and ginger root) was recorded at concentration of 100 g/100 ml ethanol extract. The large sizes of zones growth inhibition produced by ginger extracts and the three antibiotics (Chloraphenicol, Tetracycline and Ampicillin) against the two bacterial *S. aureus* and *S. pyogene* indicated the potency of the active constituents in ginger and those antibiotics. The ginger root ethanol extract showed the greatest effect on both *S. aureus* and *S. pyogene* compared to the leaf and root water extract and the leaf ethanol extract. This is an indication that ginger is effective against *S. aureus* and *S. pyogene* infections. This result showed that ethanol extracts of ginger both leaf and root can be used alongside conventional antibiotics to fight agents of infections [6].

Antimicrobial activity of fresh and dry ginger oil

The microorganisms selected for the study are *Bacillus subtilis* (gram positive bacteria), *Pseudomonas aeruginosa* (gram negative), three fungi species namely *Candida albicans*, *Aspergillus niger, Penicillium* spp, *Saccharomyces cerevisiae* (yeast). The study resulted that fresh ginger oil was on nearly equal with standard antibiotic against *Aspergillus niger, candida* and *Pseudomonas aeruginosa*, weaker towards *Saccharomyces cerevisiae* and inactive against *Bacillus subtilis*, *Pencillium spp* and *Trichodermaspp*. Dry ginger oil was more active towards *Pseudomonas aeruginosa* , nearly equal with standard towards *Candida,* weaker than standard against *Bacillus subtilis, Aspergillus niger, Pencillium spp, Saccharomyces cereviseae*. The higher content of geranial and other oxygenated compounds makes fresh ginger oil more potent than dry ginger oil. The content of hydrocarbon compounds are more in dry ginger oil compared to fresh ginger oil [7].

Effect of mixture of ginger and honey on clinical isolates

The comparative antibacterial activity of honey, methanol and ethanol extracts of ginger (*Zingiber officinale*) were investigated against some selected bacteria using the agar diffusion technique. Two Gram positive and four Gram negative bacteria were assessed for possible inhibition by the extract samples. The inhibitory potency of the extracts on the test organisms varied in the result as inhibition effects. Though all the test organisms were susceptible to the antibacterial samples with inhibition measure between 6-3mm, *E. coli* was the most inhibited where an inhibitory measure of 20mm was recorded with honey, 18mm with ginger ethanol extract and 32mm with the mixture of honey and ginger ethanol extract. While some of the commercial antibiotics (positive control) were not effective on the test organisms, gentamycin and streptomycin were effective with inhibitory result ranging between 8-25mm [8].

Allium sativum



Figure 2: Garlic

Pharmacognosy and use of *Allium sativum*

The common name of *Allium sativum* is garlic. Its close relatives include the onion, shallot, leek, chive and rakkyo. Dating back over 6,000 years, garlic is native to central Asia, and has long been a staple in the Mediterranean region, as well as a frequent seasoning in Asia, Africa, and Europe. It was known to Ancient Egyptians, and has been used throughout its history for both culinary and medicinal purposes. *Allium sativum* grows in the wild in areas where it has become naturalised. The "wild garlic", "crow garlic", and "field garlic" of Britain are members of the species *Allium ursinum*, *Allium vineale*, and *Allium oleraceum*, respectively. In North America, *Allium vineale* (known as "wild garlic" or "crow garlic") and *Allium canadense*, known as "meadow garlic" or "wild garlic" and "wild onion", are commonweeds in fields. One of the best-known "garlics", the so-called elephant garlic, is actually a wild leek (*Allium ampeloprasum*), and not a true garlic. Single clove garlic (also called pearl or solo garlic) originated in the Yunnan province of China. Garlic is easy to grow and can be grown year-round in mild climates. While sexual propagation of garlic is indeed possible, nearly all of the garlic in cultivation is propagated asexually, by planting individual cloves in the ground. In cold climates, cloves are planted in the fall, about six weeks before the soil freezes, and harvested in late spring [9-12].

Garlic is also claimed to help prevent heart disease (including atherosclerosis, high cholesterol, and high blood pressure) and cancer. Garlic is used to prevent certain types of cancer, including stomach and colon cancers. In fact, countries where garlic is consumed in higher amounts, because of traditional cuisine, have been found to have a lower prevalence of cancer. The known vasodilative effect of garlic is possibly caused by catabolism of garlic-derived polysulfides to hydrogen sulfidein red blood cells (RBCs), a reaction that is dependent on reduced thiols in or on the RBC membrane. Hydrogen sulfide is an endogenous cardioprotective vascular cell-signaling molecule. A randomized clinical trial funded by the National Institutes of Health (NIH) in the United States and published in the *Archives of Internal Medicine* in 2007 found the consumption of garlic in any form did not reduce blood cholesterol levels in patients with moderately high baseline cholesterol levels. *Allium sativum* has been found to reduce platelet aggregation and hyperlipidemia [13-21].

Botanical classification

Kingdom : Plantae
Clade : Angiosperms
Order : Asparagales
Family : Amaryllidaceae
Subfamily : Allioideae
Genus : Allium
Species : *A. sativum*

Effect of garlic on *H.pyroli* with comparison with omeprazole

In the above study the antibacterial effect of raw home mad garlic, marketed garlic tablet alone with the omeprazole was determined agnist the known ulcer causing microorganism *H.pyroli*. Diluation of raw and marketed tablet of garlic was made using distilled water. The sensitivity was determined using agar plate and blood agar plate. The concentration of raw and commercial garlic used were from 1000 to 17500mg/l. MIC values for the three commercial garlic tablets were similar (40,000 mg/L). In this study, a growth inhibitory effect of garlic on *H. pylori* was observed. In addition, a synergic effect was found for the combination of garlic and omeprazole. How-ever, no synergic or antagonistic effect was observed between garlic and amoxycillin, clarithromycin or metro- nidazole [22].

Activity against isolates of extracted carious teeth

In the above study performed the antibacterial activity was detected agnist seven bacterial species (*Streptococcus mutans*, *Lactobacillus acidophilus*, *Norcadia asteroides*, *Pseudomonas aeruginosa*, *Actinomyces viscosus*, *Staphylococcus aureus* and *Veillonella alcaligens*) isolated from 240 extracted, carious teeth**.** the bacterial isolate were prepared by suspending a loop full of each microbial growth in about 10 ml of nutrient broth. After incubation at 37°C for 12 h, the turbidity was adjusted to be visually comparable with a 0.5 McFarland's standard giving a bacterial load of about 1 - 2 × 108 cfu mL^{-1}. From the finding of the above study the result stated that there was a considerable inhibition effect using garlic. The study also resulted the use of lime and garlic for the treatment [23].

Antibacterial activity of garlic extract on different microorganism varying temperature and pH

The antibacterial effects of aqueous garlic extract against 17 multidrug-resistant gram-positive and gram-negative bacterial isolates, including *Staphylococcus aureus*, *Salmonella typhi, Pseudomonas aeruginosa, Escherichia coli*, and *Proteus* spp., were studied. Antibacterial activity of different concentrations of aqueous garlic extract by well-diffusion method was characterized by inhibition zones of 15 Gram-positives and two Gram-negative pathogenic bacteria. The maximum zone of inhibition was observed in *Bacillus subtilis* and the minimum was observed for *Proteus* sp. The minimum inhibitory concentration (MIC) was in the ranges of 6–11 mg/mL and 7–21 mg/mL, in Gram-positive and Gram-negative organisms respectively. The MIC values at 24 and 48 hours were not significant in the tested isolates. Further analysis revealed the antimicrobial efficacy of aqueous garlic extract is time and temperature dependent. Antibacterial efficacy of aqueous garlic extract maintained at room temperature was for maximum 7 days. At 20^0 temperatures the activity was maintained for 90 days. In summary, the AGE showed a wide spectrum activity and appears to satisfy all of the criteria for antibacterial agents. These results suggest that garlic can be used to protect food and consumers from the risk of contamination from pathogenic microorganisms [24].

Activity against enteric pathogens using garlic varieties

The above study was performed agnist the enteric microorganisms namely *Escherichia coli*, *Proteus m irabilis, Salmonella typhi, Shigella flexineri and Enterobacter aerogenes*. The activity was done using two varieties of garlic that is ophioscordon and sativum. Aqueous extract was made and used for to evaluate the potential of garlic varieties agnist the above microorganisms. The antibacterial activity of *Allium sativum* L (*ophioscordon* and *sativum*) was evaluated by agar well diffusion method. The above study relulted that both the garlic (aqueous) extracts showed growth inhibition activities at the concentrations of 200mg to 500mg. *Proteus mirabilis* was sensitive to aqueous extracts of *ophioscordon* at higher concentrations (400 and 500mg). *E.aerogenes* was not susceptible to the aqueous extract of both the garlic varieties, while *S.typhi* was susceptible to both the extracts of garlic varieties [25].

Syzygium aromaticum



Figure 3: Clove

Pharmacognosy and use of *Syzygium aromaticum*

The above plant part is used world wide as an important spice of kitchen. Cloves (*Syzygium aromaticum*) are the aromatic dried flower buds of a tree in the family Myrtaceae. The clove tree is an evergreen that grows to a height ranging from 8–12 m, having large leaves and sanguine flowers in numerous groups of terminal clusters. The flower buds are at first of a pale color and gradually become green, after which they develop into a bright red, when they are ready for collecting. Cloves are harvested when 1.5–2 cm long, and consist of a long calyx, terminating in four spreading sepals, and four unopened petals which form a small ball in the center. In Ayurvedic medicine it is considered to have the effect of increasing heat in system, hence the difference of usage by region and season. Cloves are used in Indian Ayurvedic medicine, Chinese medicine, and western herbalism and dentistry where the essential oil is used as an anodyne (painkiller) for dental emergencies. Cloves are used as a carminative, to increase hydrochloric acid in the stomach and to improve peristalsis. Cloves are also said to be a natural anthelmintic. The essential oil is used in aromatherapy when stimulation and warming are needed, especially for digestive problems. Topical application over the stomach or abdomen are said to warm the digestive tract. Clove oil, applied to a cavity in a decayed tooth, also relieves toothache. It also helps to decrease infection in the teeth due to its antiseptic properties. Studies have resulted that its effectiveness for fever reduction, as a mosquito repellent and to prevent premature ejaculation has been inconclusive. Clove may reduce blood sugar levels. The buds have anti-oxidant properties [26-29].

Botanical classification

Kingdom: Plantae
Phylum : Angiosperms
Order : Myrtales
Family : Myrtaceae
Genus : Syzygium
Species : *S. aromaticum*

Synonyms[30]

- *Caryophyllus aromaticus* L.
- *Eugenia aromatica* (L.) Baill.
- *Eugenia caryophyllata* Thunb.
- *Eugenia caryophyllus* (Spreng.)

Antibacterial activity on food born pathogens

The antibacterial efficacy of clove was determined on food born pathogens namely *S. aureus, P. aeruginosa, E. coli*. Agar diffusion susceptibility test revealed inhibition zone of clove sample. Compare to ethanolic extract, methanolic extract was showing best result against gram positive culture *Staphylococcus aureus* (MTCC 2940) and two gram negative cultures *Pseudomonas aeruginosa* (MTCC 2453) and *E. coli* (MTCC 739). The MIC value was determined by using broth dilution methods. Methanolic extract of clove was subjected to get the MIC against test organisms and it was found to be 2.31 mg/ml for *E. coli*, 0.385 mg/ml for *Stapylococcus aureus* and 0.01 mg/ml for *Pseudomonas aeruginosa*. In the above study little change was done by addition of metal ions (Zn++, Cu++, Pb++, Ca++, Mg++, Fe++) along with methanolic extract of clove samples gave positive results against test organisms [31].

Activity agnist some gram negative bacteria

In the above study the essential oil and the extract of clove have been studied agnist some gram negative bacteria namely *Escherichia coli*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Enterobacter aerogenes*, *Klebsiella ozaenae*, *Klebsiella pneumoniae*, *Serratia marcescens* , *Salmonella typhi* , *Shigella dysentriae* and *Vibrio cholerae*. The screening was performed by standard disc diffusion method. The aqueous infusion and decoction of clove exhibited maximum activity against *P. aeruginosa* with 10.43 mm mean diameter of zone of inhibition ± 1.76 standard deviation and 10.86 mm mean diameter of zone of inhibition ± 1.46 standard deviation respectively. Essential oil of clove exhibited maximum activity against *V. cholerae* with 23.75 mm mean diameter of zone of inhibition ± 3.03 standard deviation. *K. ozaenae, K. pneumoniae, S. marcescens, S. typhi, S. dysentriae* and *V. cholerae* were found resistant to aqueous infusion and decoction while essential oil showed strong antibacterial activity against all bacterial isolates tested [32].

Antifungal properties

In the above study the antifungal effect of clove have been studied agnist time, concentration and organism namely *Candida albicans, Penicillium citrinum, Aspergillus niger* and *Trichophyton mentagrophytes*. The fungicidal effect of CO-sugar was compared with disinfectants commonly used in hospitals, such as povidoneiodine (1% of free iodine) at 0.5% and soapy solution of chloroxylenol (0.3 %).The fungicidal effect was enhanced at 37ºC were enough to eliminate a microbial inoculum of 106 c.f.u./ml of *C. albicans*. Although clove oleoresin caused important lethal effect, *P. citrinum* and *A. niger* were more resistant. After 60 minutes, clove oleoresin dispersed (0.4% v/v) in concentrated sugar solution caused a 99.6% reduction of the initial population (106 c.f.u./ml) of *Trichophyton mentagrophytes*. The fungicidal activity of clove-sugar on *C. albicans*, after 2 min contact, was similar to that presented by disinfectants commonly used in hospitals, such as povidone-iodine and chloroxylenol [33].

Antibacterial activity agnist food born pathogen and spoilage bacteria

The activity was studied agnist food born pathogens namely *Listeria monocytogenes* (5 strains), *Staphylococcus aureus* (4 strains), *Escherichia coli* O157: H7 (6 strains), *Salmonella* Enteritidis (4 strains), *Vibrio parahaemolyticus* and *Bacillus cereus* and 5 food spoilage bacteria: *Pseudomonas aeroginosa*, *P. putida*, *Alcaligenes faecalis*, and *Aeromonas hydrophila.* The above study confirmed the activity of clove agnist the organisms. The MIC values for ethanol, aqueous extracts, and essential oil from cloves ranged from 0.5 to 5.5 mg/ml, 0.8 to 5.5 mg/ml, and 1.25 to 5 %, respectively. The result showed that essential oil of cloves reduced all *Listeria monocytogenes* cells to an undetectable level in ground chicken meat within 1 day of exposure. The above study also stated the use of clove as a preservative, clove could be useful to control *L. monocytogen* [34].

Cinnamomum aromaticum



Figure 4: *Cinnamomum aromaticum*

Pharmacognosy and uses

It's an evergreen tree native to southern China, Bangladesh, Uganda, India, and Vietnam. Like its close relative *Cinnamomum verum*, also known as "Ceylon cinnamon", it is used primarily for its aromatic bark, which is used as a spice. In the United States of America, cassia is often sold under the culinary name of "cinnamon". The buds are also used as a spice, especially in India, and were once used by the ancient Romans. The tree grows to 10–15 m tall, with greyish bark and hard elongated leaves that are 10–15 cm long and have a decidedly reddish colour when young. Cinnamomum aromaticum is a close relative to Ceylon cinnamon (*C. verum*), Saigon cinnamon (*C. loureiroi*, also known as "Vietnamese cinnamon"), camphor laurel (*C. camphora*), malabathrum (*C. tamala*), and Indonesian cinnamon (*C. burmannii*). As with these species, the dried bark of cassia is used as a spice. Some cinnamon oil-entrained compounds could prove toxic in high concentrations. Cassia's effects on enhancing insulin sensitivity appear to be mediated by type-A polymeric polyphenols. Despite these findings, cassia should not be used in place of anti-diabetic drugs, unless blood glucose levels are closely monitored, and its use is combined with a strictly controlled diet and exercise program. Due to a toxic component called coumarin, European health agencies have warned against consuming high amounts of cassia. Other possible toxins founds in the bark/powder are cinnamaldehyde and styrene. A systematic review of research indicates that cinnamon may reduce fasting blood sugar, but does not have an effect on hemoglobin A1C, a biological marker of long-term diabetes [35-40].

Botanical classification

Kingdom : Plantae
Phylum : Angiosperms
Order : Laurales
Family : Lauraceae
Genus : Cinnamomum
Species : *C. aromaticum*

Activity agnist some food born microbes

The study have been evaluated agnist some food born bacteria and fungus namely Gram-positive bacteria *Bacillus cereus, Bacillus subtilis, Bacillus* sp., *Staphylococcus aureus, Staphylococcus epidermidis, Listeria monocytogenes* and *Micrococcus luteus*, while the Gram-negative bacteria comprised *Escherichia coli, Klebsiella* sp. and *Pseudomonas aeruginosa.* The fungal isolates used in this study were *Alternaria* sp., *Aspergillus fumigatus, Aspergillus niger, Aspergillus* sp., *Penicillium* sp., *Rhizopus* sp. And *Rhizomucor* sp. The antimicrobial activities of cinnamon extract and oil were determined by the agar well diffusion method. Cinnamon extract was found to be effective against almost all of the food-borne microbes. *B. cereus* was found to be the most sensitive to cinnamon extract with an inhibition zone diameter (IZD) of 17 mm, followed by *S. aureus* (16 mm). *Bacillus* sp., *B. subtilis* and *S. aureus* were found to be partially sensitive to the test extract with an IZD of 14, 14 and 13 mm, respectively. The organisum *P. aeruginosa* was found to be resistant. cinnamon oil inhibited the growth of all the test bacteria, it produced the widest IZD against *B. cereus* (29 mm), followed by *S. aureus* (20 mm). It also inhibited the growth of *P. aeruginosa* and produced an IZD of 16 mm [41].

Activity against microorganisms isolated from patients of oral infection

The *Strep mutans, Staph. aureus, Cand.albicans* and *Cand. Glabrata* are the most common cause of oral infection. The organisms are prone to drug resistance so in the above study the cinnamon and Eucalyptus oil have been evaluated for the effect. The oils were prepared by steam distillation and their inhibitory activity at different concentrations and the minimum inhibitory concentrations (MIC) were determined. All of the bacterial and fungal isolates were sensitive to Cinnamon and Eucalyptus. Cinnamon oil showed strong promising inhibitory activity on all the *S.mutans* isolates at a concentration as low as 3.12%. Eucalyptus oil showed less inhibitory activity, as the least effective concentration of this oil was 25%. The MIC of Cinnamon and Eucalyptus oil ranged 12.8- 51.2 and 64-256mg/ml [41].

CONCLUSION

Infection and related disease are been problematic to human because of the health complication but also due to the difficulty in there management. The infection creates many complication and the for most issue is the drug resistance. After all taking precaution the issues of drug resistance have been more and more reported. Another problem is the side effect of the synthetic antimicrobial drug. The herbal drugs have been always the alternative and the answers for all the above issues. In the above article the spices and the use as antimicrobial have been discussed. These are the food supplement and the additives which have been used by the humans daily. The main concern of the article have been to bring out the use of spices in health rather than provide taste to the food.

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