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Article in *Journal of Applied and Natural Science* · March 2021

DOI: 10.31018/jans.v13i1.2535

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Review Article

## Assessment of Indian cooking practices and cookwares on nutritional security: A review

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### Article Info

[https://doi.org/10.31018/](https://doi.org/10.31018/jans.v13i1.2535)

[jans.v13i1.2535](https://doi.org/10.31018/jans.v13i1.2535)

Received: February 1, 2021

Revised: March 8, 2021

Accepted: March 12, 2021

### How to Cite

Saxena, S. *et al.* (2021). Assessment of Indian cooking practices and cookwares on nutritional security: A review. *Journal of Applied and Natural Science*, 13(1): 357 - 372. <https://doi.org/10.31018/jans.v13i1.2535>

### Abstract

Food provides us nutrients and the energy required for growth, reproduction, and maintenance. Energy is required to perform all voluntary and involuntary activities like digestion, respiration, circulation, carrying out professional, household and recreational activities. Despite having rich food diversity, we are using only a few items as our staple food. With the adoption of eastern cooking practices and cookwares, risk of both pre-and post-transitional diseases like diabetes, cardiovascular diseases, malnutrition, obesity, etc. has increased significantly. Aluminium toxicity and nutrients breakdown has become a common problem in pressure cooking. To overcome this problem, it is important to shift from the modernized cooking methods to our traditional cooking practices, i.e., use of earthen cookwares, clay pots and some selected metal utensils, e.g., copper, iron, brass, etc. It has been shown that earthen, copper, iron, and soapstone cookwares do not leach toxic trace elements into the food and enhance the sensory qualities without decreasing the food nutrients. Adoption of traditional Indian cooking practices (such as fermentation, roasting, germination, etc.), cookwares (such as earthen, copper, iron, soapstone, etc.) and increasing the consumption of healthy diet grains like millets, etc. can easily combat the pre- and post-transition health problems in India, effectively. This review would provide a deep understanding to the people to decide the best cookware and cooking processes that will improve their health and provide ample nutritional value to them.

**Keywords:** Cookwares, Earthen, food, Metal toxicity, Millets, Nutri-cereals, Underutilized food

### INTRODUCTION

India is leading the world in many sectors. Indian culture, tradition, heritage, values, and food are rich in almost all things. Eating is a physiological necessity for growth and a central component of travelling

(Duttgupta, 2013). Indian food is famous for its wide variety from Kashmir to Kanyakumari, and from Bhuj to Itanagar. It consists of numerous spices, millets, and herbs that we are consuming since ancient times. In an era of modernization, all of us want to live a luxurious life and, hence, achieve a significant increase in our

per capita income, literacy, urbanization, and poverty decrease. On the contrary, in such competitive situations, people are also losing their valuable day-to-day cultural and traditional practices (Pingali *et al.*, 2019). In the current scenario, due to shortage of time and busy schedule, people are attracted to fast cooking practices or ready to eat food and in the process do forget their traditional food knowledge and values associated with it. People are losing or trying to get rid of them for their comfort and have started preferring ready to eat foods, preferring noodles over *poha*, and herbal tea instead of *chach*, which is initiating globalization (Simi and Matusitz, 2017). So, this rapid drift is creating some fathomable intricacies, such as pre- and post-transition problems due to malnutrition, under-nutrition, and over-nutrition viz. stunting, anaemia, malnutrition, diabetes, obesity and other contemporary health problems (Chera, 2020). In the last few years, due to changing lifestyle patterns, risk of non-communicable disease such as diabetes have increased alarmingly. So, poor health has become a major issue, and people have started focusing on it in order to prevent them from such diseases (Tandon *et al.*, 2018). The type of food products that are being consumed nowadays is not good for our health and causing several problems hence, we are expecting some quality food that can treat some basic health issues as oncological disorder and cardiovascular diseases. So, choosing a highly nutritive, inexpensive food with higher acceptance has become necessary (Nandy, 2004).

The Indian food industry is the world's 6<sup>th</sup> largest food market growing at the Compound Annual Growth Rate (CAGR) of 9.23% and expected to reach 827 billion dollars by 2023 (Mukherjee *et al.*, 2019). India is rich in food diversity and a leading producer of millets. Food and Agriculture Organization (FAO) data in 2018 shows that India produces around 35.7% of the worldwide millet production and is leading in the production of millet (Table 1). Millets refer to a common group of small-seeded annual grasses which belongs to the family *Poaceae*. India is a leading country in the production of a variety of millets, such as pearl millet, finger millet, foxtail millet, proso millet, barnyard millet, little millet, *kodo* millet, etc. All these food crops are rich in nutrients; however, they have become obsolete due to the contraction of our food habits towards rice and wheat. Millets are cereal crops native to Ethiopia and successfully adopted by the world (Fig. 1-C). Millets are pest resistant and can grow in diverse conditions (Thakur and Tiwari, 2019). Based on indigenous knowledge, land use and techniques, millet production is always considered pest free and does not require fumigants and pesticides. Some millets like; foxtail millets act as an anti-pest in the similar storage conditions of rice and pulses. Millets are stress-tolerant grains with the ability to grow in low-quality soil with less nutritional require-

ments, tolerant to temperature variations and having a very short growing season (Malathi *et al.*, 2016). Millets refer to the group of highly seeded small annual grass which are tolerant to drought and other extreme weather conditions. These can grow in both waterlogged and moist areas to drought affected regions and give a good yield and can grow in arid and semi-arid regions (Assefa *et al.*, 2015; Michaelraj and Shanmugam, 2013). As compared to other cereals and staple food-rice and wheat, millets are highly nutritious crops. Millets contain a high amount of dietary fibre, proteins, essential fatty acids, some minerals viz. calcium, potassium, iron, zinc, magnesium, vitamins, mainly vitamin-B complex (B3, B6 and B9). Millets also help in combating many diseases like blood pressure, cardiovascular diseases, diabetes, celiac diseases, thyroid (Ambati and Sucharitha, 2019). Due to its high nutritional qualities, these are considered as Nutri-cereals. Both dietary patterns and our history reveal that millets are the first and oldest known food crop cultivated for thousands of years by humans because, in the Middle Ages, Pauls and Romans were consuming it in place of rice (Ambati and Sucharitha, 2019). Number of evidences indicate that the millets cultivation dates back to 3500 BC (Kim and Park, 2020). Till now, millets are playing a significant role in the traditional diet of many states of India. People from different localities and cultures consume several millet varieties. Millets are the staple food of Indians and some other African and Asian millet producing countries and consuming numerous varieties of underutilized millets, pulses and spices other than rice and wheat in food. However, due to a rapid shift in our food habits towards Eastern and Chinese fast foods, we have started consuming processed and ready to eat food and started utilizing fortified foods instead of our pre-existing underutilized food crops (Nandy, 2004).

**Table 1.** Top ten millet producer countries of 2018.

S.N.	Country	Production (Tones)	Production (%)
1	India	11,640,000	35.7
2	Niger	3,856,344	11.8
3	Sudan	2,647,000	8.1
4	Nigeria	2,240,744	6.8
5	Mali	1,840,321	5.6
6	China	1,566,363	4.8
7	China, mainland	1,565,965	4.8
8	Burkina Faso	1,189,079	3.6
9	Ethiopia	982,958	3.0
10	Chad	756,616	2.3
World-wide millet produced in 2018		32,585,735	

Source: FAOSTAT-2018, "FAOSTAT\_data\_12-26-2020"  
<http://www.fao.org/faostat/en/#data/QC>

So, ironically most of these underutilized millets were in use as fodder (Kumar *et al.*, 2012) and in alcohol production (Wu *et al.*, 2016) which can help us to conquer the modernized problems i.e., pre- and post-translational diseases. So, the Government has announced a millets revolution in India. Since 9000 BC before the aggrandization of hard metal or metal pots, earthen cooking pots were the major utensil known and used by the humans (Frink and Harry, 2008). People are using earthen cookwares from an ancient time and earthen cookwares cooked food is reported more effective in terms of nutrient enhancement, taste and texture acceptability. Our history and archaeology have revealed that we were cooking our food in mud pots to gold or silver vessels, from iron to copper and brass utensils (Trivedi *et al.*, 2017) but now we have started using aluminium and non-stick utensils in order to avoid inconveniences in cooking, leakage and break because metal utensils are durable and attractive. Undoubtedly cooking in metal utensils is fast and they are good with durability and handling, but they nowhere stand with the nutritive value and possess potential hazard of releasing bis-phenol A. Due to the excessive use of aluminium and non-stick utensils, we cannot receive the proper amount of nutrition, vitamins, protein, fibre, antioxidants etc., because aluminium and non-stick utensils result in nutrients loss, metal toxicity, or change in texture, colour and properties of food. The Global Hunger Index (GHI) 2019 has given us very low merit (GHI, 2019). In 21 out of 29 states more than 30% children under 5 years of age are stunted and in 22 states more than 10% of children died below 5 years. In 22 states more than 50% of women are anaemic, but in only 5 out of 29 Indian states high-level nutrition missions are being run to cope with these problems. According to the latest reports, an average of 34.68% of children under 5 years of age are stunted while an average of 13.256% of children are wasted in India. On the other hand, the nutrition rate, obesity, diabetes, and cardiovascular diseases are also increasing alarmingly (Table 2). The United Nations Children's Emergency Fund's (UNICEF) latest report-2019 has revealed that the mortality rate of new borns is 8.8% and 68% deaths of kids underneath 5 years occurs due to malnutrition in India. The report also states that every second child below 5 years is affected by some form of malnutrition (UNICEF, 2019; UNICEF-WHO-The World Bank, 2019). Besides, India has become the major contributor to the growth of diabetic people and continuous increase in diabetes patients is projecting India as the Diabetic Capital of the world. The Global Heart Initiative of the World Health Organization (GHI-WHO) has indicated that 80% of deaths due to cardiovascular disease occur in middle and low pay nations (GHI-WHO, 2019). Due to the aforementioned scenario and increase in consumer's awareness, the demand of

nutrient-rich food and functional food is increasing expeditiously that has turned food industries to think innovatively. To strengthen our efforts against food crisis, pre- and post- progress problems and for encouraging the farmers towards millet production, Indian Government has been successful in sponsoring a resolution in UNGA supported by 70 nations for declaring 2023 as International Year of Millets. Escalating trend of millet bio-fortification and multi-grain flour is causing a notable increase in millet production (Birania *et al.*, 2020) and it has increased 3-fold as compared to 1960s in which 2-fold increase in the case of rice (Figure 1-D). Thus, we are combating these basic as well as modern problems by utilizing our traditional, indigenous knowledge and using our underutilized millets along with the traditional cooking practices in order to cook nutritive food (Pennington and Schoen, 1995). Indian culture is very rich in its heritage; our indigenous practices are having more scientific explanations than others. Therefore, the present review deciphers the basic Indian culinary practices that can fight pre- and post-transition diseases in terms of grains, cooking practices and cookwares. This review will help the scientists and researchers and is also of societal importance due to the issues addressed here.

#### **Millets: a nutri-cereal**

Millets have a great potential to become small- and large-scale supplements of alkaline nature and act as the best fortification agent (fortificant). Millets have the power to combat cell and tissue injuries. It contains phenolic mixer and lecithin. Millets lower the harmful cholesterol like LDL, VLDL, triglycerides etc., and lessen the danger of numerous malignant growths (tumour or cancer) and cardiovascular diseases. Millets containing significant amounts of fat, protein, nutrients, vitamins, minerals, dietary fibre (Table 3), HDL, phenols, flavonoids, antioxidants, cancer preventing agents, and gluten-free, are called Nutri-grains (Michaelraj and Shanmugam, 2013; Saini *et al.*, 2021). Barnyard millet effectively reduces blood sugar level and prevents us from celiac diseases due to its gluten-free nature (Rao *et al.*, 2018). Watanabe (1999), has isolated three antioxidative phenolic compounds, one serotonin derivative and two flavonoids that shows its strong antioxidative activity. Luteolin, tricetin and serotonin are its major anti-cancerous, anti-diabetic and anti-rheumatic compounds (Thakur and Tiwari, 2019). Finger millet is considered as the best diabetic food that controls blood sugar level and hyperglycaemia (Rao *et al.*, 2018). Millets contain catechins, daidzein, epicatechin, epigallocatechin, galactocatechin, myricetin, kempherol, tricetin, luteolin, taxifolin, vitexin, pyrocyanidin B1, apigenin and pyrocyanidin B2 that all are vital in the treatment of cardiovascular diseases and diabetes. Finger millets are also antimicrobial and anti-

**Table 2.** State-wise data health and nutrition data of India.

S. No.	State	Children under 5 years (stunted) (in %)	Children under 5 years (wasted) (in %)	Women with anemia (15-49 years) (in %)	Does state have a high-level nutrition mission?
1	Arunachal Pradesh	28	17	1	No
2	Andra Pradesh	34.5	19	68.1	No
3	Assam	40.6	9.7	69.5	No
4	Bihar	49.4	13.1	67.4	No
5	Chhattisgarh	43	12.9	57.5	No
6	Delhi	29.1	14.3	44.3	No
7	Gujarat	41.6	18.7	55.3	YES
8	Goa	21.3	15.4	63.4	No
9	Haryana	36.5	8.8	57.7	No
10	Himachal Pradesh	34.2	10.1	44	No
11	Jammu and Kashmir	31.7	7.1	52.1	No
12	Jharkhand	47.40	15.6	69.5	YES
13	Karnataka	34.2	17	62.5	YES
14	Kerala	19.4	15.5	32.7	No
15	Madhya Pradesh	41.5	17.5	56	YES
16	Maharashtra	35.4	18.6	65.3	YES
17	Meghalaya	42.9	13.1	53.9	No
18	Mizoram	26.9	14.3	64.1	No
19	Manipur	33.2	7.1	65.3	No
20	Nagaland	29.1	11.8	50.2	No
21	Orissssa	38.2	18.3	61.2	No
22	Punjab	30.5	8.7	52.7	No
23	Rajasthan	36.4	14.1	53.1	No
24	Sikkim	28	5.1	70.6	No
25	Tamilnadu	23.3	19	49.2	No
26	Tripura	31	17.1	45.6	No
27	Uttar Pradesh	50.4	10	49.9	YES
28	Uttarakhand	34	9.3	55.2	No
29	West Bengal	34.7	15.3	76.3	No
	Average value	34.68	13.56	55.62	5Y:24N

Source: India Health Report on Nutrition 2015 Explore state level data, <http://www.transformnutrition.org/india-health-report-on-nutrition-2015/india-health-report-on-nutrition-2015-explore-state-level-data/>

tumorigenic in nature (Thakur and Tiwari, 2019). Foxtail millet contains apigenin, catechin, kempherol and quercetin that helps in combating cardiovascular disease, diabetes and dyslipidemia. These are anti-microbial, anti-tumorigenic, anti-cancerous and help in body detoxification (Thakur and Tiwari, 2019). Kodo millets contain lecithin which is effective in strengthening our nervous system (Rao *et al.*, 2018). Kodo millet consumption is good for postmenopausal women and those suffering from high cholesterol problems, heart

related diseases and high blood pressure. Kodo millets can also be used in rendering general debility, haemorrhages, hepatopathy and inflation (Jain *et al.*, 2010). Little millets are B group vitamins, phosphorus and iron-rich. Germinating little millets produces the  $\alpha$ -amylase of higher purity with higher yield (Usha *et al.*, 2011). The soluble fraction of little millets contains 80% of flavonoid (luteolin and kaempferol) and phenolic (ferulic, caffeic and sinapic acids) contents (Pradeep and Sreerama, 2015). Millets contain a good amount of cop-

**Table 3.** Composition of millets.

S. No.	Crops	Common Name	Scientific Name	Calcium (mg)	Fat (gm)	Fiber ((gm)	Iron (mg)	Minerals (mg)	Protein (gm)	Energy (Kcal)
1	Barnyard Millet	Banti, oodalu, shyama, swank	<i>Echinochloa</i> spp.	11	3.9	10.1	15.2	4.4	11.2	342
2	Finger Millet	Ragi, mandua, nachni, mandiya,	<i>Eleusine coracana</i>	34	1.5	1.5	3.9	2.7	7.3	336
3	Foxtail Millet	Kangani, kanghzu, navane, tanai	<i>Setaria italica</i>	31	4	8	2.8	3.3	12.3	473
4	Kodo Millet	Anika, kodon, Kodra, varaku	<i>Paspalum scrobiculatum</i>	27	3.6	9	0.5	2.6	8.3	309
5	Little Millet	Gajrao, kutki, samalu, sava	<i>Panicum miliare</i>	17	5.2	7.6	9.3	1.5	7.7	207
6	Pearl Millet	Bajra, bajri, Cumbu, saja	<i>Pennisetum glaucum</i>	38	4.8	1.3	16.9	2.3	10.6	378
7	Proso Millet	Bachari, baragu, chena, vari	<i>Panicum miliaceum</i>	14	2.9	2.2	0.8	1.9	12.5	356
8	Sorghum	Cholam, jola, jowar, rotla	<i>Sorghum bicolor</i>	25	3.1	2	5.4	1.6	10.4	329

Source: Thakur and Tiwari ( 2019)

per, folate, zinc, magnesium, iron, calcium, unsaturated fatty acids and vitamin B complex (Rao *et al.*, 2018). Pearl millet shows protective activity against DNA damage. Due to the higher concentration of folate, it can also be used as fortificant to fortify the foods for anaemic population. Magnesium fosters migraine treatment and can reduce asthmatic patients' respiratory problems (Ambati and Sucharitha, 2019). Proso millets are good for bones and help in combating blood-pressure, dyslipidemia, breast cancer and cardiovascular diseases (Rao *et al.*, 2018). Its carotenoids extract has high cellular antioxidant activity as compared to fruits and vegetables. Proso millets also have higher dose dependent anti-proliferative activity against human liver cancer cells and contain around 65% of phenolic compounds and some bioactive phytochemical compounds like ferulic acid, caffeic acid, chlorogenic acid and syringic acid beneficial for human health (Zhang *et al.*, 2014a). Quinoa contains a high amount of protein, minerals, dietary fibre and vitamins that help in combating diabetes, celiac diseases, protein-energy malnutrition, dyslipidemia and cardiovascular disease (Li *et al.*, 2018). It is rich in minerals and contains methionine and lysine that are lacking in cereals. Due to high amounts of oil such as omega-6 fatty acid, vitamin-B and vitamin-E, it is also considered as an oil crop (James, 2009). The nutritional qualities of sorghum are better than rice and it contains folic acid,  $\beta$ -carotene, fibre, thiamine and riboflavin (Rao *et al.*, 2018). Sorghum is rich in flavonoids, condensed tannins and phenolic acids. Its pigment and antioxidant properties are competitive to vegetables and fruits. It is anti-carcinogenic and lowers the risk of oesophageal cancer. However, compounds responsible for its anti-carcinogenicity are still unexplored (Dykes and Rooney, 2006).

### Effect of cooking methods

There is less or no information available to show the effect of cooking on nutritional composition, especially on water-soluble vitamins and proteins of food. Indian culinary is wide and for a long-time, we are incessantly consuming food cooked by germination, fermentation, boiling, roasting, frying and pressure cooking. All these cooking methods draft a unique impact on food in terms of their nutritional and sensory properties. The cooking method affects the nutrients, minerals, vitamins, proteins, fats, amino acid, phenolic and flavonoid concentration in food. So, researchers started exploring the potential factors to enhance food's nutritional quality (Otemuyiwa *et al.*, 2018).

### Germination

Eating sprouts is considered a more nutritive and healthy food supplement in India. Sprouts are an excellent source of amino acids, proteins and vitamins and some phytochemicals (Ghani *et al.*, 2016). Germination is an old practice and done by soaking. It enhances the bio-accessibility of minerals and reduces the level of anti-nutritional factors such as oxalate and phytate (Suma and Urooj, 2014). It positively increases the antioxidant activity, dietary fibres, total phenolic, total flavonoid content (Sharma *et al.*, 2016) and also affects the concentration of free amino acids and non-protein amino acids depending on the type of crop (Kuo *et al.*, 2004). Gamma-aminobutyric acid (GABA) content is always increased after germination (Suma and Urooj, 2014; Sharma *et al.*, 2016; Kuo *et al.*, 2004) which regulate the blood pressure, cardiovascular diseases, alleviate the pain and anxiety (Bai *et al.*, 2008). Some new bioactive compounds viz. butyl-6,9,12,15-octadecatetraenoate, hexa-decanoic acid, hexa-

**Table 4.** Advantages, disadvantage and health anomalies pertaining to the cookware/utensils.

S. No.	Cookware	Advantages	Disadvantages	Health Anomalies
1	Aluminium Cookware	<ul style="list-style-type: none"> <li>• Inexpensive</li> <li>• Lightweight</li> <li>• Easy to clean</li> <li>• Thermally responsive</li> <li>• Energy saver</li> <li>• Hygienic</li> <li>• Corrosion resistant</li> <li>• Recyclable</li> </ul>	<ul style="list-style-type: none"> <li>• High leaching</li> <li>• Interacts with acidic food</li> <li>• Leaches Cd, Pb and other harmful heavy metals</li> <li>• Long cooking or storage leads to the higher aluminium leaching into food</li> </ul>	<ul style="list-style-type: none"> <li>• Arthralgia</li> <li>• Alzheimer</li> <li>• Auto immune diseases</li> <li>• Breast cancer</li> <li>• Carcinogenic</li> <li>• Chronic fatigue</li> <li>• Chronic renal failure</li> <li>• Dementia</li> <li>• Myalgia</li> <li>• Muscle weakness</li> <li>• Neurological syndrome etc.</li> </ul>
2	Copper Cookware	<ul style="list-style-type: none"> <li>• Antimicrobial activity</li> <li>• Effective heat conduction</li> <li>• Easy temperature controlling</li> </ul>	<ul style="list-style-type: none"> <li>• High leaching may occur if cooked acidic foods in cooper cookware</li> <li>• Rusting and corrosion occurs easily</li> </ul>	<p>High copper intake may cause;</p> <ul style="list-style-type: none"> <li>• Alzhiemer</li> <li>• Cirrhosis</li> <li>• Copper toxicosis</li> <li>• Diabetes</li> <li>• Tumor inducing</li> </ul>
3	Earthen/ceramic Cookware	<ul style="list-style-type: none"> <li>• Inexpensive</li> <li>• Enhances the aroma, texture colour and other sensory qualities of food.</li> <li>• Retains the nutrition of food</li> <li>• Keeps the storing materials cool</li> <li>• Easy cleaning</li> <li>• High temperature resistant</li> <li>• Wear and corrosion free</li> <li>• Traditional pride</li> </ul>	<ul style="list-style-type: none"> <li>• Inner polishing may lead to Pb and Cd leaching</li> <li>• Heavy weight</li> <li>• Delicate to handle because easily breakable</li> <li>• Leakage may occur easily</li> </ul>	<ul style="list-style-type: none"> <li>• Polishing or clazing the inner surface may present the Pb and Cd toxicity.</li> </ul>
4	Iron Cookware	<ul style="list-style-type: none"> <li>• High heating capacity</li> <li>• Releases less iron in food which is necessary for the body</li> <li>• Retains heat for long time and keeps the food warm</li> </ul>	<ul style="list-style-type: none"> <li>• Easy corrosion</li> <li>• Reduces the natural aroma, colour and texture of food</li> </ul>	<p>High iron intake may cause:</p> <ul style="list-style-type: none"> <li>• Cancer initiation</li> <li>• Neuro degeneration</li> <li>• Tissue damage etc.</li> </ul>
5	Non-stick or anodized Cookware	<ul style="list-style-type: none"> <li>• Easy to handle</li> <li>• Aesthetic appearance</li> <li>• Hard and durable</li> <li>• Convenient cooking</li> <li>• Easy to clean</li> </ul>	<ul style="list-style-type: none"> <li>• Coatings breaks, unwind or flake off after some times</li> <li>• Leaches highly toxic PPFASs compounds in food</li> </ul>	<p>Leaches Perfluorooctanonic acid (PFOA) which is carcinogenic.</p> <ul style="list-style-type: none"> <li>• PPFASs may lead to the:</li> <li>• Increases cholesterol level</li> <li>• Lowers the pregnancy chances</li> <li>• Reduces the vaccine generated disease control</li> <li>• Harmful effect on tests and kidney</li> </ul>
6	Stainless steel	<ul style="list-style-type: none"> <li>• Light weight</li> <li>• Aesthetic appearance</li> <li>• Durable</li> <li>• Stores energy for long time</li> <li>• Keeps food warm</li> <li>• Contains less toxic compounds as compare to Aluminium or non-sticks</li> <li>• Less susceptible to leaching</li> </ul>	<ul style="list-style-type: none"> <li>• Chromium leaching may possess high health risk</li> <li>• Alloy contents may leach into food</li> </ul>	<p>Leaches chromium which may cause:</p> <ul style="list-style-type: none"> <li>• Eryptosis</li> <li>• Dermatitis</li> <li>• RBC damage etc.</li> </ul>
7	Soapstone	<ul style="list-style-type: none"> <li>• High energy storage potential</li> <li>• Heat shock proof</li> <li>• Durable</li> <li>• Hard to brake</li> <li>• Leaches calcium and magnesium into food within the range</li> </ul>	<ul style="list-style-type: none"> <li>• Heavy weight</li> <li>• Delicate handling</li> <li>• Inconvenient washing</li> </ul>	<ul style="list-style-type: none"> <li>• High calcium and magnesium intake affects the bones</li> </ul>

Source: (Guidetti and Simonetti 2000; Kontoghiorghes and Kontoghiorghes 2020; Duwe and Niedzwiecki 2020; Zhang *et al.* 2014a,b; Quan 2019; Ingle *et al.* 2018); Anderko and Pennea 2020; Quintaes *et al.* 2002; Anthony *et al.* 2013; Trivedi *et al.* 2017)

decanoic acid-methyl ester, n-propyl-9, 12, 15 octadecatrienoate, pregan, 20-one-2hydroxy, 5,6, epox-15 methyl, 9, O-ctadecenoic acid are also reported after germination in kodo millet (Sharma *et al.*, 2016). Germination also lowers the glycemic index of seeds so that diabetic people can also consume it (Cornejo *et al.*, 2015).

### Fermentation

In India, fermentation is used to prepare several food items and these food items are providing food security to communities. A variety of dough, porridges and beverages are prepared by fermentation. Fermentation increases the nutritional value, total reducing and non-reducing sugars, and significantly affects the protein, vitamins, minerals and fat concentration (Khetarpaul and Chauhan, 1990). It also increases the total phenols, total flavonoids, free amino acids and other phytochemical components (Subastri *et al.*, 2015). Fermented foods are popular because they lower the amount of anti-nutrients such as tannins, phytic acids and trypsin inhibitors. Fermented food also provides certain nutritive and therapeutic values (Samtiya *et al.*, 2020; Farag *et al.*, 2020). Balli *et al.* (2020) has demonstrated that phenolic extract of fermented millets has a high antioxidant level on human erythrocytes by an ex-vivo procedure. Another similar study has revealed that phenolic extracts of fermented millets increase the DNA damage protection activity of millets (Purewal *et al.*, 2020). It also increases the protein digestibility of millets (Ali *et al.*, 2003). Ezeji and Ojmelukwe (1993) have demonstrated that fermented millet feeds increase the weight gain and PFR value in rats and suggested that fermented food supports infants' growth better than other food alternatives.

### Roasting and frying

Roasting is a dry cooking method preferred for its nutritional credibility. Roasted or puffed grains are consumed not only in India and South Asian countries but throughout the world. Consumption is directly dependent on the locality, food habits, convenience and availability of the type of grains e.g., popcorns are the oldest and most used roasted grain (Srivastav *et al.*, 1990). Roasting increases the concentration of available mineral content and it has been proved by the increase in their mineral's extractability (Gahlawat and Sehgal, 1993). Roasting does not significantly affect the physicochemical properties of food grains, but it contributes to fostering its aroma and storage parameters (Griffith and CastellPerez, 1998). Modgil and Sood (2017) have demonstrated that roasting decreases the energy value, antioxidative activity, phenolic and flavonoid content. High-temperature roasting significantly decreases the phenolic content of food grains but increases its functional properties (Obadina *et al.*, 2016). In contrast,

frying is wet cooking done in hot oil or fat. Indians use ample amounts of fat in food. So, frying is the most preferred cooking practice here after pressure cooking. However, research and literature reciting its effect on the nutritional, physicochemical and sensory properties is available. Annapure *et al.* (1998) has stated that there is no correlation between the proximate content of food and oil composition.

### Microwave oven cooking

Dry heating in small domestic furnaces and heated ovens is an old practice used in bakeries, while microwave assisted oven cooking is an emerging cooking practice in India. Yadav *et al.* (2012) has stated that microwave lowers the lipase activity so it extends the shelf life of millet flour at ambient conditions. Microwave-assisted millet cooking significantly affects the antioxidant activities, phenolic activities and inhibitory effect against the  $\alpha$ -glucosidase and  $\alpha$ -amylase. So, it can be used against hyperglycemia in diabetic people (Pradeep and Sreerama, 2015). Baba *et al.* (2016) has studied the antioxidant and anticancer activity of microwave assisted cooking and reveals that microwave roasting decreases the anticancer potential and DNA damage inhibition activity in barley. Microwave cooking increases the protein content but does not affect the physicochemical properties except for the water solubility index (WSI). WSI increases and enhances the functional properties, suggesting its industrial utilization (Kumar *et al.*, 2020). Microwave cooking effectively reduces the level of toxins especially aflatoxins in food so considered as a healthy cooking practice (Meenatchi *et al.*, 2015).

### Nutrients loss due to pressure cooking

A Nigerian study on nutrient loss by cooking methods has revealed that various cooking methods e.g., ordinary cooking, parboiling, microwave and pressure cooking positively affect the vit C, vit B6, vit B1 and vit B9 concentration of food. The study demonstrated that vitamins retention in parboiling was higher than conventional and microwave cooking methods. The least vitamin retention was seen in pressure cooking methods (Otemuyiwa *et al.*, 2018). Another similar study has shown that the loss of vitamin C in pressure cooking was more as compared to open pan cooking of cabbage and Ethiopian green collard (Hailemariam and Wudineh, 2020). Dutta *et al.* (2019) has suggested that millets are rich in micronutrients and provide a balanced diet if consumed in an adequate amount. The study also implies that bioactive components (phenolic and flavonoids) of millets reduce as the temperature and pressure increases (Figure 1-E). Reduction in phenolic and flavonoid content is reported higher in pressure cooking. Another study has demonstrated that



pressure cooking causes the denaturation of proteins, essential amino acids, carbohydrates and saturated or unsaturated fatty acids. It also implies that cooking methods directly impact the amino acid composition of food (Figure 1-F) (Seena *et al.*, 2006). Liu *et al.* (2019) has studied the impacts of washing, soaking, and cooking and suggested that reduction/denaturation of vitamins occur due to high pressure and temperature. At 121°C, thiamine losses were more than at 99°C or less temperature.

#### **Cookwares: Types and effects on nutritional values**

Cookwares affect the nutritional composition of the food, both positively and negatively. Different metal cookwares can cause metal or trace metals toxicity (Dan and Ebong, 2013). Cookwares are made up of a variety of materials like metals, mud, stone etc. Some most commonly used cookwares are made up of gold, silver, aluminium, copper, brass, bronze, iron, steel, stainless steel, nonstick, food grade plastics, clay or soapstone (Alabi and Adeoluwa, 2020). All these cookwares have their own advantages and disadvantages in terms of durability, convenience, and cost (Table-4). Cooking in an aluminium pressure cooker leads to the breakdown of nutrients. Due to its high pressure and uneven heat circulation, pressure cookers cause the breakage/denaturation of protein, vitamins and other important minerals. So, it is essential to look back in time when people used to cook food in earthenware pots, clay pots or other handy metal cookwares that do not lead to higher nutrient loss during cooking. Earthen cookwares absorb moisture due to its porous nature and retain nutrition. They also absorb toxic substances which are neutralized by fire. Food cooked in earthen cookwares provides a comparatively high number of proteins, vitamins, minerals than cooked in aluminium pressure cooker and metal cookwares.

#### **Non-stick**

Non-stick cookwares are the most emerging cookwares throughout the world due to its lightweight, convenient handling, easy cooking practices and microwave usage. Non-stick cookwares are the metal cookware with a nonstock coating of PFASs. Per- and polyfluoroalkyl substances (PFASs) are the synthetic chemical compounds that are detrimental to the environment as well as human health (Yamijala *et al.*, 2020). PFASs are one of the emerging concerns because its exposure may cause irregularities in growth, behaviour and learning of infants and mature children. In women, it also lowers the chances of getting pregnant, affects the immune system, increases the cholesterol level and also may reduce the vaccine generated disease protection in children (Anderko and Pennea, 2020). It also drafts an adverse effect on fish, causing toxicity and change in their swimming abilities (Menger *et al.*, 2020). Among

the PFASs, short-chain polyfluoroalkyl carboxylic acid (SC PFCA) and perfluorooctanoic acid (PFOA) are mostly detectable in polluted streams. Han *et al.* (2020) has demonstrated the noxious effects of SC PCFA on the liver, testes and kidney through *in vivo* model. The study also reveals that PFOA also causes microscopic abnormalities and decreases the thickness of the skin. An independent science review panel of United States Environmental Protection Agency (US EPA) has proposed perfluorooctanoic acid (PFOA) to be acknowledged as "likely to be a carcinogenic compound" after reviewing an *in vivo* study that has revealed PFOA causes death in laboratory rats (Steenland *et al.*, 2010).

#### **Iron**

Iron is one of the essential elements for humans. It is required for the production of red blood cells. Excess iron in the body is, however, poisonous but in India the number of anaemic populations is higher. We take around 20% of the iron intake from cookwares (Health Canada, 2006). Cheng and Brittin (1991) have demonstrated that older cookwares add more iron in food than the new one and suggested that cooking in iron cookware enhances some factors that can increase the adsorption of non-heme iron which makes it more bioavailable. Due to the nutritional advantages of cooking food in iron cookware, food scientists and researchers are recommending it as a potential remedy to cope up with anaemia. However, another study has revealed that cooking in iron cookwares doesn't affect the sensory qualities but decreases the colour and flavour, leading to declining consumers' acceptance (Park and Brittin, 2000). Quintaes *et al.* (2007) has reported that cast iron cookware cooked food drastically improves the iron level and decreases anaemia in the population. The study also implicates that cooking of low pH foods is more likely to add higher amounts of iron and possibly manganese. In humans, due to iron imbalance, a variety of diseases occur. Other than anaemia, lack of iron can cause hemoglobinopathies, the most common genetic disorder and idiopathic hemochromatosis. However, excess iron content can also lead to neurodegeneration, cancer initiation and tissue damage in pathological conditions (Kontoghiorghes and Kontoghiorghes, 2020).

#### **Aluminium**

Aluminium is the third most common element available on earth's crust. Variety of aluminium cookwares are currently in use. However, its corrosion rate increases with the salt concentration and it starts leaching (Al Zubaidy *et al.*, 2011). Before the British rule, Indians were using copper, iron and brass cookwares. Aluminium was first introduced in Indian jails but later spread to all parts of the country due to its lightweight, fast cooking and convenience. Aluminium based pressure

cookers (Figure 1-A) and other cooking vessels have become the most commonly used cookwares in the current era. However, many studies have reported the leaching and nutrient loss during cooking (Semwal *et al.*, 2006). Aluminium is a toxic heavy metal that is non-essential to humans and not taking part in the metabolism of the body for functioning and maintenance. It is present in human food from animals as well as plant sources. Various plants grown in acidic soils uptake aluminium and accumulate it (Stahl *et al.*, 2017). Neelam *et al.* (2000) has shown that cooking in aluminium cookwares increases the aluminium intake in humans significantly. Besides, it aids more aluminium burden in food if stored in aluminium utensils. Duwe and Niedzwiecki (2020) have precisely accentuated the adverse effects of aluminium on mitochondrial energy production and its role in causing alzheimer, breast cancer, dementia, autoimmune syndrome, myalgia, chronic fatigue, arthralgia, muscle weakness and cognitive dysfunction. Another study has revealed that in low- and middle-income countries people use low cost locally casted aluminium cookwares that are basically manufactured by recycling the computer hard disk cover, radiators, engine parts of motorbike, cans, construction materials, some part of computers and other metal scraps. These cookwares leach the aluminium, lead and cadmium into the food and can possess serious health issues (Weidenhamer *et al.*, 2014). Street *et al.* (2020) has listed and identified the 18 metals viz. Fe, Cd, Hg, Pb, Co, Cr, Zn, Sn, Cu, Mn, Se, As, Ag, Ba, Mo, Ni, Sb and V in these artisanal cookwares. Aluminium toxicity in diabetic patients is comparatively higher. It is reported that the patients of diabetes mellitus type-2 are associated with the increased risk of renal dysfunctioning, cardiovascular disease, atherosclerosis and many more. Aluminium is the only element found in elevated concentration in neurofibrillary tangles. The evidence far indicated that aluminium is toxic to brain and it is possible that it has a pathogenic role in alzheimer's disease (Krishnan *et al.*, 1988). Rittirong and Saenboonruang (2018) have demonstrated the carcinogenic and anticarcinogenic activities of pressure-cooked rice. Aluminium foils are the most emerging food wrapping item worldwide, but it gets leached to the extent that can cause serious potential illness in smaller children and in people suffering from chronic renal failure (Dordevic *et al.*, 2019).

### Stainless steel

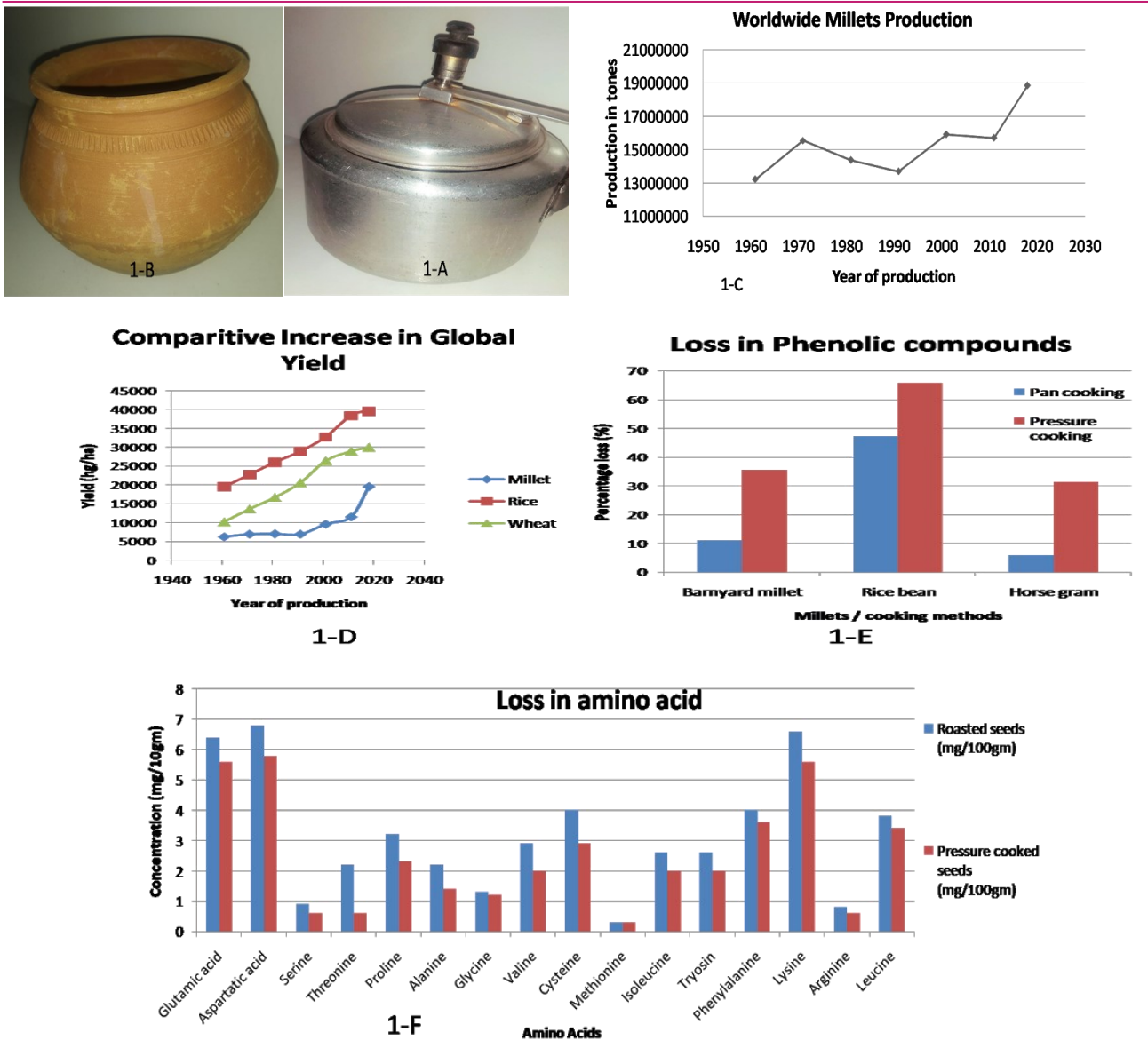
Stainless steel is an iron based alloy which contains up to 30% chromium (Reardon, 2011). Stainless steel has become one of the most commonly used metals in the cookware industry due to its various advantages like inexpensiveness, durability, light weight, easy to handle, cooking conveniences, high heat and wear resistance properties (Health Canada, 2006). Stainless

steel cookware also leaches aluminium but less than aluminium cookwares, hence, does not create any harmful impact on humans (Dan and Ebong, 2013). During cooking in new cookwares, leaching is higher, and chromium and nickel concentrations increase 35 and 34 folds, respectively (Kamerud *et al.*, 2013). Hexavalent chromium can cause eryptosis, and increased rapid ATP consumption and RBC damage (Zhang *et al.*, 2014b). Quan (2019) has stated that the average intake of nickel is about 300 µg per day, demonstrating that present stainless cups leaches nickel to the extent that can cause dermatitis. Leaching of metal irons from coffee machines and electric kettles is also a point of concern as it releases the Cr, Ni, Mn, Pb and Zn in the fluid (Müller *et al.*, 2015).

Kandavel *et al.* (2015) have reported that different cookwares affect the boiling of water significantly and demonstrated that cookwares made up of teflon and stainless steel have increased the fluoride level after boiling while it decreases if boiled in earthen, aluminium and glass vessels. So, utilization of stainless steel and teflon cookwares in direct cooking can toxify the food. Roy *et al.* (2012) has shown that stainless steel vessels give more yield during fermentation of Bakhar-Handia as compared to plastic vessels.

### Copper

Copper is a metal available in abundance and used in plumbing, storage, drinking and cooking vessels. The use of copper gets popularize due to its high thermal conductivity, aesthetic appearance, light weight and antimicrobial activity. WHO has classified copper (Cu) as an essential trace metal for humans and it amounts around 70-100 mg in the human body. Copper tableware viz. plates, bowls, jugs, spoons and mugs are frequently used as compared to the copper cookwares. Tableware too leaches the copper in food and beverages and it is helpful for humans if within the limits (Ishiwata *et al.*, 1986). Jiang *et al.* (2019) have demonstrated that nano copper polypropylene composite food wrapping film has higher antimicrobial activity against *Bacillus subtilis*, *Escherichia coli*, *Shigella castellani* and *Staphylococcus aureus*. Copper cookwares and foils leach the copper and it is dependent on the pH and temperature of the food and it doesn't get affected by the long term continued utensil cleaning (Koontz *et al.*, 2020). Copper is present in almost all sort of human tissues. It is absorbed in the human gut and stored in liver, brain, heart, kidney and muscles after transport (Bhattacharya *et al.*, 2016). Copper is an essential micro-element required for many biological processes of humans and other life forms like growth and survival. It also allows some enzymes for their proper functioning. So, its use is recommended since vedic-period. Lack of copper in humans causes the menke's disease, cardiovascular diseases, occipital horn syndrome, acerulo-



**Fig. 1.** 1A- Aluminium pressure cooker, 1B- Earthen cookware, 1C- worldwide millet production trend (FAOSTAT Data 2018), 1D- Worldwide comparative yield of rice, wheat and millets (FAOSTAT 2018), 1E- loss of phenolic compounds in pan and pressure cooking (Dutta *et al.* 2019), 1F- Comparative loss in amino acid by roasting and pressure cooking (Seena *et al.* 2006).

plasminemia and zinc induced myeloneuropathy etc. whereas excess copper causes wilson’s and non-wilson’s diseases like Indian childhood cirrhosis, copper toxicosis, diabetes, alzheimer’s, etc. (Ingle *et al.*, 2018). Higher copper accumulation in tissues leads to cancer development by angiogenesis because copper (Cu) stimulates the migration and proliferation of endothelial cells required for secreting various angiogenesis factors by tumor cells (Gupte and Mumper, 2009; Lowndes and Harris, 2005). On the contrary, researchers are also focusing on turning the tumor inductive copper into anti-cancer by using high throughput chemistry (Wang *et al.*, 2010). Tang *et al.* (2013) has demonstrated that dietary copper improves the growth, adsorption, digestive capacities and decreases the protein

adsorption and lipid peroxidation.

**Earthen**

Clay pottery is an ancient craft in India that has grown with the civilizations. Earthen or clay cookwares, storage vessels and toys are used here for a long time. Earthen cookwares/pots (Figure 1-B) are widely used by Indian villagers or tribes for cooking purposes till now. Not only nutrients but also taste, texture, color, and fragrance, earthen pots enhance all the food parameters in terms of acceptability. In traditional indigenous knowledge and Ayurveda, the use of earthen pots is recommended in many medicine and fermentation processes (Chakrabarty *et al.*, 2010; Deori *et al.*, 2007; Etejere and Bhat, 1985; Saxena and Dutta, 1975; Bhat

*et al.*, 1990; Soibam and Ayam, 2018; Wokoma and Aziagba, 2001). The heat transfer efficiency of earthen pots is higher, which helps them to keep the storing material cool. Domestic water pots for potable water usage are the most common example of this (Trivedi *et al.*, 2017). Beverages fermented in earthen pots are more intoxicating and of higher yield and earthen wears put a positive effect on minerals content (Roy *et al.*, 2012; Mohamadou *et al.*, 2008). Traditional preparation of Mbujha in earthenware pots by fermenting *Hibiscus sabdariffa* seeds significantly increases the aluminium, manganese, magnesium, sodium, zinc and decreases the calcium level (Mohamadou *et al.*, 2008). It is observed that boiling of water in earthen pots decreases the heavy metal concentration in water due to soil composition (Kandavel *et al.*, 2015). Besides boiling, cooking in earthen-were also enhances the flavonoids, crude protein, and higher acceptability (Gupta and Nagar, 2010). Food cooked in earthen cookware increases iron and zinc concentration and decreases the other toxic heavy metals during cooking (Anthony *et al.*, 2013). Due to its low cost, many small production industries uses earthen pots for production e.g., *gur* or jaggery making (Pattnayak and Misra, 2004). Eating on ceramic or earthen plates is much healthier and non-toxicant than other metal and plastic plates (Trivedi *et al.*, 2017).

### Soapstone

Soapstones are metamorphic rocks rich in actinolite, dolomite and talc. It is commonly known as steatites. These are soft and easy to carve stones along with some essential thermal properties that made it effective for use in cooking as a cookware or cooking stone. These are very fragile, so they require proper and meticulous handling during cooking and washing. Due to its high density, mechanical strength and temperature resistance quality soapstone cookwares are used in cooking food that require longer cooking time. Soapstone cookwares doesn't affect the natural taste and aroma of the food besides act as a storing pot (Kora, 2020). Quintaes *et al.* (2011) has demonstrated that the use of soapstone cookware significantly increases the hemoglobin, hematocrit, serum iron, serum ferritin, transferrin, and transferrin saturation index (TSI) and total iron binding capacity (TIBC) in the volunteers. New or crude soapstone pans leaches Al, Ca, Cd, Co, Cr, Fe, Mg, Mn, Ni and Pb but later, after continuous cooking cured pans stopped contributing toxicity in food and used as mineral nutrition in food (Quintaes *et al.*, 2002). Another study reveals that the use of soapstone cookwares and vessels in arctic regions is high because of its thermal qualities; temperature shock resistance, heat absorption and storage abilities etc. Besides, research stated that soapstone vessels are better as compared to other metal and

ceramic containers (Frink *et al.*, 2012). Soapstone cookwares are contemporary to the pottery and were used in remote time. Due to the new technological inventions and lack of availability, they become obsolete. In some southern states areas of India, these are still in use and has spread up to the tribes of Northeastern India (Wells III *et al.*, 2014). Lack of proper research and literature on soapstone cookware is causing a gap between our traditional indigenous practices and scientific inventions, which needs to be bridged.

### Conclusion

Underutilized millets are Nutri-cereals with high nutritional qualities, dietary fiber and effective in small and large scale supplements or as a fortificant. Millets are nutrients rich and contain various minerals, e.g., calcium, iron, magnesium, manganese, potassium, zinc and phosphorus. These are soothing, gluten-free, intestine friendly, and alkaline, so gluten/wheat intolerants and patients suffering with constipation can consume them. Its cells and tissue maintenance actions are effective in inflammations. Millets contain tannins, phenolic mixes, flavonoids and other important amino and fatty acids. Millets and millet products are very useful in obesity, diabetes, malnutrition, cardiovascular disease, celiac diseases, protein energy malnutrition etc. Aluminium cookwares or pressure cookers adversely affect the food quality by leaching and nutrient denaturation, while earthen cookware increases the nutrients, texture, color but not durable and causes cooking inconveniences. People are using a variety of cookwares like aluminium, earthen, iron, copper, soapstone, stainless steel etc., and all are having different advantages and disadvantages. Aluminium cookwares are the most harmful cookwares among all. This review has revealed that some of the major health issues such as chronic renal failure, cirrhosis, cancer, dermatitis, neurodegeneration etc., we are facing nowadays might be due to the shift and change in our culinary practices. Presently used cookwares are leaching some harmful chemical compounds that pose critical health issues ranging from diabetes to alzheimer and cancer. On the other side, using earthen or clay pots, copper and iron cookwares instead of aluminium pressure cooker and nonstick/anodized cookwares in cooking practices can be a great deal in combating the pre- and post- transition health problems, especially in India. However, some modifications and improvements can be helpful for increasing their acceptability.

### ACKNOWLEDGEMENTS

The authors are thankful to SERB-DST (File no. EC-R/2016/001893) for financial support.

**Conflict of interest**

The authors declare that they have no conflict of interest.

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