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**Rejuvenating  
the ancient Indian  
food preservation  
methods:  
A critical analysis**

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# Rejuvenating the ancient Indian food preservation methods: A critical analysis

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## Abstract

Right from the dawn of civilisation, every society had this problem: How to save food for the proverbial rainy days – safe from microbes and insects out to spoil it.

The ancient Indian wisdom of preserving food, both perishable and non-perishable, has survived for centuries. Based on wisdom passed through generations, our ancestors practised several food preservation methods. For several years, these methods were on the decline. However, of late they are staging a comeback with necessary modifications. Regardless of the recent advances in modern food storage technologies, the revival of low-cost, readily available, environment friendly ancient food storage methods appear to be a promising option to minimise the post-harvest losses. Understanding the science behind these traditional practices and improvising them to make them relevant in the present context is the need of the hour as borne out by the studies we conducted in different climatic conditions of India. We studied the various food preservation methods prevalent in these regions and reviewed their potential for modern times. There is no doubt that traditional storage methods, when appropriately modified, can significantly reduce losses and contribute to increased food security and poverty alleviation by increasing the returns of smallholder farmers.

## Introduction

Food, by its very nature, starts to spoil as soon as it is harvested. Ancient man was able to live in one place and form a community because of food preservation. He didn't have to eat the kill or harvest right away, and he could save some for later. Each culture used the same basic food preservation methods to preserve their local food sources.

Food preservation has been a part of Indian history since the dawn of time. Whether it is the perishables that spoil shortly after harvesting or the non-perishables which take a little longer to rot, the goal was to make food safe to eat by delaying its decay and extending its shelf-life. The ancient wisdom was efficient as it was time tested. With the advent of technology and the spread of modern practices such as freezing, canning, vacuum-sealing and chemical additives, classical ways of food preservation were side-lined for a while. Of late, however, food preservation practices (fermenting, pickling, drying, salting, and smoking, among others) have seen a remarkable resurgence.

## **1. Need for better practices**

According to an estimate of Food Corporation of India, as much as 15 per cent of food loss occurs during storage, making it a leading cause of post-harvest losses for all types of food. In the case of fruits and vegetables the annual storage loss is pegged between 4.6–15.9 per cent, followed by dairy, meat, and poultry per annum (Shaila and Begum, 2021). In the case of grains, while technical advancements have increased India's grain output manifold and have made India self-sufficient, lack of sufficient storage facilities accounts for 6 per cent of the total loss (Bahri, 2020). It is in this context that there is a need to re-evaluate the ancient food storage methods which are comparatively cost effective and can be constructed with readily available local resources, are eco-friendly, low-energy and impart considerable high shelf life to stored food grains, fruits and vegetables and meats. These methods can be improved upon or modified where necessary for effective storage of grains and other foods to ensure the full realisation of agricultural potential to meet the increasing food and energy needs.

## **2. The history of food preservation and its popularity in ancient times**

The history of food preservation can be traced back to hunter-gatherers who preserved meat or food grains in bogs (soft wet regions) or ponds to avoid hunting often and to make food grains last until the next harvest. Little did they know that the ponds were rich in lactobacilli, which produced lactic acid due to anaerobic respiration and helped preserve the food the ancients had stored (Tonde, 2018).

The historical roots of Indian food preservation tradition can be traced to the Indus Valley Civilization, also known as the Harappan Civilization, around 8000 years ago (Sarkar et al. 2016), where farming groups cultivated grain crops like wheat and barley as staple (Possehl, 2002).

The indigenous knowledge in agriculture with reference to seed storage, seed treatment, horticulture and pest control can be traced back to ancient Indian texts including Sharangdhara Samhita (13 AD), Brihatsamhita (5 AD) and Vrikshayurveda of Lokopakara (5 AD). Roychoudharuy described a number of traditional agricultural methods and has highlighted a variety of traditional farming methods found in Vrikshayurvedic texts. During the early periods, the knowledge on pest management in agriculture in India was disseminated through folk songs, proverbs, folklore, riddles, street dances and other means (Narayanasamy, 2002). Understanding food preservation techniques was the first and most significant step toward establishing stable communities.

## **3. Diverse traditional food preservation methods practiced in India**

Drying, fermenting, salting, pickling, freezing, heating, smoking, and chilling in natural refrigerators, like streams and underground pits, using

anti-microbial agents and insect repellents are some of the oldest ways to prolong the storage life of foods (Mobolade et al., 2019). Diverse traditional food preservation methods are practiced in various parts of the country.

To meet their vegetable requirement through winter, the inhabitants of Ladakh store crops such as cabbage in the basement of the house, onions by hanging from the ceiling, tuber and root crops by keeping them in underground pits for 5–6 months (Ali et al., 2012). Pulses are stored for long period in Tamil Nadu by mixing them with chilli, neem leaves and sand, by splitting, frying and oiling them with coconut oil (Karthikeyan et al., 2006). Ghee is stored in Rajasthan by boiling it with methi powder (*Trigonella foenum graecum*) and pouring it into an airtight container (Gupta et al., 2007). In the Dharwad district of Karnataka, numerous indigenous grain storage structures such as Kanaja/Galagi (bamboo structure), Sandaka (wooden structure), Kothi (chamber), and Utranis (mud pots) were reported to be in use (Nagnur et al., 2006).

#### **4. Major traditional food storage techniques in India, their scientific rationale and potential application in modern time**

##### **4.1 Sun drying:**

Sun drying or solarization removes water which inhibits the growth of micro-organisms in the stored products. This technique has been in use for a long time and is still used for a variety of products such as red chillies, papad, pickles, potato chips, spices, dry fruits, meat and fish. Many Indian scriptures and works of literature recognise the importance of the sun as a vital source of energy. Food is preserved by sun drying until it can be delivered to a market and sold.

Dehydrated foods have a longer shelf life, allowing them to be consumed year-round, even during the off-season and are easier to store due to their relatively low weight and volume. The energy and space required is significantly less than that for canning jars and freeze containers. It is also the cheapest and most environmentally friendly method.

“Dried meals are delicious, healthful, light, and easy to manufacture, store, and utilise,” as per a study conducted by Dr. Naseer Ahmed of RIMT University. Drying has little effect on the nutritional quality of food. It is also considered the most effective method. Because the sun drying method requires gradual and consistent drying, the distinctive and unusual flavours that it imparts to sun-dried food might differ greatly from those of fresh food. “The high sugar and acid content in fruits make them safe to dry in the sun,” says Dr. Naseer Ahmed. Sun drying is not recommended for vegetables or meats. Vegetables have a low sugar and acid content. This raises the chances of food spoilage.

### Potential use in modern time:

Due to high electricity prices, inadequate infrastructure, high transportation cost and lack of capital to invest in building storage facilities, Indian farmers are unable to keep their food for more than one to two weeks. In addition, the current expanding population and high fuel prices have necessitated the consideration of solar drying methods as alternative. Solar dryers are the best alternative that can concentrate solar energy for immediate and localised use (Eswara and Ramakrishnarao, 2013).

### Scientific rationale:

Dehydration removes water from the product which inhibits microbial growth. Due to water removal micro-organisms and enzymes cannot thrive thereby hindering food spoilage (Ahmad et al., 2021).

Table 1. Various food items dried in solar dryers for storage

Sr. No.	Product	Time (hours)	Solar dryers' temp. °C	Permissible limits of moisture (per cent)
1	Potatoes	4	50	5
2	Carrot slices	4	50	5
3	Curry leaves	6	55	4
4	Drumstick leaves	5	50	4
5	Tulasi (Ocimum tenuiflorum) leaves	2	50	4
6	Fish	7	55	5

### 4.2 Fermenting:

In the modern world chemicals as preservatives are widely used due to their low cost, efficiency in extending shelf life and ease of synthesis. However, its negative effect on human health and well-being is raising concerns (Shrivastava and Samuel, 2019). When ancient food preservation methods are revisited, fermentation appears to be a good technique.

Fermentation is the process of breaking down carbohydrates with the help of microbes and enzymes (Amit et al., 2017). Fermentation improves the nutritive value and digestibility of food and is a better option than hazardous chemical preservatives (Lewin, 2012)

Fermentation is an ancient food storage strategy that began when long-distance sailors carried fermented fruits and vegetables with them. Ancient fermented foods and beverages are documented in the Rig Veda (Achaya, 2009). There is evidence of oral history on the origins of gundruk and sinki, the Himalayan fermented vegetable preparations (Tamang, 2010) (Table 2). Gundruk is made from leafy vegetables, while sinki is made from radish tap roots. Aged radish slivers are pressed into a hole lined with bamboo and straw, then covered with vegetation, rocks, wood, and finally mud to make this generation-old indigenous dish. After a month of bacterial curing, the preserved vegetable is sun-dried and stored for a few years.

More than 350 types of major and region-specific ethnic fermented foods and alcoholic beverages are produced naturally or by adding mixed starter cultures using indigenous food fermentation knowledge. Historically, many foods including fish meat, grains, dairy, vegetables, fruits and other legumes have been fermented to preserve them for times of scarcity (Rolle and Satin, 2002). When applied to fruits and vegetables, the process is known as pickling (Panda et al., 2005).

#### Potential use in modern time:

Table 1. Various food items dried in solar dryers for storage

Sr. No.	Name	Fermented foods	State/region
1	Ayaiba	Smoked fish, curry pickle	Manipur, Mizoram
2	Chucha	Smoked fish, curry pickle	Assam
3	Jawla	Sun-dried shrimps	Maharashtra
4	Ankamthu	Mustard leaf	Mizoram, Manipur, Nagaland
5	Cutocie	Fruits and leaves of cucumber	Nagaland
6	Ekung	Tender shoots of young bamboo	Arunachal Pradesh
7	Sinki	Radish taproot	Sikkim
8	Panitenga	Rapeseeds	Assam
9	Tsutocie	Cucumber	Nagaland
10	Dingkyo	Smoked meat	Arunachal Pradesh
11	Luk chilu	Sheep fat	Darjeeling,, Sikkim
12	Yak kargyong	Yak	Darjeeling hills, Arunachal Pradesh

Fermentation appears to be one of the best methods to store food for future use and due to the proposed health benefits of fermentation owing to their potential probiotic microorganisms, such as lactic acid bacteria that benefit the gut bio-actives, peptides, and polyamines may have effects on cardiovascular, immune, and metabolic health, especially during pandemics. (Pessione and Cirrincione, 2016; Marco et al., 2017). Also, preservation of food by the fermentation process on an industrial scale (Mani, 2018).

#### **Scientific rationale:**

The increase in the acid or alcohol content and decrease in the water activity kills the harmful microorganisms preventing food spoilage.

#### **4.3 Salting and sugaring:**

The use of salt or sugar to store food by protecting against microbial spoilage has ancient roots and is generally referred to as curing or salting. Curing may utilise solid forms of salt and sugar or solutions in which salt or sugar is mixed with water. Brine is a salt solution that is used in curing or pickling preservation methods (Fig. 1). The most noticeable effects of salt and sugar is the dehydration caused by simple osmosis. Dry salting is also used in India to preserve tamarind, raw mango, aonla (*Embllica officinalis*), fish, and meats.

#### **4.4 Pickling:**

Pickling dates back to thousands of years, with the first record of pickled cucumbers existing in ancient India. It is one of the earliest methods of fruit and vegetable preservation (Raj et al., 2016). Pickling is the preservation of food using acidic brine. Salt water, sugar water, lemon juice, or vinegar is used to make acidic brines. Either substance (or a combination of them) is poured over vegetables, fruit, meat, or fish before being stored in a tightly sealed jar for a few days. The taste of the vegetables changes as a result of this process, becoming more sour.



Fig1. Vegetables in salt solution (brine) to avoid microbial spoilage

(Jayanth, N. 2020)

#### **4.5 Freezing:**

Temperature and humidity are significant considerations in food preservation. Refrigerated storage is an established technology that is widely used for food storage all over the world (Sunmonu et al., 2014). Mechanical refrigeration, on the other hand, is energy-intensive and expensive, requiring a constant supply of electricity, hence cannot be installed in remote areas (Vala et al., 2014). As global warming gains momentum, the demand for passive refrigeration will increase in

next decades (Rehman et al., 2020). All these constraints have persuaded us to relook at some of the ancient methods of food storage as viable alternatives to the present day storage systems which are energy-intensive and costly.

There are numerous instances where freezing technique for the food storage was practised in ancient India. Fig. 2 illustrates an old method to make ice in India (Allahabad and Calcutta). On a piece of land, 3 to 4 excavations are made, each measuring about 30 square feet. The bottom of the pit is strewn with eight inches of sugar-cane, or the stems of dried corn. Upon this bed water containing earthen pans intended to be frozen are placed in rows, near to each other. In the evening, these pans are filled with boiled water. The spongy nature of sugar-canes, or the stems of the corn, allow the circulation of cold air, making a passage under the pans which are carrying the heat and freezing the water to form ice. The sherbets, creams, and other liquids intended to be frozen are placed in thin silver cups with a conical shape and placed in a large vessel filled with ice, salt-petre, and common salt in equal amounts, with a little water added to dissolve the ice and combine all the ingredients. This composition froze the contents of the cups to the same consistency as the present-day ice cream.

People living in India's cold climates, such as Jammu and Kashmir, Sikkim, Uttarakhand, Arunachal Pradesh and Himachal Pradesh, have mastered the art of storing food during the winter months when the temperature is sub-zero and these regions were cut off from the rest of the country. These storage approaches are completely based on the usage of local natural resources and do not require electricity. Traditional food storage technologies continue to play an important role in these regions (Ali et al., 2012). Also, as mentioned in the case studies in this paper.

### **Scientific rationale:**

Plasmolysis of cells occurs as a consequence of the high osmotic pressure caused by salt. Furthermore, when ionised, the chloride of NaCl is toxic to bacteria. The brine generated when salt draws water from food offers a medium for the growth of lactic acid bacteria that are essential for the fermentation process. Also, the added salt and sugar will interfere with the enzymatic activity of micro-organisms and weaken the chemical structure of its DNA. Sugar may also provide an indirect kind of preservation by hastening the accumulation of antibacterial chemicals produced by the growth of certain other species. In cheese and cured meat, salt also inhibits the growth of undesirable microbes (Ahmad et al., 2021).

## 5. Methodology

The ancient methods of food storage have remained largely unchanged since they were first used. They simply got passed on from one generation to the next as received wisdom. They are the result of a deep understanding of their environment and have proven to be effective due to the accidental application of scientific values (Prakash et al., 2016). Climate along with the regional natural resources and the prevailing culture influences the choice of an appropriate food storage technology (Hall, 1970). Proper food grain storage is required to avoid wastage and to make it last till the next harvest. Despite the fact that chemical pest management approaches are extremely successful, it is estimated that 60–70 per cent of the farmers still use the traditional storage methods (Kanwar and Sharma, 2003; Shaila and Begum, 2021) (Fig. 3). Given this subtext, it is essential to document, revitalise and promote age-old food preservation techniques that were both eco-friendly and economically beneficial as well as affordable.

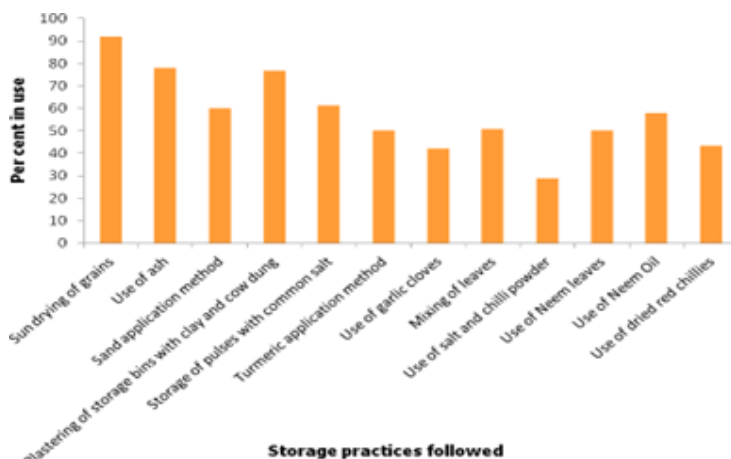


Fig 3. Traditional storage practices followed by the farmers of Karnataka for food grains and seeds

(Prakash et al., 2016)

Such ancient practices vary greatly not just across the states of India due to their unique tradition, culture and climate, but within a state as well. This paper therefore analyses and reviews the ancient food preservation methods prevailing in cold and monsoon regions and diverse traditional grain storage methods practised in various parts of the country and their underlying scientific rationale. With some modifications these methods can be made suitable to meet the present-day need. India's climate zones range from rainy in the west and east to tropical in the south to temperate and alpine in the north. For our study, we selected the several regions, representing diverse climates (with highly variable weather conditions throughout the year as represented in Fig. 4).

6. For collection of information and documenting the ancient knowledge of food preservation techniques we had one-on-one conversations with the respondents including farmers, indigenous people of specific regions, and farm women. An attempt to elucidate the science behind the ancient storage practices has been made. Tactics to make these practices relevant and effective for the current situation have also been discussed in this paper.

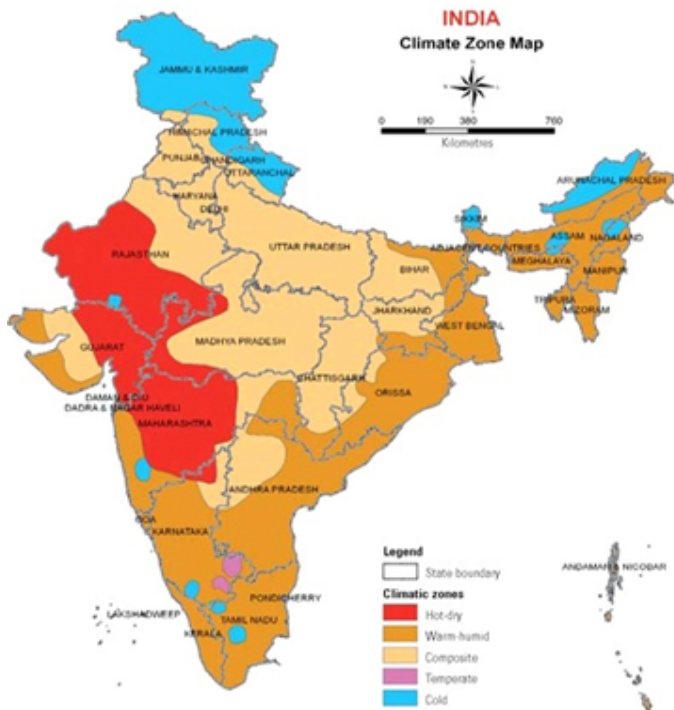


Fig 4. Map indicating different climatic zones of India

(Prakash et al., 2016)

## 6. CASE STUDY 1

### Food storage systems in Jammu and Kashmir

Climate: Cold

Kishtwar district, Paddar Sub-division

#### Prevalent food storage practices

##### a. Kanzaar:

Every household has a traditional large wooden rectangular grain storage structure called Kanzaar (Fig. 5A). It is made of deodar wood (Deodar-Cedrus deodara Loud. /Kashmir Cedar), the best timber in the region, and can withstand hot and humid climatic conditions. This structure is divided into 6–8 sections. Each section can store 400–500 kg of different grains such as rice, wheat, maize, dried apricots, amaranths and others.

As the etymology of deodar (devadaru) suggests, it is revered as a sacred tree among the Hindus. Deva signifies divine. Daru is associated with the word tree. Ancient Indian sages and their families who were devoted to Lord Shiva preferred to live in forests of deodars. Darukavana, which means “forest of deodars,” is also mentioned as a sacred location in ancient Hindu epics and Shaivite literature. This tree is mentioned in several Hindu texts such as Valmiki Ramayan’s Kishkinda khanda (Arya and Arya, 2020).

#### Scientific rationale:

Due to the insecticidal properties of deodar wood, storage structures made of deodar trees protect grains from numerous pests. It also works against fungi and other types of worms (Slathia et al., 2007). For the modern era if it is difficult to build storage facilities using deodar wood, its oil can be applied to the grains as an alternative to synthetic pesticides. The oil not only protects the grains but also imparts therapeutic benefits to them. Also, since wood is a bad conductor of temperature, it will keep the temperature stable.

##### b. Ghan:

Every household in Jammu and Kashmir has a specialised food storage room called Ghan, where root vegetables such as carrot, potato, and radish are preserved in underground pits after harvesting (Fig. 5B). After digging a 2”–4” deep pit of 4”–5” dia its edges are lined with sand. The pit is then filled with vegetables. The top is covered with soil slightly above ground to prevent rainwater or moisture from entering. The structure is occasionally coated with cow dung. This is done in early winter, and the vegetables are stored for 5–6 months, until the following summer.

**Scientific rationale:**

The microclimate in the soil is ideal for storing fruits and vegetables since it makes use of natural cooling, insulating, and humidifying properties of earth. It also keeps food from freezing in the winter and cooling in the summer, minimising spoilage. This approach is ideal for places with temperatures ranging from 0 °C to 4.5 °C since the cool temperatures reduce the generation of ethylene gas from crops and restrict the growth of microbes, slowing down the process of ripening and spoiling of the stored fruits and vegetables (Newton, 2021) Another method for storing vegetables and fruits is to cut and completely dry them before putting them in a cotton bag and hanging the bag in Ghan, the food storage room. The bag allows the air to pass through, extending the shelf life of the products up to 7–8 months.

**c. Gou:**

It is a closed neck, barrel-shaped wooden vessel carved out of pine wood and is buried underground as shown in Fig. 5C. It is used to preserve butter milk and curd made from milk of yak, sheep, goat, and the indigenous breed of cow Chaunri. The water that has gathered on the surface of the curd and buttermilk is removed and the products can be preserved in gou for 3–4 months and also used as medicine.

**d. Kalair:**

It is an earthen pot used to store ghee, honey and buttermilk. A plate is placed on top which is covered with a 6" layer of soil (Fig. 5D). For storing ghee, stem of Bhoj patra (*Betulia Utilis*) is sectioned into a thin paper and lined through the Kalair and then ghee is poured into it. This approach may keep ghee fresh for 2 to 3 years, and it can also be used to treat nursing mothers, pregnant women, and weak children.

**Scientific rationale:**

Ghee will not remain fresh for long time in warm months. Ghee has to be stored in airtight Kalair which is kept in a place which is cool and dark as well as free from moisture to remain fit for consumption for a longer period of time. Betulin oil in Bhoj patra is responsible for longer shelf life of ghee. Betulin is a triterpenoid that aids in lipid-lowering, hypocholesterolemic, antioxidant, and antibacterial activity (Chauhan, 2019). Furthermore, betulin nano suspension has been known to prevent potato bread disease and prolong the shelf life of wheat flour (Zavorokhina et al., 2020).

**e. Meat storage:**

Care must be taken when handling meat and fish as they do not last long. After cleaning the meat, salt and turmeric are applied, and the meat is hung until it

is dehydrated. Meat can be stored for a month using this technique.

**Scientific rationale:**

Salt works by drying out the food. When salt removes water from meat, it becomes difficult for harmful mould or germs to thrive. Turmeric, on the other hand, is one of the earliest known antibacterial substances utilised by ancient civilisations. So, both the preservatives arrest the microbial activity (Latifa et al., 2014).

**f. Khoued:**

It is a bag made of sheep or goat skin (Fig. 5E). It is used to store and also carry food grains, seeds and flour. Since it is moisture free it hinders the growth of micro-organisms, the main cause of food spoilage.



A. Kanzaar



B. Underground storage structure



C. Gou



D. Kalair



E. Khoued

**Fig 5.** Images showing the various traditional food storage structures used in Kishtwar district of Jammu and Kashmir.

(Parihar, R. 2022)

## 7. CASE STUDY 2

### Food storage systems in Uttarakhand

Climate: Cold

Uttarkashi Chamoli

#### Prevalent food storage practices

- a. The people of Uttarkashi and Chamoli are experts in meat preservation and processing. To store meat, they wash, clean and fully dry it before hanging it in their kitchen. Due to cold ambient temperature meat can be stored up to 3–4 months.
- b. During cold months meat is stored after fermenting it.
- c. Lentils to be stored is washed, boiled and ground into paste which is then mixed with mustard oil, dried leaves of walnut, and turmeric. The mixture is made into balls and put out to sun to remove moisture. The product can be stored for one year without any infestation.

#### Scientific rationale:

The strong odour of mustard oil is known to repel insects and pests. Curcumin in turmeric has antibacterial properties that prevents rotting.

- d. Various traditional additives are used during the storage of grains (Table 3).
- e. Apricot (*Prunus armeniaca*) is dried and used during winter months as a substitute of tamarind and tomato.
- f. Pomegranates (*Punica granatum*) are harvested in mid–October. Seeds are removed from sarcotestas and the pulp is sun dried for 10 to 15 days (Fig. 6). It is then crushed, mixed with salt and stored for a year. It is used as a substitute for mango, tamarind, and tomato to impart a sweet–sour flavour to local cuisines. It is also believed to be medicinal, heart– healthy and soothing to the stomach.



Fig 6. Sundried seeds and pulp of anardana.

(Gupta, V. 2022)

**Table 3.** Additives used during grain storage in Uttarakhand and their scientific rationale

<b>Sr. No.</b>	<b>Additives</b>	<b>Scientific rationale</b>
1	Pulses powder are combined with chalk powder	Chalk powder (calcium carbonate) is an insect repellent and anti-feedant.
2	Food grains combined with dung ash	Ash absorbs moisture, and the ash coating on wheat prevents egg-laying and larval production.
3	Storing black gram with salt	Salt absorbs the moisture and it leaves an abrasive effect on the skin of insects, inhibiting them from moving and restricting their development during storage.
4	After sun drying, pulses, paddy and millets are stored with walnut ( <i>Juglas regia</i> ), neem leaves ( <i>Azadirachta indica</i> ) and mint ( <i>Mentha</i> )	Salt absorbs the moisture and it leaves an abrasive effect on the skin of insects, inhibiting them from moving and restricting their development during storage.
5	Pulses coated with mustard oil	Salt absorbs the moisture and it leaves an abrasive effect on the skin of insects, inhibiting them from moving and restricting their development during storage.

## **8. CASE STUDY 3**

### **Food storage systems in Arunachal Pradesh**

**Climate:** Cold

**Adi tribe**

#### **Prevalent food storage practices**

a. Smoking the meats (pork, mutton, beef, fish and chicken) and vegetables (chilli, corn and beans). Excess oil and salt are used for the pickling of bamboo, smoked meat, green chillies, etc.

b. Before storing the grains from fresh harvest, the granary is smoked to reduce moisture and also to avoid fungus or insect infections.

c. Neem leaves are used as additive in the grains and pulses before storing them in the granary.

d. The use of wood smoke to preserve foods is nearly as old as open-air drying. Smoking of fish and meats has been done for ages and its origin dates back to prehistoric times. Our ancestors smoked meat after a successful hunting expedition or for large feasts on special occasions in the past. They smoked the meat because they couldn't eat it all right away. They found smoking to be a simple and convenient way of preservation (Hauzel, 2017).

Smoking is gaining popularity in recent times due to its ability to enhance the food flavour, besides preserving it. The primary goal of smoking is to give food desirable flavours and colours, and some of the compounds formed during the process have been shown to have preservative properties. Smoking fish traditionally involves passing hot smoke from a variety of woods over the fish to partially dry it and impart the smoke's flavour and aroma (Rahman, 2007).

### Smoking of food in Arunachal Pradesh

Smoking of sanna ayek adin (dried pork and meat Fig. 7A), sanna engo (dried fish Fig. 7B) and vegetables including chilli, maize cobs, beans, tubers, taro leaves etc. is popular in Arunachal Pradesh.



Fig 7A. Smoked pork  
(Sanna ayek adin)



Fig 7B. Smoked fish (Sanna engo)

(Parihar, R. 2022)

A majority of the tribes prepare their food with wood, dried leaves, and earthen stoves. The fireplace is generally situated in the centre of the kitchen (Fig. 8). A square or rectangle shaped wooden structure is suspended from the roof. The semi-processed or raw food items to be smoked are placed on this structure. The smoke from the fire goes through the food, removing the moisture. It preserves the quality and flavour of the products as well as prevents the attack of insect, thereby increasing their shelf life. The meat is suspended for two weeks or longer, depending on how long it has to be preserved. Completely desiccated food can be stored for a month or even a year.

### Scientific rationale:

In ancient times, people smoked their meat to preserve it. They discovered that smoking dehydrates the meat, kills bacteria, and even improves the flavour. Although many of the compounds in wood smoke, such as formaldehyde and phenolic compounds and some alcohols, are helpful in avoiding lipid oxidation in meat and fish products, the drying action of the smoke tends to preserve the meat (Ahmad et al., 2021). The smoke itself leaves an acidic coating, inhibiting the growth of most bacteria. Furthermore, the desiccated meat produces an environment hostile to bacteria (Plotch, 2014).



Fig 8. A typical traditional kitchen of Adi tribes of Arunachal Pradesh, with a fire place and smoke passing through the wooden structure suspended from the roof.

(Lucy T, 2022)

## 9. Food storage technique at lower temperature in the modern era

### Evaporative cooling:

Certain low-cost technologies which are the improvised versions of the ancient Indian techniques such as evaporative cooling can be employed in the current situation due to lack of space for digging pits and also because there is no guarantee that the temperature will be appropriate for storage. Evaporative cooling as a storage method is ideal for hot, dry regions. When hot and dry air blows over a wet surface, evaporation is hastened, resulting in rapid cooling.

#### a. Janta cooler:

It consists of a smaller storage pot which is put inside a large earthen pot filled with water and set on moist sand. Fresh food is kept in the inner pot, which is covered with a wet cloth. As the water in the cloth evaporates, it keeps the storage pot cool.

#### b. Pot-in-pot cooler (Zeer storage):

In this cooler, two pots of varying sizes are separated by moist sand, with the smaller pot inside the larger pot. Inside the inner pot, fruits and vegetables are kept. This cooling system increases vegetable shelf life from 2–4 days to 17–20 days (Fig. 9).

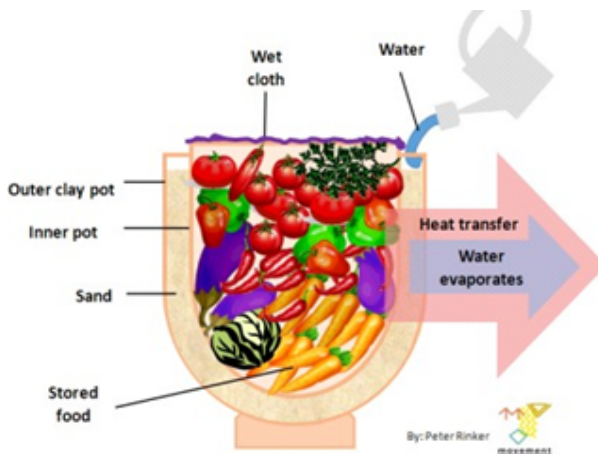


Fig 9. Pot-in-pot cooler used to store fruits and vegetables.

(Wikimedia)

**c. Zero energy cool chamber (ZECC):**

It is a double-walled structure with a 75-mm gap that is filled with sand. It is enclosed with a cane, wood or sack cover as shown in Fig. 10. To keep the sand damp, it is drenched with water. Evaporative cooling dissipates heat from the chamber. This system can be used to store fruits and vegetables for a shorter duration (Table 4). ZECC can maintain a relative humidity of about 90 per cent and a temperature which is 10–15 °C lower than the ambient temperature (Kale et al., 2016).

**Table 4.**Storage life of fresh fruits in zero energy cool chamber and ambient conditions

Crop	ZECC		Ambient conditions	
	Days	Weight loss (%)	Days	Weight loss (%)
Mango	9	5.0	6	14.9
Banana	20	2.5	14	4.6
Lime	25	6.0	11	25.0
Potato	90	7.7	46	19.1
Tomato	15	4.4	7	18.6
Carrot	12	9.0	5	29.0

(Kale et al., 2016)



**Fig 10.** Zero energy cool chamber to store fruits and vegetables

(Mishra et al., 2020)

**Scientific rationale:**

Freezing at low-temperature prevents microbial reproduction, slows down chemical reactions, and impairs cellular metabolic responses (Delgado and Sun, 2001).

## 10. CASE STUDY 4

### Food storage systems in Karnataka

Climate: Tropical monsoon

Mangalore

#### Prevalent food storage practices

Mangalore is a port city in South India's western coast. It has a tropical monsoon climate that is influenced by the southwest monsoon. It receives approximately 95 per cent of its total annual rainfall between May and September and is extremely dry from December to March. (Subrahmanyam, 1983). This climatic environment necessitates the development of methods to store food during summer and monsoon.

#### 10.1 During summer

a. Sun drying is the preferred way of storing food available during the summer months so that it can be used during the monsoon.

b. Vegetables such as pumpkin, local and Mangalorean cucumbers are carefully tied to the ceiling by thin coconut fibre ropes until the rainy season ends as shown in (Fig. 10). Mangalore cucumbers can be stored up to 8-10 months without losing their freshness.



Fig 11. Mangalorean cucumbers tied to the ceiling where they remain during summer.

(Kamath, 2021)

c. Various types of papads (a thin, crisp Indian wafer) are prepared and stored for monsoons using rice, jackfruit, mango, sweet potato and other ingredients.

d. Mambala (dried mango pulp): During summer mambala is one of the most popular methods of preserving mango pulp. This is made by squeezing the mango pulp and spreading it on a clean towel to dry in the sun. The pulp is poured till a sheet 3-4 inches thick is formed (Fig. 12). This can be stored for a year. Its shelf life can be extended by



Fig 12. Mambala prepared out of mango pulp for long term storage.

(Kamath, 2021)

storing it at a lower temperature. This can be eaten raw or added to a cuisine to give it a tangy taste. The same procedure is used with jackfruit also.

e. For shorter time the fish is stored in ice (Fig. 13) and for longer duration it is salted and sundried.

f. Various fruits and vegetables, including spices, are sundried for prolonged usage (Fig.14A). Fresh ginger (Fig.14B) are stored in underground pits. Alternatively, they may also be sundried to remove moisture for long term usage.



Fig 13. Fish placed in ice to avoid the spoilage

(Author, 2021)



Fig 14A. Dried ginger for long term storage



Fig 14B. Fresh ginger

(Author, 2021)

## 10.2 During monsoon

### a. Fermentation

During monsoon, fermentation and pickling are the commonly used storage methods. Fruits and vegetables such as jackfruit, raw and ripe mangoes, lemons, tapioca, etc. are pickled and stored in traditional ceramic jars (Fig. 15).



Fig 14B. Traditional ceramic jars used to store pickles.

(Sushma V, 2018)

### Scientific rationale

Due to a lack of adequate sunlight and since people are prone to illness during monsoon, fermentation and pickling are the preferred techniques to store fruits and vegetables so that these products are available when they needed the most to boost immunity. Traditional ceramic jars are used as they do not react with the ingredients. Moreover, their glazed surface prevents oil leakage.

## b. Kanile:

During monsoon Kanile is a popular traditional preservation technique, using tender bamboo shoots, to provide a year-round supply. The ancient Indians knew that tender bamboo shoots were anti-inflammatory, anti-diabetic, and anti-oxidant. Also, they were aware that the tender shoot cannot be eaten on the day of collection due to its toxins. After cutting the shoots into small pieces, they were soaked in water for two days to take out the toxins and then used for preparing various dishes.

## Scientific rationale:

Tender bamboo contains anti-nutrients and toxins such as oxalate, tannin, heavy metals and cyanides. Boiling and soaking in either water or brine is the most effective method of removing cyanogens from bamboo shoots (Wang et al., 2020).

c. Akki mudi: It is an ancient practice of storing 40 kg of rice for a year in a sphere shaped structure made of rice straw and other locally available materials (Fig. 16). The rice, seeds, or pulses are wrapped in rice straw and tied from the outside to form 12 segments of a sphere; additional knots are tied to prevent entry of air.; The structure is stored in a cool chamber. This is also offered as a wedding gift.



Fig 16. Akki mudi is a sphere shaped grain storage structure made of rice straw and other materials.

(Kamath, 2021)

## 11. CASE STUDY 5

Table 5. Diverse traditional grain storage methods practised in various parts of the country and their underlying scientific rationale

Sr. No.	Methods	Scientific rationale	Practised in
1	Before storage in gunny bags or moisture proof steel bins (Fig. 17), the dried leaves of eucalyptus, neem and wood ash are mixed with maize, sorghum and paddy. In this method grains can be stored for 4–9 months.	The leaves of eucalyptus and the active ingredient in neem azadirachtin have been reported to have antimicrobial, antifungal, antiviral, and insecticidal properties against stored pests (Russo et al., 2015).	Belgaum, Karnataka

2	Pulses are mixed with dried chrysanthemum flower petals before being stored.	The natural esters pyrethrins present in the petals evaporate into the grains, and act as insect repellent. This can also be used in place synthetic pyrethroids (Yan et al., 2021)	Vizianagara, Andhra pradesh
3	Paddy, maize, sorghum, wheat and pulses are stored in a structure called Bori–Basket made of bamboo and coated with cow dung (Fig. 18).	The cow dung has an insect repellent property.	Belgaum, Karnataka
4	Sun drying of grains is the most prevalent and traditional method. If the moisture level is high, the grains are sun-dried for a longer period of time. Optimum grain moisture (10–12%) is necessary for proper storage of food grains/seeds.	Reduces the moisture content, enhances the dormancy period of grains and destroys insects, pests, etc. (Kumar and Singh, 2013).	All parts of India
5	3/4 of earthen pots are filled with grains, leaving 1/4 for wood or cow dung ash..	Ash contains silica, which prevents insects from feeding and inhibits fungal growth. It also reduces relative humidity in the storage environment (Rekha and Padmakar, 2014).	Belgaum, Karnataka
6	A paste of red soil and water are mixed with seeds, shade dried and stored in airtight, dark conditions.	Red soil forms a barrier to prevent insects from feeding or laying eggs. Also, the soil absorbs moisture that has been left in the seeds and grains (Mathad et al., 2013)	Gulbarga, Raichur, Yadgir, Koppal, Bidar, and Bellary, Karnataka
7	Pulses and paddy are stored by mixing with dry chilli	Pests avoid the pungency of dried red chillies.	Parts of Maharashtra



Fig 17. Steel moisture-proof bins used to store grains

(Shivanand, 2022)

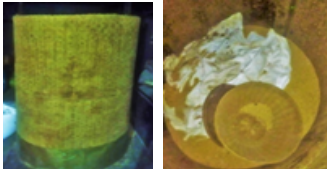


Fig 18. Bori - the traditional grain storage structure made of bamboo and coated with cow dung.

(Shivanand, 2022)

## 12. Relevance of ancient food preservation methods in modern time

In the field of food storage, many problems are encountered. The majority of problems arise due to a lack of focus, guidelines, and knowledge of food storage systems. Furthermore, because many food preservation methods are affected by climate, the problems get aggravated.

Environmental factors such as temperature and humidity have a significant impact on food preservation performance. These have a substantial impact on food storage. The ancient Indians emphasised the reduction of moisture as a way to reduce proliferation of micro-organisms. In the modern era we fail to observe these practices.

They ensured that there was no moisture on the surface of or inside the vegetables before storing them whereas we directly put vegetables in refrigerators after washing them. Also, when storing the grains they used to add moisture absorbents in the storage structures.

The ancient Indians did not store different types of vegetables together; we do, and we notice a shift in the storage life of vegetables, as the hormone ethylene triggers the ripening of vegetables, thereby hastening their spoilage.

Ancient people knew that food needed to be stored in a place which is cool, dry, and out-of-direct-sunlight in appropriate containers. For example, they used ceramic jars to store pickles, but in the present times, we choose to use plastic containers for convenience ignoring the fact that as they get warm, they not only create perfect condition for microbial growth, but also leach out dangerous chemicals. As a result, in modern times, efforts must be taken to store food in an appropriate manner, taking into account all facts.

## Summary

Traditional food storage and preservation techniques are not only less expensive than the high-cost modern methods, but they are also widely available and play an important role in conserving and sustaining the environment. It is critical to use traditional ways passed on to us by our ancestors in order to ensure the long-term sustainability of agriculture (Sundaramari et al., 2009). As a result, this study reviewed the ancient food storage methods, the science behind them and their relevance in modern day food trends organic, locavore, or farm-to-table. Based on rationale the insights gained from re-examining the traditional approaches, we may develop low energy food storage methods in various climatic zones of India to further increase the shelf life, quality of food grains, fruits and vegetables. It will also help reduce the post-harvest losses and ensuring seasonal food security along with improving rural income, promoting self-sufficiency and still remaining environmentally benign.

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