5. SUMMARY AND CONCLUSION

The role of antioxidants in health and disease is well documented. Various factors like changing lifestyles and environment have led to great changes in the health profile of the human population. Higher stress level, sedentary lifestyle and deficient diets among the population have increased the onset of degenerative and non-communicable diseases like cancer, diabetes mellitus and cardiovascular disease. Increase in environmental pollution whether it is noise, dust, radiation or pollutants have directly or indirectly contributed to the aggravation and sometimes onset of the above mentioned diseases.

Free radicals are generated as a consequence of natural metabolism and aggravated by some of the above factors and recent focus is on quenching the free radicals when antioxidants come into play. Many compounds, especially, vitamins and minerals have been found to have antioxidant properties and recent focus is on phytochemicals present in foods as natural sources of antioxidants. Flavonoids, polyphenols, terpenoids and other compounds have been isolated from plant foods mainly from fruits and vegetables and have been proved to possess antioxidant properties. Since there are a wide range of compounds in a single food and more than the individual phytochemicals, it is the synergistic action of the compounds that benefit.

Hence the total antioxidant capacity of foods will be a useful measure to know the plasma antioxidant capacity of population. This has shifted focus on overall dietary pattern and dietary total antioxidant capacity in the preventive therapy. There are a wide variety of Indian foods indigenous to India and the data on the antioxidant capacity of these foods is scarce.

Moreover, food intake influences plasma antioxidant capacity and hence the influence of diet on plasma antioxidant capacity needs to be assessed. Considering the above facts the study entitled, “Dietary Flavonoid intake and its relation with plasma antioxidant capacity among the population of Vallabh
Vidyanagar - Semi Urban Population” was undertaken.

**Objective 1**

Commonly consumed Indian foods were selected and their total phenol, flavonoid and total antioxidant capacity were measured. The total phenolic content of food was estimated using the Folin ciocalteau method using gallic acid as the standard and the values were presented as mg of gallic Acid equivalents per 100g of fresh weight. Flavonoids were estimated as Rutin equivalents and total antioxidant capacity was measured by DPPH RSA using gallic acid as standard and the values were presented as gallic acid equivalents on fresh weight basis.

The influence of diet on plasma antioxidant capacity was analysed for which healthy adults, both men and women was measured as gallic acid equivalent on fresh weight basis. Age group between 18- 70 years and above were selected. Their dietary intake was assessed by food frequency questionnaire. Fasting blood samples were drawn and the plasma total antioxidant capacity was estimated by FRAP method.

Antioxidant capacity of the diet was calculated using the own dietary database of the total antioxidant capacity of selected foods whereas flavonoid content in the diet was calculated after determining the flavonoids in foods consumed by the participants. To the best of our knowledge, this is the first attempt made to estimate the antioxidant and flavonoid intakes in the general Indian adult population in a study.

Among cereals and cereal products the total phenolic content (TPC) was found to be ranging between 23.24 to 301.77 mg GAE/100g. Moriyo had minimum total phenol whereas Maize had maximum of it.

The flavonoid content in cereal and its products ranged from 1.54 to 14.67mg RE/100g. Moriyo had minimum flavonoid while Maize reported as the highest.
The DPPH RSA ranged between 163.87 to 218.37 mg GAE/100g. Lowest was observed in Wheat highest value was found in Rice Flakes.

The total phenols and flavonoid content as well as DPPH RSA of whole legumes and split legumes were also studied. TPC content of whole legumes ranged from 129.32 to 267.45 mg GAE/100g. The least total phenol content observed in Bengal Gram (chole) (129.32 mg GAE/100g) while highest value was observed in Black Gram (udad) (267.45mg GAE/100g). Flavonoid content of whole legumes was ranging from 21.12 to 105.24 mg RE/100g. Masoor (whole) had minimum flavonoid while Black Gram (udad) reported as the highest. DPPH RSA activity of legumes was found to be ranging between 66.70 to 263.38 mg GAE/ 100g. The least RSA was found in Green Gram whole and the highest RSA was found in Black Gram (udad).

Among the split legumes the total phenolic content (TPC) was found to be ranging between 111.64 to 188.68 mg GAE/100g. Green Gram dhal without husk had minimum TPC whereas Black Gram dhal with husk possessed maximum value. The total flavonoid content was ranging from 17.54 to 95.26 mg RE/100g. Bengal Gram dhal had minimum flavonoid while Black Gram reported as the highest value. DPPH RSA of spilt legumes ranged from 204.98 to 258.31 mg GAE/100g. The least DPPH RSA was found in Green Gram dhal with husk and higher DPPH RSA was found in Masoor.

The antioxidant profile of other vegetables showed that the total phenolic content was ranging between 63.44 to 275.37 mg GAE/100g. The highest levels of phenolic compounds were found in Brinjal (round) whereas Cauliflower had minimum TPC. Flavonoid content in vegetables ranged from 16.43 to 129.86 mg RE/100gm. Parwar had minimum flavonoid while Corn reported as highest. DPPH RSA was ranging between 19.4 to 136.4 mg GAE /100g. Lowest was in Cauliflower while highest was found in Green Peas.

The total phenol and flavonoid content as well as DPPH RSA of green leafy vegetables were also analysed. Total phenol content of green leafy vegetable
ranged from 100.00 to 665.81 mg GAE/100g. The least phenolic content was observed in Coriander leaves and highest content was observed in Colocasia leaves. Flavonoid content of green leafy vegetables ranged from 27.71 to 202.23 mg RE/100g. Again the least flavonoid content was observed in Coriander and highest in Colocasia leaves. DPPH RSA of green leafy vegetable ranged from 10.70 (Coriander leaves) to 136.53 mg GAE/100g (Amaranth leaves).

In the present study, total phenol content of studied roots and tubers were higher than green leafy vegetables in general. It ranged from 89.70 to 306.98 mg GAE/100g. The least phenolic content was seen in Turmeric (white) and highest TPC was seen in Turmeric (orange). The flavonoid content of roots and tubers ranged from 39.58 mg to 127.21 mg RE/100g. The flavonoid content of Turmeric (orange) was found to be the highest while Turmeric (white) contained the lowest flavonoid. DPPH RSA of roots and tubers ranged from 25.73 mg GAE/100g to 162.55 mg GAE/100g. The least DPPH RSA was found in Turmeric (white) and the highest DPPH RSA was found in Green Onion.

In nuts and oilseeds the total phenol was found to be ranging between 133.02 to 334.53 mg GAE/100g. Almonds had minimum total phenol whereas Cashews had the maximum. The flavonoid content was ranged from 13.57 to 21.06 mg RE/100g. Groundnuts had minimum flavonoid while Cashew showed the highest. The DPPH RSA was ranged between 113.35 to 159.65 mg GAE/100g. Lowest was in Ground Nuts and highest was observed in Cashew. The results indicated that among nuts and oilseeds Cashew had maximum amount of total phenol, flavonoid content and DPPH RSA.

Fruits were studied in three classes as citrus fruits, yellow and orange fruits and other fruits. The data reveals that the total phenol content of citrus fruits ranged between 107.29 to 141.72 mg GAE/100g. The least total phenol was detected in Pomegranate while the highest was detected in Guava. Flavonoid content of
citrus fruits ranged from 23.36 to 84.57 mg RE/100g. Minimum flavonoid content was found in Pomegranate and maximum was found in Lemon. DPPH RSA of citrus fruits ranged from 19.13 mg to 51.52 mg GAE/100g. The least DPPH RSA was seen in Lemon and the highest was seen in Guava.

Among the yellow and orange fruits studied the reported values for total phenol content of yellow orange fruits ranged from 131.25 to 314.84 mg GAE/100g. The highest TPC was detected in Jamboo and the least in Mango (Kesar). The flavonoid content of yellow orange fruits was ranging from 61.69 to 220.28 mg RE/100g. The flavonoid content of Jamboo was found to be the highest and Mango (Kesar) contained the lowest flavonoid content. DPPH RSA was ranging between 12.70 mg to 41.73 mg GAE/100g. Lowest was in Papaya and highest was observed in Mango (Desi).

Miscellaneous food commodities total phenol ranged between 93.41 and 378.57 mg GAE/100g. Total phenolic content was minimum was seen in sugar and maximum in Jaggery. Flavonoid content of miscellaneous foods was range from 4.56 to 74.13 mg RE/100g. The least flavonoid content was found in Sago and the highest was found in Jaggery. Total antioxidant capacity of miscellaneous foods ranged from 81.32 to 161.76 mg GAE/100g. The highest DPPH RSA was observed in Sago and the least was in Jaggery.

**Objective 2**

In the survey carried out, the subjects enrolled had a wide range of age ranging from 18 to 70 years and above who were divided in six different age groups as indicated in results. A Maximum of 857 (34.9%) respondents were from age group of 18 to 30 years. 704 (28.6%) were within the age group of 40 to 50 yrs. There were 1181 (48.0%) males and 1277 (52.0%) females. Out of a total 2458 number of respondents 1740 were married, 615 were single and 89 were widows/widower. In terms of their occupation; 823 (33.5%) number of respondents were housewives, 490 (19.9%) were professionals (government
and private), 413 (16.8%) were businessmen & 453 (18.4%) were students. A Maximum 964 (39.2%) respondents were graduates, 340 (13.8%) were Post graduates & 458 (18.6%) had completed their High School education. Out of a total of 2458 respondents, 2097 (85.3%) respondents lived in the nuclear family as per the current trend. The maximum of the respondents were found to be in the total monthly family income range of Rs.10000 to Rs.25000 i.e. 938 (38.2%) and 299 (12.2 %) respondents fell in the range of less than Rs.10000.

A fair amount of 573 (23.4 %) respondents were found to be in the highest income range of Rs.50000 and more.

BMI analysis was also carried out by taking height and weight of the subjects with the help of appropriate tools. 1509 (61.4%) respondents were found to be within normal BMI range and 477 (19.4%) were pre obese. 4% were found to be in obese category.

Looking in to the role of health in a person’s life and increasing trend of having life time diseases like blood pressure and diabetes, in our research in baseline survey we have also taken care of factors related to health. From the total population only 317 (13%) reported that they were suffering from Blood Pressure, 126 (5.1%) have been reported suffering from Type II diabetes whereas, 14 (0.6%) were having Type I diabetes and 2387 (97.1%) were reported to be normal.

Lifestyle factors like tobacco consumption, alcohol consumption, smoking and exercise were also taken into consideration. Only 99 (4%) respondents reported to have a habit of consuming tobacco from total sample of 2458 respondents. A small percentage (1.3%) 32 of respondents reported that they have a habit of smoking. Only 17 (0.7%) used to consume alcohol. Only 358 (14.6%) respondents used to exercise regularly.

Dietary history depicted that, 185 (7.5%) were non vegetarians & 139 (5.7%) were ovo vegetarians. As expected a majority of 2134 (86.8%) respondents were vegetarians.
With Chi-square ($\chi^2$) analysis, every socio economic factors were tested with BMI. The gender, marital status, occupation, education, type of family and income with corresponding P-values of 0.000, 0.000, 0.000, 0.051, 0.019 and 0.043 has shown a significant association (at 0.05 level) with BMI among studied population of Vallabh Vidyanagar. Among the age of 40-50 years many respondents (23%) were having overweight and obesity was seen in 5% of the respondents in the age group of 18-30years.

From ANOVA results it was found that there was a statistically significant difference in the BMI among different age groups (F=3.630, P=0.003) at 0.05 level. Highest average BMI was found in the age group of 70 years and above.

In gender among males, large number of males (N= 731) fall under normal BMI. In comparison to females (N=215), male respondents (N=262, which accounts to 22% of males) fall in pre obese range. This could be due to sedentary lifestyle of males.

ANOVA test indicated that there was a statistically significant difference in the mean values of BMI of two genders (F= 17.188, P= 0.000) at 0.05 level.

The different categories of occupation have also shown a significant (P=0.000) association with BMI. Among the different categories (student, professional, business, housewife, others) of occupation, most of them had normal BMI. The BMI of quite a few professionals (N=114, which was 24% of the respondents) was in the pre obese category.

ANOVA also indicates that there was a significant difference between various categories of occupation and BMI (F=10.044, P=0.000) at 0.05 level, with highest average BMI was found in the students.

Different levels of education (elementary, high school, diploma, graduate, post graduate, Ph.D.) had shown significant (P=0.05) association with BMI at 0.05 level. Highest number of population fall in graduate group (N=964) in
education. Interestingly it was found that 200 out of a total of 964 graduates were in pre obese category.

According to ANOVA results a statistically significant difference was found in the mean values of their BMI among subject with different categories of education (F=10.044, P=0.000) at 0.05 level. It was clearly seen that as education level goes up the average BMI also went up.

There was no significant difference between various income group respondents in terms of their average BMI. Type of family showed significance (P=0.019) with BMI at 0.05 level. This can be due to lifestyle changes and more of income as there is less number of family members.

Results reveal the association of health factors like blood pressure, diabetes and other disease with BMI. Chi square results indicated that there was no significance of blood pressure and diabetes with BMI, however other diseases showed a significance (P= 0.000) with BMI at 0.05 level.

ANOVA also validated the same results that there was no significant difference in BMI of people with normal blood pressure and blood pressure related problems as well as diabetic and non-diabetic respondents. For other diseases it showed significant difference in BMI (F= 3.009, P=0.006) at 0.05 level.

Association of lifestyle factors with BMI shows the association between other factors like tobacco consumption, smoking, alcohol consumption and exercise with BMI. Alcohol showed significant association (P=0.016) with BMI at 0.05 level. No other factors showed any significance with BMI. While comparing means it was found that respondents with a habit of consuming alcohol had higher BMI as compared to other people.

Association of dietary factors with BMI, we have observed that, type of diet did not show any significant association with BMI. However while comparing means of BMI; it was found that non vegetarian respondents had higher BMI compared to vegetarian and ovo vegetarian respondents.
Impact of various sociodemographic factors on total phenol, flavonoid and dietary antioxidant intake (DPPH RSA) showed statistically significant differences between different age group mean values as determined by one-way ANOVA for total phenol (F=4.351, P=0.001), flavonoid (F=8.622, P=0.000) and dietary antioxidant (DPPH RSA) intake (F=7.266, P=0.000) at 0.05 level.

ANOVA did not show any statistically significant differences in the mean values of total phenol, flavonoid and dietary antioxidant intake (DPPH RSA) between different gender, marital status, education level, type of family and family income groups. Total polyphenol intake was influenced by gender with a higher intake of polyphenols in men than in women.

For various BMI range groups no significant difference was found in the mean values of total phenol and dietary antioxidant (DPPH RSA) intake. However, it was found that there was a statistically significant difference in the mean values of flavonoid (F=3.699, P=0.011) among various BMI ranges at 0.05 level.

For various health related groups like Blood Pressure, diabetes and other diseases, it was found that there was no statistically significant difference in the mean values of total phenol, flavonoid and dietary antioxidant (DPPH RSA) intake. However for diabetes related groups little significant difference was found for the mean values of flavonoid (F=2.951, P=0.052).

It can be noted that, between a group of people consuming alcohol and not consuming alcohol there was a statistically significant difference in the mean values of dietary antioxidant intake (DPPH RSA) (F= 4.284, P=0.039) at 0.05 level. Respondents consuming alcohol were found with lower dietary antioxidant intake (DPPH RSA) as compared to the other people. Alcohol group did not show any significant difference in the mean values of total phenol and flavonoid. For rest of the factors like tobacco, smoking and exercise groups there was no significant difference in the mean values of total phenol, flavonoid and dietary antioxidant (DPPH RSA) intake.
Dietary factors had some impact on total phenol, flavonoid and dietary antioxidant (DPPH RSA) intake. There were statistically significant differences between vegetarian, non vegetarian and ova vegetarian group of respondents determined by one-way ANOVA in the mean values of total phenol ($F=5.097$, $P=0.006$) and dietary antioxidant (DPPH RSA) intake ($F=8.024$, $P=0.000$) at 0.05 level. The results were evident of the fact that total phenol and dietary antioxidant (DPPH RSA) intake were significantly found to be in the ascending orders from vegetarian to non vegetarian followed by ovo-vegetarian diet. ANOVA did not show statistically significant difference in the flavonoid means.

The correlation of sociodemographic factors (age, gender, marital status, occupation, level of education, type of family, family income and BMI) with total phenol content, flavonoid content, dietary antioxidant intake (DPPH RSA).

With help of correlation analysis it was found that age had shown negative correlation with total phenol, flavonoid and dietary antioxidant intake (DPPS RSA) of foods with $r= -0.088$, $P=0.000$; $r= -0.123$, $P=0.000$ and $r= -0.114$, $P=0.000$ respectively at 0.01 level.

Total family income had shown a significant positive correlation with total phenol intake ($r=0.054$, $P=0.007$) at 90% confidence level. Total family income also showed a significant positive correlation with flavonoid intake ($r=0.40$, $P=0.047$) at 95% confidence level. However it did not show specific correlation with dietary antioxidant intake (DPPH RSA). The interpretation of positive correlation indicated that, with higher income group people, possibly with proper dietary intake might have contributed to higher total phenol and flavonoid.

The correlation of health factors like blood pressure, diabetes and other diseases with total phenol, flavonoid and dietary antioxidant intake (DPPH RSA). From the analysed data it is observed that there was no significant
correlation of blood pressure, diabetes and other disease with total phenol, flavonoid and dietary antioxidant intake (DPPH RSA).

Consumption of tobacco and habit of smoking did not show correlation with the total phenol, flavonoid and dietary antioxidant intake (DPPH RSA). Consumption of alcohol also did not show significant correlation with total phenol, flavonoid. However it was found that there was a correlation of alcohol with dietary antioxidant intake (DPPH RSA) \((r=0.042, P=0.039)\). Exercise did not show any significant correlation with the three parameters.

Correlation with dietary habits like vegetarian, non-vegetarian and ova vegetarian showed significant correlation at 90% confidence level with total phenol \((r=0.063, P=0.002)\) and dietary antioxidant intake (DPPH RSA) \((r=0.080, P=0.000)\). It did not show significant correlation with flavonoid though.

Correlation analysis was carried out to between intakes of foods according to different food groups and total phenol, flavonoid and dietary antioxidant intake (DPPH RSA). Cereal intake had shown a significant correlation with total phenol \((r=0.245, P=0.000)\) and DPPH RSA \((r=0.314, P=0.000)\) of foods at 90% confidence level. Cereals intake did not show a significant correlation with flavonoid intake of respondents.

Pulse intake had a significant correlation with total phenol \((r=0.170, P=0.000)\), flavonoid \((r=0.120, P=0.000)\) and dietary antioxidant (DPPH RSA) \((r=0.229, P=0.000)\) at 0.01 level. Vegetables intake had shown a significant correlation with total phenol \((r=0.301, P=0.000)\), flavonoid \((r=0.186, P=0.000)\) and dietary antioxidant (DPPH RSA) \((r=0.397, P=0.000)\) at 0.01 level. Fruits intake had also shown a significant correlation with total phenol \((r=0.366, P=0.000)\), flavonoid \((r=0.230, P=0.000)\) and DPPH RSA \((r=0.237, P=0.000)\) at 0.01 level.
Nuts and oilseeds intake had a significant correlation with total phenol ($r=0.651$, $P=0.000$), flavonoid ($r=0.839$, $P=0.000$) and DPPH RSA ($r=0.295$, $P=0.000$) at 0.01 level.

**Objective 3**

To analyse the impact of sociodemographic factors with plasma total antioxidant capacity ANOVA was performed. There were no significant differences between means of plasma total antioxidant capacity among various age groups. For different gender, marital status, occupation, income and BMI groups, it was found that there was no statistically significant difference in the mean value of plasma total antioxidant capacity. ANOVA further resulted in to statistically significant difference in the mean values of plasma total antioxidant capacity for different types of families. It was seen very clearly that mean value of plasma total antioxidant capacity of the respondents belonging to nuclear family (10.58±2.43) was higher than that of respondents from joint family (10.22±2.61).

It was also inferred with the results of ANOVA that there were no statistically significant differences in the mean values of plasma total antioxidant capacity among various groups like respondents with normal and high blood pressure; with the two types of diabetes and respondents without diabetes and among the other diseases.

The results of ANOVA for impact of various lifestyle factors on plasma total antioxidant capacity reveals that there were statistically significant differences in the mean values of plasma total antioxidant capacity of respondents consuming alcohol and the others who are not consuming it ($F=4.499$, $P=0.034$ at 0.05 level). No significant difference was found in the mean values of plasma total antioxidant capacity among respondents with and without a habit of tobacco consumption. The same result was obtained for the two groups with or without a habit of smoking. A statistically significant difference was found in the mean values of plasma total antioxidant capacity of respondents who
exercise and who did not (F=12.336, P=0.000 at 0.05 level). The mean of plasma total antioxidant capacity of respondents who exercise (11.06±2.46) was found to be higher than the ones who did not exercise (10.45±2.45).

In the present study it was found that there was no statistically significant difference in the mean values of plasma total antioxidant capacity of respondents falling in to vegetarian, non-vegetarian and ovo-vegetarian dietary groups.

Pearson correlation analysis between sociodemographic factors and plasma total antioxidant capacity depicted that age, gender, marital status, occupation, income and BMI did not show any significant correlation with plasma total antioxidant capacity.

Level of education and type of family showed positive correlation with plasma total antioxidant capacity (r=0.052, P=0.028) and (r=0.052, P=0.025) at 0.05 level. With these results it can be interpreted that with increase in education the plasma total antioxidant capacity also showed improvement.

With Pearson correlation analysis it was found that there was no significant correlation of the health factors namely blood pressure, diabetes and other diseases with plasma total antioxidant capacity. Still with negative r values it can be inferred that respondents with blood pressure and diabetes had lower plasma antioxidant capacity than normal subjects.

Correlation between lifestyle factors and plasma total antioxidant capacity showed that there was no significant correlation of tobacco and smoking with plasma total antioxidant capacity. Correlation of alcohol and plasma total antioxidant capacity was negative (r=-.050, P=0.034) at 0.05 level. Even correlation of exercise with plasma total antioxidant capacity was significant (r=-0.082, P=0.000) at 0.01 level.

Vegetarian, non-vegetarian and ovo-vegetarian type of dietary patterns did not show any significant correlation with plasma total antioxidant capacity.
Correlation analysis was carried out to between intakes of foods according to different food groups and plasma antioxidant capacity. It was found that pulses, fruits and nuts had a positive correlation with plasma total antioxidant capacity while cereals and vegetables intake did not show statistically significant correlation with plasma total antioxidant capacity.

Pulses intake had a statistically significant correlation with plasma total antioxidant capacity \( r=0.047, P=0.043 \) at 95% confidence level.

Fruits as well as nuts & oilseeds showed a significant correlation with plasma total antioxidant capacity \( r=0.105, P=0.000 \); \( r=0.324, P=0.000 \) at 90% confidence level.

Pearson correlation analysis was carried out for finding out relationship between total phenol, flavonoid and DPPH RSA intakes with plasma antioxidant activity. There was a statistically significant correlation of total phenol intake with plasma total antioxidant capacity \( r=0.342, P=0.000 \) at 0.01 level. Flavonoid intake also showed a strong and significant correlation with plasma total antioxidant capacity \( r=0.386, P=0.000 \) at 0.01 level. It was found that dietary antioxidant intake (DPPH RSA) showed a significant correlation with plasma total antioxidant capacity \( r=0.211, P=0.000 \) at 0.01 level.

Further regression analysis was also carried out to establish the strength of relationship of total phenol, flavonoid and dietary antioxidant intake (DPPH RSA) with plasma total antioxidant capacity. With \( r^2 \) values of 0.1172, 0.1489 and 0.0446 it was concluded that there was a moderate relationship between them.

In conclusion, from present research foods commonly consumed in India, especially, vegetables and nuts have high antioxidant capacity. In earlier studies of dietary antioxidant intake, it has been difficult to differentiate between increased intake of fruits and vegetables and antioxidant intake because an increase in fruits and vegetables consumption is associated with
increased antioxidant intake and also with increased plasma antioxidant capacity. The need for increased vegetable consumption has been known and recommended for many years. Increased fruits and vegetable consumption has also been associated with reduced risk of mortality in men (Rissanen et al., 2003). The dietary total antioxidant intake (DPPH RSA) influences the plasma total antioxidant capacity and hence inclusion of foods rich in total antioxidant capacity will improve the plasma total antioxidant capacity. Total antioxidant capacity has been associated with reducing risk for various diseases. Consumption with antioxidant rich foods can reverse oxidative stress resulting from antioxidant consumption of an antioxidant free meal (Ronald et al., 2013). Values of the total phenols, flavonoid and the total antioxidant (DPPH RSA) intake of foods will be useful in choosing antioxidant rich foods. Furthermore, from the present study, we would have better estimates of the quantities of antioxidants we may need in our diet. However, further in-depth research validating the association between the above variables and gender differences in plasma total antioxidant capacity needs to be done to strengthen the results.