SUMMARY
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Free radicals have been implicated in the etiology of a large number of major diseases. They can adversely alter many crucial biological molecules leading to loss of form and function. Such undesirable changes in the body can lead to diseases conditions. Antioxidants can protect against the damage induced by free radicals acting at various levels. There are epidemiological evidences correlating higher intake of foods with antioxidant abilities to lower the incidence of various human morbidities or mortalities. Dietary and other components of plants form major sources of antioxidants. Hence, estimation of antioxidants from foods is already an interesting area of research. In the literature, reports on antioxidant capacity of foods are found. These are based on extraction of antioxidants using polar solvents. Nevertheless, the amount of nutrients and phytochemicals absorbed during digestion is governed by the physical properties of the food matrix which affects the efficiency of physical, enzymatic and chemical digest. So, the conventionally extracted food samples may not reflect the antioxidant capacity of foods that is bioavailable. Phenolic compounds mainly exist as glycosides linked to various sugar moieties or as other complexes linked to organic acids, amines, lipids, carbohydrates, and other phenols. These are gradually released during the hydrolysis process in the digestive system. The enzymatic treatments during digestion hydrolyze starch and protein, which may favour the release of polyphenols. Therefore, the of antioxidant compounds in the gastrointestinal tract is not only quantitatively, but also qualitatively different to the one in the chemical extraction. In addition, these studies extract food sample in raw form. Most foods especially cereals, legumes and vegetables are consumed after cooking. Some food processing steps contribute to degradation and loss of phenolic compounds. Also, as mentioned earlier, phenolic compounds are in bound
form with proteins and other biomolecules. Cooking may set the phenolic compounds free from these linkages to make them more bioaccessible.

This study was an attempt to overcome these downsides of the antioxidant measurement in foods found in the literature. To the best of our knowledge, no study has so far evaluated the antioxidant capacity of traditional Indian diet. Here, we have not only assessed the antioxidant capacity or whole diet, but also evaluated their bioavailability. 88 commonly consumed Indian foods were analyzed in this study to derive an idea of the total antioxidant (phenol) intake per day of an Indian. In a nutshell, 12 cereals, 15 legumes, 18 fruits, 26 vegetables, 7 nuts and oilseeds and 10 lipids were evaluated in their edible form i.e. either raw or cooked. Both, conventional method and in vitro gastrointestinal digestion were employed as extraction procedures.

The results have been summarized according to the food groups viz. Cereals, legumes, fruits, vegetables, nuts & oilseeds and lipids. In the cereal group, highest total phenol was found in pearl millet whereas lowest phenolics were showed by rice in the conventional extracts (C). On in vitro gastrointestinal digestion, 10.30 and 6.74 folds higher phenolics were discovered in T3 extracts. Again, the flavonoids were found to be highest in pearl millet and lowest in rice samples in the conventional extracts. Also, 3.78 and 5.56 folds rise in the flavonoids was found respectively in pearl millet and rice samples in T3 samples. Flavonol content was highest derived in the sorghum (red) sample whereas the least content was recovered from rice. Rise of flavonols was found to be 86.72% and 202.04% in these samples respectively in the T3 counterpart. The reducing power was quite correlated with the Total Phenol. Pearl millet and rice had the highest and lowest FRAP respectively in the Control extracts (C). They gained 3.73 and 4.88 folds antioxidant power respectively after enzymatic treatment. Again the reducing power was highest in the pearl millet and lowest in the rice samples. 3.56 and 4.99 folds higher reducing power was detected in the T3 counterparts in pearl millet and rice
respectively. Similarly, pearl millet and rice had highest and lowest radical scavenging ability of all cereals in their Control extracts. 1.88 and 2.28 folds higher ABTS radical scavenging ability was detected in the raw enzymatic extracts (T3) of pearl millet and rice respectively. The DPPHRSA exceeded by almost 1.94 and 1.72 folds in pearl millet and rice respectively.

Among legumes, black gram had maximum phenolic content and faba beans had the lowest. These contents raised by 4.89 and 3.66 folds in the T3 extracts. Similar results were observed in the flavonoid content. Flavonoid content of these samples increased by 4 and 3.64 folds in the enzymatic extracts (T4). Further, the flavonol content in the methanolic extracts of legumes was found to be highest again in black gram and lowest in faba beans. These raised by almost 2.3 and 2 folds after the in vitro gastrointestinal digestion. Evidently, the FRAP also was highest in the black gram and least in faba beans. These values were 2.14 and 1.66 folds higher in the T3 counterparts. They gained 273.11% and 96.97% of reducing power when extracted with the help of enzymes (T3). However, in the T4 extracts, soya bean scored highest reducing power. Similarly, the radical scavenging ability of legumes was also found to be highest in black gram and lowest in faba beans when extracted conventionally. Black gram had 428.23 mg TE/100g of ABTSRSA which rose by 3.5 folds after enzymatic extraction and faba beans had 65.72 mg TE/100g which rose by 2.67 folds after enzymatic extraction. Conversely, in the T4 extracts, kidney beans had highest antioxidant potential among all. Also, in DPPHRSA, increases were found to be as high as 4.3 and 3.8 folds in these samples on exposure to simulated digestion.

Among fruits, wide range of total phenol content was observed when extracted in methanolic solvent (C). Highest amount was discovered in gooseberry and lowest was found in mosambi. Like cereals and legumes, fruits too gained significant phenolic content after in vitro gastrointestinal digestion. Almost 1.25 and 1.87 folds higher TPC was noticed in the T3 extracts of
gooseberry and mosambi samples. Also, the flavonoid content was found to be highest in gooseberry extracts but lowest in mango (unripe). 1.53 and 1.97 folds hike in the flavonoids was seen after T3 extraction of gooseberry and mosambi respectively. After T3, lowest flavonoids were discovered in orange. Again, gooseberry possessed maximum amount of flavonol among all fruits evaluated whereas grapes (green) scored lowest flavonols when methanolic extract was assessed. These results were improved by 25.46% in gooseberry and 184.84% in grapes (green) when the in vitro gastrointestinal extracts were observed. Similarly, gooseberry topped the FRAP score in Control extracts. On the other hand, lemon had the lowest FRAP among all fruits in both Control and enzymatic extracts. 1324.19 and 15 mg TE/100g was the FRAP of gooseberry and lemon in the control extracts. Further, 1.86 folds increase in gooseberry and 3.47 folds increase in lemon was observed on exposure to in vitro gastrointestinal digestion. In the RPA, gooseberry again scored the highest and lemon had the least reducing power. The difference noticed was 1.5 and 1.67 folds in gooseberry and lemon respectively. In contrast, Jamun scored highest ABTSRSA of all fruits when extracted by C and lemon remained the weakest radical scavenger among all fruits. Nevertheless, jamun lost radical scavenging activity after T3 extraction and banana topped the fruits in ABTS radical scavenging when the bioaccessible extracts were assessed. When the DPPHRSA was measured from fruits extracts, gooseberry was again the strongest radical scavenger in all extracts. Least radical scavenging ability was noticed consistently in lemon. These results improved by 2.62 and 2.17 folds in gooseberry and lemon respectively in the in vitro gastrointestinal digestion. Colocasia leaves had the highest phenolic content among all the vegetables and cluster beans had the least. In cluster beans, there was found an improvement as high as 9.29 folds and in colocasia leaves 2.47 folds more phenolics were discovered after in vitro gastrointestinal digestion. In the Control extracts, flavonoids were highest recovered from curry leaves among
all vegetables. On the contrary, cluster beans had had lowest flavonoids. These were increased by 2.8 folds and 5.8 folds when curry leaves and cluster beans were exposed to simulated digestion respectively. The flavonol content was found maximum in the coriander leaves. On the contrary, sponge gourd lacked flavonols in all its extracts. Flavonol content was enhanced by 3.38 folds after in vitro digestion of coriander. However, the mint leaves had the highest FRAP of all vegetables. Peas had the minimum FRAP. After T3, these values were enhanced by 2 folds in mint leaves and 2.4 folds in peas. Results of the reducing power of vegetables revealed that mint leaves had the strongest antioxidant capacity and peas had the lowest. In mint leaves extracts, rise of reducing power was observed up to 1.68 folds and in peas it was 4.26 folds after T3. In contrast, brinjal scored the highest ABTS radical scavenging ability and garlic scored the lowest in the control extracts. Upon enzymatic treatments, 166.5% rise was observed in brinjal samples and 18.32% rise was observed in garlic samples. Results of DPPHRSA revealed that green chillies were the strongest radical scavenger and peas were the weakest. Both samples showed a rise of almost 1.96 folds after in vitro gastrointestinal digestion.

Walnuts proved to be the richest source of total phenols when nuts and oilseeds were evaluated from the Control extracts. In contrast, coconut possessed the lowest phenolic content among all. 43.53% and 77.88% increase was revealed respectively in their T3 counterparts after in vitro digestion. The oilseeds were roasted whereas the nuts were assessed as such because they are seldom consumed so in Indian diet. Thus the bioaccessible form of groundnuts, sesame seeds and coconut is T4 and that of the nuts is T3. Flavonoids also were highest in walnuts and the lowest was discovered in coconut samples when extracted conventionally. These values increased by 21.93% and 80.7% in the T3 extracts. Consistently, walnuts were the richest source of the flavonols content also and coconut remained the poorest
flavonol source in the Control extracts. Walnuts gained 63.35% flavonols after T3 whereas 162.23% higher flavonol content was observed in coconut samples. The FRAP of nuts and oilseeds was dependent on the phenolics contents. Similarly, walnuts had the highest and coconut had the lowest FRAP in their control extracts. T3 extracts of these samples had 63.40% and 162.69% more FRAP than their Control counterparts. Results of RPA revealed that the walnut had the strongest antioxidant capacity among all samples. Almost similar rise as FRAP was noticed in the RPA (60.19% and 182.17% respectively in walnut and coconut) after the T3 extraction. ABTS radical scavenging ability was again found to be highest in walnut and lowest in coconut. The difference they shared with the enzymatic extracts was 139.86% and 196.12% respectively. The T3 extracts were found to have 46.91% and 288.2% better DPPH radical scavenging ability in these samples.

In lipid samples, mustard oil scored highest and ghee scored the lowest total phenol content. Unlike other food groups, lipids scored lower phenolic content in the enzymatic extracts (T3). The losses suffered by mustard oil and ghee were -83.9% and -66.6% after T3 extraction. The FRAP of lipids ranged from 2.24 to 29.5 mg TE/100g where mustard oil had the highest and ghee scored lowest FRAP as extracted by conventional method. Losses were noticed in FRAP of lipids after enzymatic treatment. Almost -84.56% and -97.77% lower FRAP was noticed in these samples respectively. In the RPA, rice bran-safflower blended oil had maximum reducing power whereas ghee again had the least. Upon enzymatic treatment, -19.6% and -30.27% lower RPA was observed in these samples respectively. ABTS radical scavenging ability was found to be highest in sesame oil whereas the lowest was found in ghee. However, the ability diminished when the samples were exposed to in vitro gastrointestinal digestion (T3). On the other hand, the results of DPPH RSA revealed that the strongest radical scavenger was mustard oil when extracted conventionally and ghee consistently proved to be the weakest lipid when the
antioxidant capacity was concerned. They lost the radical scavenging ability by almost -58.70% and -53.7% respectively on enzymatic extraction (T3). The NSS data on food consumption reveals that the population in urban areas of India consumes 1082.4 mg of polyphenols from cereals, 170 mg of polyphenols from legumes, and 9841 mg of phenolics from fruits and vegetables. Data for consumption of nuts and oilseeds was not surveyed by the NSS. However, lipids also provide negligible amounts as compared to these food groups (0.09 mg/day). Rural Indians have 1537.5 mg of phenolics from their cereal consumption, 156 mg of phenolics from legumes and 7120 mg of phenolics from fruits and vegetables in a day. Lipids provide as low as 0.07 mg of polyphenols in a day to the rural population of India.

6.1 HIGHLIGHTS

This study shows the wide variation in the antioxidant capacity between two different extracts of same food sample i.e. conventional and physiological extracts. It also reveals the variation between the antioxidant capacity of the raw and cooked extracts of the same food. 88 different foods of the traditional Indian diet were analysed. They were cereals, legumes, fruits, vegetables, nuts and oilseeds and lipids.

- In the cereal group, millets like finger millet and pearl millet possessed highest antioxidant capacity after cooking as well as digestion whereas rice had the lowest.
- Among the legumes, black gram and soya bean were the richest antioxidant sources but faba bean was the poorest.
- Gooseberry, guava, banana and sapota scored consistently high antioxidant capacity among all fruits whereas citrus fruits had the lowest antioxidant potential.
- In the vegetable group, leafy vegetables revealed to be the best source of antioxidants and gourds were the poorest.
Among nuts, walnuts scored maximum antioxidant capacity among all whereas coconut had minimum amount of antioxidant capacity.

Mustard oil and rice bran-safflower blended oil were the richest antioxidant source among lipids but ghee and coconut oil had the lowest.

6.2 RECOMMENDATIONS

From the results, it is recommended that the diet should include wide varieties of cereals, legumes, fruits, vegetables, nuts and oilseeds as well as variety of edible oils. Appropriate selection of food will make diet rich in antioxidant which will ultimately reduce the oxidative stress and thus occurrence of chronic diseases, if any.