

REVIEW ARTICLE

INDIAN SANDALWOOD (*SANTALUM ALBUM* L.): A COMPREHENSIVE REVIEW OF ITS CULTURAL HERITAGE, TRADITIONAL USES, AND MODERN PERSPECTIVESPadma S¹., Mamatha, N²., Sundararaj, R²., Prashanth, M². and Nalini, U.R.^{2*}¹Indian Institute of Science, Bangalore – 560012, India²*ICFRE- Institute of Wood Science and Technology, Malleswaram Bangalore-560003, IndiaEmail: nalini@icfre.org

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Abstract: Indian Sandalwood (*Santalum album* L.) is one of the most valuable plant species in the world that have been associated with human civilization for more than four millenia. This review aims to document the historical significance of sandalwood, its mythological background, cultural importance, economic value, and its traditional and scientific applications. Indian sandalwood has been widely celebrated and discussed abundantly in old Indian literary works like the Ramayana, Mahabharata, Vedas, and Arthashastra. It is being used extensively in different religious and spiritual practices of Hinduism, Buddhism, Jainism, and Zoroastrianism. Traditional uses of sandalwood are from birth till death, including homa and abhishekam in ceremonies, Ayurvedic medicine preparations like Chyawanprash, skincare products, and handcrafts. The efficacy of various traditional applications of sandalwood has been established by modern science through its pharmacological attributes like antitumor, antibacterial, anti-inflammatory, and neuroprotective effects. Main bioactive constituents are α - and β -santalols. Unfortunately, due to over exploitation for its cultural and economic importance, sandalwood has become a threatened species.

Keywords: *Santalum album*, Cultural heritage, Traditional, Pharmacological, Santalol, Handcraft, Bioactive

INTRODUCTION

From ancient times until now, Indian sandalwood (*Santalum album* L., Family: Santalaceae) has been one of the most highly valued tree species because of its long-lasting fragrance, exquisite carving quality, and high cultural value (Sundararaj *et al.*, 2019a). Unlike many other fragrant plants, sandalwood keeps its aroma for several decades, thus making it an excellent ingredient in perfumes, medicines, and religious artefacts. The English name "Sandal" derived from word Chandana (Srinivasan *et al.*, 1992). In the Indian tradition, the sandalwood tree plays a significant role, being utilized in every sphere of people's life from the cradle to the crematorium, with the help of which spiritual liberation can be reached, tension is relieved, and peace of mind is ensured (Sandeep & Manohara, 2019). This review is designed to gather information about the culture of Sandalwood in order to emphasize its value and the necessity of its conservation.

CULTURAL AND HISTORICAL SIGNIFICANCE

Sandalwood in Ancient Indian Texts

Indian sandalwood has inextricable links with Indian culture and plays a very important role in Indian legends and religious writings. In historical studies, it is stated that Sandalwood has been found in writings like Milinda Panha (200 BC), Patanjali's Mahabhashya (100 BC), Ramayana and Mahabharata. In Ramayana, Valmiki cited the importance of sandalwood as "The breeze that wafts through the sandal trees is very invigorating and cleans the atmosphere with the intoxicating scent of sandal". Rabindranath Tagore described sandalwood as a symbol of selfless virtue and stated "The sandalwood tree is sure to be the sweetest that could even conquer hate, love, and perfumes the cruel axe that lays it low". Kalidasa (4th-5th Century CE) writes about sandalwood trees in his epic poem entitled "Raghuvamsha." His statement goes like this: "The neck halter of elephants breaking their food chains did not slip, being fixed in the marks of coiling serpents round the sandalwood trees". In addition to that, the two mountains named Malaya and Dardura with their peak covered with

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sandalwood trees: "Dally over me uplands of Malaya, strew with Tamala leaves, where the trees have cardamom creepers clinging to them and betel trees (Puga) are girt about with betel creepers (Tambula)". Sandalwood is also listed among the objects entered into the treasury in Chapter XI of Kautilya's "Arthashastra," 320 BC to 300 AD). Periplus of the Erythraean Sea or Periplus of the Red Sea is a Greco-Roman periplus. It was written in Greek and describes the navigation and trade prospects from the Roman Egyptian ports such as Berenice along the coast of the Red Sea. During 1st century, the Greco Roman navigational logbook called Periplus had mentioned the traded route of Sandalwood from India. Sandalwood is mentioned in the Tamil -epic poem "Silappathikaram" (2nd -5th century AD) as originated from the Southern Mountain range (Malaya Tenmalai piranda chandanam). Later Ayurvedic texts like Charaka samhita described Chyawanprash formulations, a herbal paste associated with the historic reference of restoration of youth and vitality of sage Chyavana, had components of sandalwood along with amla, cinnamon, and cardamom (Scartezini *et al.*, 2006; Sharma *et al.*, 2019). In Hitopadesa II Verse 163, it was said 'The root is infested by serpents, the blossoms by trees, the branches by the monkeys, and the summit by bears'. Essentially every part of the sandalwood tree is free from impurities but rich in its natural incredible qualities.

Religious and Ritualistic Uses

Indian sandalwood is an integral part of Hindu rituals such as homa/havana (offerings to sacred fire), abhishekam (bathing deities with liquids), and temple constructions (Fig. 1). According to the Brahma Vaivarta Purana, Goddess Lakshmi dwells within the Sandalwood trees, making them symbol of prosperity and fortune. *Vamana Purana*, prescribes the use of sandalwood paste for worshipping Lord Shiva. According to Hindu Mythology, the birth of Lord Ganesha is often associated with the sandalwood and turmeric paste made by Goddess Parvati. As per the Bhagavata Purana, Goddess Parvati bestows her blessings on a dwarf woman called Kubja when she puts sandalwood paste on Lord Krishna's body. The Lord Venkateshwara is often known as 'Chandana Charchita Govinda', which translates to "The Lord with a pure and beautiful form, adorned with sandalwood paste, and possessing a complexion resembling that of a cloud". The Tirumala Tirupati Devasthanam (TTD) uses over half a tonne of sandalwood annually for rituals like *Snapanam* *Thirumanjanam* (Sandeep & Manohara, 2019). Sandalwood is equally important in other religions, in Jainism, the paste of sandalwood mixed with saffron is applied during prayers of the Tirthankaras and in Buddhism, sandalwood incense is offered to Buddha and it is believed that Buddha's remains were burnt upon a pyre made up of sandalwood in 543 BC. Zoroastrians offer Sandalwood twigs to

maintain sacred fires. The people of Greece came to know about this enchanting fragrant oil used in medicine during the period of Alexander, the great and an European Hakeem (physician) of Madarsa Salarno. The ancient Egyptians used sandalwood oil for embalming mummies and treating skin disorders. It is used as perfume or burned as "bukhoor" to fumigate rooms and spaces of worship in the Islamic world.

Economic History and Conservation

Realizing its importance, Tipu Sultan, who ruled over Mysore from 1782-1799, conferred it with the status of being a "Royal tree" and even formed a monopoly for it. The British too monopolised the sandalwood trade in southern India, and overexploited the species as far as the market would allow (Rashkow, 2014). After independence, the states framed state forest laws with provisions of Challenges in the Production and Protection of Indian Sandalwood to maintain the control regime. The state governments of south India held exclusive authority over all the sandalwood resources, even those located on private properties until 2002 which led to rampant smuggling and illicit trade that resulted this species at risk of extinction (Neil, 1986). However, Sundararaj, (2026) concluded that the primary cause of the unfortunate depletion of sandalwood resources in India is undeniably the widespread occurrence of SSD, which is lethal to sandalwood trees and their subsequent extraction. IUCN (2000) has classified it as a vulnerable plant species. The state governments of Karnataka and Tamil Nadu amended the Sandalwood Act in 2001 and 2002, respectively, and made the grower himself an owner of the sandalwood (Dhanya *et al.*, 2010). The amended acts explicitly stipulate that "every land occupant or holder shall have a legal entitlement to the sandalwood tree on their land." These amendments are encouraging the farmers and corporate bodies to take on sandalwood plantations to meet the growing demand (Gowda *et al.*, 2008) and sandalwood cultivation is increasing in areas outside forests (Sundararaj *et al.*, 2019b). The Economic Advisory Council of the Prime Minister and NITI Aayog established "Sandalwood Development Committee" as a guiding force for sustainable production and conservation of Indian sandalwood. Furthermore, the Government of India has released postal stamps (Fig. 2) to promote its conservation (Purohit, 2018).

TRADITIONAL USES

Ceremonial Applications

It is customary in certain communities of Hindus to put a piece of sandalwood in the funeral pyre as a mark of respect to their departed relatives. Sandalwood paste is used in rituals and ceremonies and to mark religious utensils and to decorate the icons of the deities (Fig. 3) and distributed to

devotees, who apply it to their foreheads or the necks and chest. It is also applied on the entire head after shaving. The body of the philosopher saint Ramanujacharya (after 1137 AD) is preserved in Sri Ranganatha Swamy Temple using only sandal wood paste and saffron.

Skin Care and Cosmetics

Conventionally, women in India have applied Sandalwood paste on their skin for beautifying purposes. Sandalwood paste is beneficial for various skins, especially for dry, oily, and acne-prone skins, since it has moisturizing and astringent qualities. It helps relieve irritated skin that is dry or chapped. Moreover, this is applied on stretch marks and scars. Guests in marriages are greeted by putting sandalwood paste on cheeks (for women) or wrists (for men). Furthermore, it is used in making incense or agarbatties and burning incense, and sandalwood mala (Fig. 4) (Dastur, 1962; Farooqui & Sreeramu, 2001). Sandalwood oil is extensively used in the oil skin-care soaps, lotions, perfumes, and creams (Fig. 5).

Handicrafts

Around 5% of the yearly output of sandalwood goes into making beautiful sculptures of deities, boxes to keep jewellery, picture frames, combs, toys and decoratives (Fig. 6). Sandalwood oil has an inherent characteristic of being an insect repellent, thus adding to its utility. Skilled artisans who practice wood sculpture art and who are referred to as "Gudigars" in Karnataka have passed down their tradition from generation to generation. The places famous for this practice include Thirupathi (Andhra Pradesh), Ankola, Bangalore, Honnavar, Kumta, Mysore, Sagar, Sorab, Sirsi Talaguppa (Karnataka), Thiruvananthapuram (Kerala), Surat (Gujarat), Jaipur, Jodhpur, Pali, Mathopur ((Rajasthan) and some places in Tamil Nadu, Uttar Pradesh and West Bengal. "Cauvery" (Karnataka State Arts and Crafts Emporium) and Tamil Nadu's Poompuhar Corporation market promotes these handicrafts of Karnataka and Tamil Nadu respectively.

MEDICINAL USES

Applications in traditional medical systems:

Traditional medical systems like Ayurveda, Homoeopathy, Siddha, Tibetan, Unani, and Western medicine, use sandalwood to treat various illnesses. It was mentioned in 'De Materia Medica' written by Discorides, the father of pharmacology. It principally acts as a demulcent, diuretic, and mild stimulant in Ayurveda (Pande, 1977) and prescribed to treat bronchitis, dysuria, urinary infection, and gonorrhoea (Dikshit & Hussain, 1984). Sandalwood's wood, roots, bark, and leaves are used by native tribal healers to cure liver conditions, including jaundice. In Ayurveda as therapeutic uses, it is recommended for many ailments that include biliousness, fever, bleeding piles, diarrhoea with internal bleeding, eye

infections, haemorrhage, hiccoughs, inflammation of umbilicus poisoning, the initial phase of pox, urticaria, and vomiting (Kirtikar & Basu, 1933; Desai & Hirenath, 1991). Also, applying cooled sandalwood to the forehead helps to calm the mind. In Unani medicine sandalwood is used to neutralise the adverse effects of intense sunlight and fever, quench thirst, and impart a soothing and invigorating sensation. Sandalwood paste is topically applied to treat localized inflammations, boils, and skin illnesses. It is also applied to the forehead to alleviate fever and to the nostrils to alleviate migraines. Decoction of sandalwood is used for genito-urinary abnormalities. Mixture of sandalwood paste and lime juice as a remedy for itching, scabies, eczema, and several other dermatological conditions in Siddha medicine. Sandalwood oil is advocated in Aromatherapy to treat sleeplessness, neurological tension, and stress disorders (Lawless, 1999) because of its santalol content (Holmes, 1989).

Modern Scientific Pharmacological Perspectives

Modern research has validated many traditional claims, revealing diverse bioactivities, primarily attributed to α - and β -santalol, the major constituents of sandalwood oil (Verghese *et al.*, 1990) and its broad pharmacological action renders it extremely significant (Aftab *et al.*, 2023). Sandalwood extracts have shown memory enhancement potential in animal studies (Papaiah *et al.*, 2010) and affect the sleep-wake cycle (Ohmori *et al.*, 2007). Sandalwood oil is demonstrated as a relaxant, calming and soothing nerves, muscles, and blood vessels, effectively relieving spasms and contractions. Due to its calming and relaxing properties, sandalwood oil is used to treat respiratory tract infections (Holmes, 1989; Davis, 1999) and for coughing up blood (hemoptysis) and coughing up pus (purulent expectoration). Furthermore, it is used to treat genitourinary tract infections (Imdorf *et al.*, 1999) and as a cure for malodorous and pus-filled menstrual discharge, excessive menstrual bleeding, abnormal vaginal discharge and abnormal passage of semen. It potentially alleviates dry skin disorders and the symptoms of eczema and psoriasis (Davis, 1999). Applying sandalwood oil during meditation proved to reduce mental distractions and beneficial for promoting healing and self-healing (Rippin, 1997). When sandalwood oil inhaled through the olfactory system, it relaxes the sympathetic system, resulting in decrease in heart rate and blood pressure and an increase in heart rate variability. It has the potential to prevent headaches, insomnia, and nervous tensions (Battaglia, 2007), depressant effects (Ohmori *et al.*, 2007), memory enhancement (Jackson *et al.*, 2009) and treatment of Alzheimer's disease and skincare (Misra & Dey, 2013a). Sandalwood oil is used as a dietary supplement (Burdock & Carabin, 2008), known to have Antihyperglycemic and antihyperlipidemic effects (Kulkarni *et al.*, 2012) and prevents gastric ulcers (Ahmed *et al.*, 2013). Hegde

et al. (2014) reported that the hydroalcoholic extract of its leaves could protect the liver from damage caused by CCl₄ and paracetamol. Water-based sandalwood extract protects the heart muscle by lowering lipid oxidation and the cardiotoxic effects of doxorubicin (Khan *et al.*, 2014) and the saponins present in the leaves of sandalwood have haemolytic effects (Deepak *et al.*, 2014). Experimentally sandalwood oil is proved to have antimicrobial activities that includes antibacterial (Jones *et al.*, 1995, Ochi *et al.*, 2005, Jirovetz *et al.*, 2006; Bakkiyaraj & Pandiyaraj, 2011), antifungal (Chaumont & Bardey, 1989) and antiviral properties (Schnitzler *et al.*, 2007, Koch *et al.*, 2008, Singh & Nulu, 2010, Misra & Dey, 2013b).

The presence of antioxidant principles in the plant by phytochemical and pharmacological tests justified its traditional therapeutic effects (Scartezzini & Speroni, 2000). The extracts of sandalwood demonstrated considerable scavenging effect on Nitric Oxide and DPPH antioxidant activity (Jagetia & Baliga, 2004; Patrick & Timothy, 2002, Pedapati *et al.*, 2012), protect cardiac tissue from oxidative stress-induced damage (Khan *et al.*, 2014) and has anti-hyperglycemic properties (Misra & Dey, 2013c). Ximenynic acid from sandalwood seed oil has the ability to detoxify and strengthens the Extracellular Matrix (ECM) resulting in stronger dermis and more flexible skin (Vasundhara *et al.*, 2015). It also has the potential to treat cellulitis, hair loss, and varicose veins (Hettiarachchi *et al.*, 2013) and has anti-aging activity (Shivatare *et al.*, 2020). The methanolic extracts of heartwood exhibit anti-inflammatory effects (Saneja *et al.*, 2009).

Anticancer effect of sandalwood and its products have been demonstrated during the recent days. J82 human bladder cancer cells were killed by sandalwood oil and stopped the cell cycle (Dozmorov *et al.*, 2014). α -santalol inhibits skin cancer (Dwivedi *et al.*, 2003; Kaur *et al.*, 2005; Zhang & Dwivedi, 2011; Santha & Dwivedi, 2015) and prevents development of skin tumours generated by UVB radiation (Dwivedi *et al.*, 2006; Bommarreddy *et al.*, 2007). It exhibits cytotoxicity against prostate and oral cancer cells (Bommarreddy *et al.*, 2012; Lee *et al.*, 2015). It is also source of novel antitumor sesquiterpenoids. A few new sesquiterpenoids, two aromatic glycosides, and a number of neolignans obtained from heartwood of sandalwood possess a strong blocking effect on EBV-EA activation resulting in strong stopping effect on two-stage carcinogenesis on mouse skin. (Kim *et al.*, 2006). Matsuo and Mimaki (2012) demonstrated tumour-selective cytotoxicity in HL-60 human promyelocytic leukaemia cells and TIG-3 normal human diploid fibroblasts by the derivatives of α -santalol. Two ligands sourced from the

heartwood showed apoptosis induced tumour cell cytotoxicity against HL-60 human promyelocytic leukemia cells and A549 human lung adenocarcinoma cells (Matsuo and Mimaki, 2010). Cytotoxic properties of α - and β -santalol against many head and neck squamous cell carcinoma (HNSCC) were demonstrated by lines by Lee *et al.* (2015).

Other uses

Roy *et al.* (2017) observed the unique properties of sandalwood oil with its potential to use as a pesticide for managing various pests. "Triterpene palmitic ester", a chemo-sterilant compound isolated from the bark of sandalwood showed insect growth regulation property (Shankaranarayana *et al.*, 1980a), that can be used as a third-generation pesticide (Shankaranarayana, *et al.*, 1980b). A triterpenoid isolated from sandalwood bark showed growth inhibition and chemosterilant activities (Chaumont & Bardey, 1989). The sandalwood oil has the potential as termiticide (Kaikini, 1969; Srinivasan *et al.*, 1992) and acaricide (Imdorf *et al.*, 1999). Santalol exhibits protective role against the spider mite *Tetranychus urticae* and prevents it from laying eggs (Roh *et al.*, 2011; Roh *et al.*, 2012). It has been approved as food additives by the United States Food and Drug Administration (FDA), Flavour and Extract Manufacturers Association (FEMA), Council of Europe (COE), and Joint FAO/WHO Expert Committee (Desai & Hiremath, 1991; Kraft *et al.*, 2000). Palmitone, and d-10-hydroxypalmitone, the wax compounds derived from leaves on saponification, are free of paraffin (Sindhu *et al.*, 2010). The fatty oils of sandalwood seeds are suitable for paint production. The tannin present in the bark has good potential in the tanning industry and the leaves make excellent green manure and improving the soil (Kumar *et al.*, 2015).

CONCLUSION

Sandalwood (*Santalum album* L.), indigenous to India, represents a remarkable natural resource that intertwines culture, tradition, and contemporary practices. It is revered as a sacred plant throughout ancient texts, has significant cultural significance during religious rituals, and is used in skincare products and crafts. Pharmacological studies carried out recently have shown that sandalwood provides a wide range of health effects such as antitumor, antibacterial, anti-inflammatory, and metabolic effects due to santalols. The overexploitation, habitat degradation, illegal harvesting and disease pressures have highly threatened their natural population. In the future, much work needs to be done to sustainably cultivate and trade sandalwood, as well as conduct clinical trials.



Fig. 1. Religious uses of sandalwood (a) Sandalwood, Ghee, Mustard & Myrrh in Homa, (b) Bathing of Shivalinga with sandalwood powder, (c) Abhishekam of Nandi with sandalwood mixed with water.



Fig. 2. Postal stamps from government of India in recognition of the importance of sandalwood (Source: Purohit, 2018)

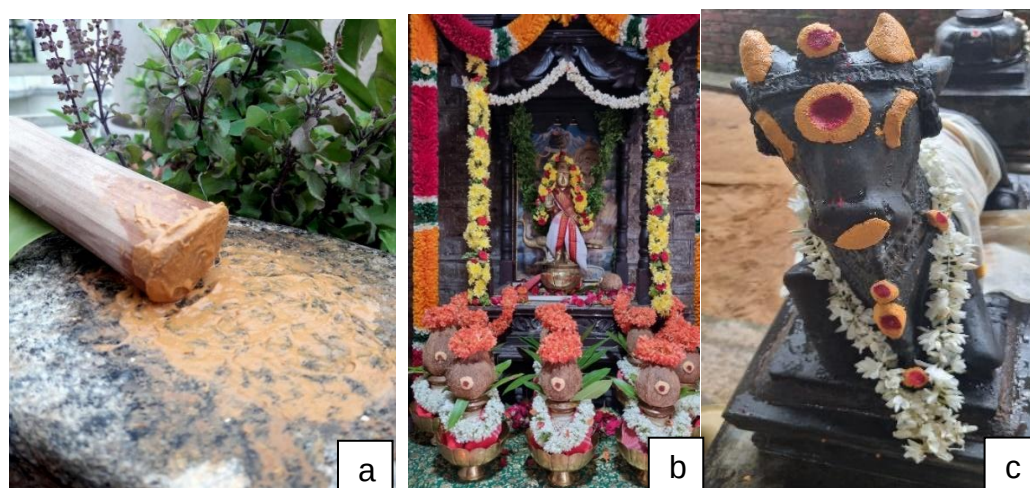


Fig. 3. Traditional use of Sandalwood (a) Preparation of sandalwood paste, (b & c) Decorating the icons of the deities

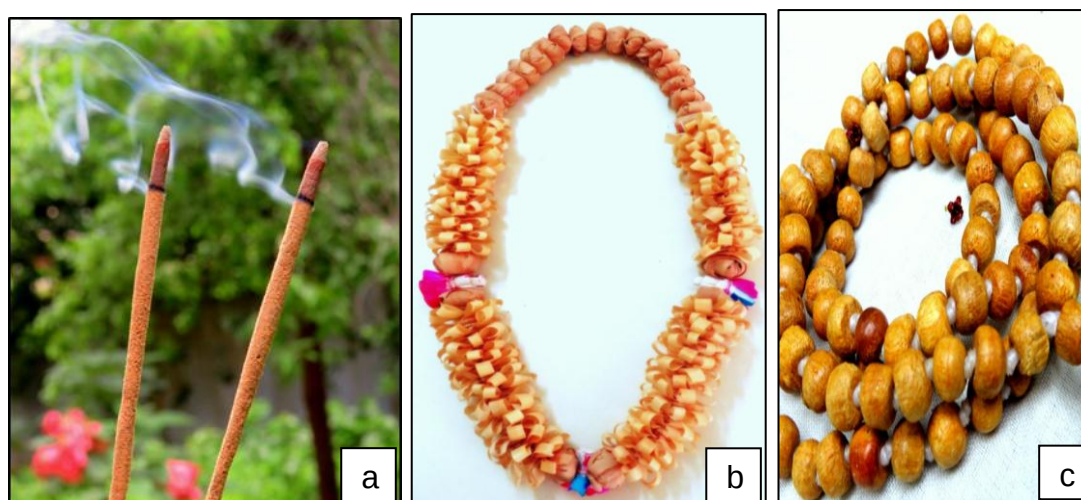


Fig. 4. Spiritual application (a) Incense Sticks, (b) sandalwood garland, (c) Japamala

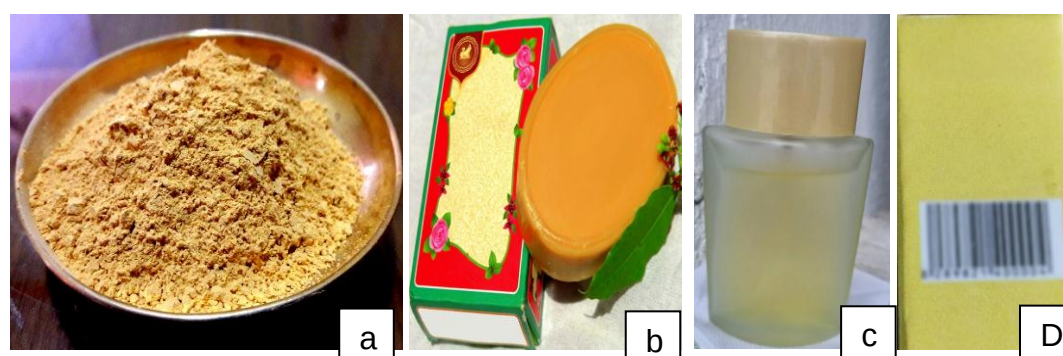


Fig. 5. Cosmetic use of sandalwood, (a) as powder, (b) Soap, (c) sandalwood oil based perfume, (d) sandalwood oil



Fig. 6. Sandalwood based handicrafts (a) toys, (b) God's statues

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