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Wavelet and Statistical Analysis of Milk Products, Fruits and Vegetables Intake in India

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Abstract: *Milk products, fruits and vegetables intake are the main components of a healthy diet and have vitamins, proteins, minerals, fats and many more which help in fulfillment of daily energy need and protection from many diseases and disorders. Milk products, fruits and vegetables intake index decide the true development of any country, because healthy people can live happy and longer life and can play inportant role in the development of society and country. Wavelet transforms is a powerful and efficient tool which captures the localized time frequency information of the signal and suitable for analysing non-stationary and transient signals. The approximation represents average behaviour or trend of the signal, while detail represents differential behaviour of the signal corresponding to each level of decomposition. Milk products, fruits and vegetables data of India from Jan. 2013 to Aug. 2021 are taken as raw data. Wavelet transforms of this data is performed by software dyadwaves using Haar wavelet, decomposition level-5. Approximation is the slowest part of data and corresponds to the maximum scale value describes the trend of the signal. The statistical analysis of given data is also performed through skewness, kurtosis, standard deviation and correlation coefficients. The wavelet analytical results are strongly consistent with statistical analytical results of the milk products, fruits and vegetables intake.*

Keywords: Approximation, detail, milk, fruits, vegetables, wavelet transforms

I. INTRODUCTION

Health is a state of fitness and harmony of one's body, mind and spirit. It is also a parameter which decides development of any country. For a good health proper diet is required for a person [1]. Milk products also known as lacticinia, fruits and vegetables are the main components of proper diet. Milk products are source of vitamin A, D, K & E, proteins, calcium, riboflavin, phosphorous, magnesium, iodine, minerals and fats. Fruits contain vitamins, volatiles, sugars, amino acids, organic acids, ascorbic acid, minerals, carotenoids, fibres, polyphenols, anthocyanins, flavonoids, triterpenes and other nutrients [2-3]. Vegetables contain dietary fibres, proteins, vitamins and other nutrients. Milk has antibacterial, antiviral and antimicrobial properties [4]. Main structural component of the bone is protein, which helps in air growth and muscle growth. Milk products also have calcium which is essential for bone health. The low intake of milk products causes greater risk of hair fall, fractures, and osteoporosis. The protein of milk products helps in calcium absorption to improve bone mineral density and bone health. Milk products intake plays an important role to improve insulin sensitivity and blood-glucose regulation. Milk products, Fruits and vegetables are universally promoted for good health of a person. The Dietary Guidelines recommend that more than one-half of your plate should be occupied with milk fruits, fruits and vegetables. Fruits and vegetables provide dietary fibres which is responsible for lower incidence of cardiovascular disease and obesity. Fruits and vegetables are good source of vitamins and minerals that work as antioxidants, anti-inflammatory and phytoestrogens agents [5-6]. At the time of independence, the milk products, fruits and vegetable consumption index of India was very poor, but along with time Indian government have been working in this direction so that there is an appreciable increment is being observed regularly. The credit of growth in milk products, fruits and vegetable consumption goes to agricultural and technological revolution in India and also to the sincere efforts of Indian government [7].

Fourier transforms have been an important tool for long period to analyse finite, single valued and stationary signals. In fourier transforms, any signal is considered as equivalent of infinite sinusoidal components having frequencies integral multiple to a single one. Wavelet transforms have advantage over fourier transforms for analysing non-stationary and transient signals because fourier transforms are only frequency localised while wavelet transforms have an additional time localisation property with frequency localisation [8]. The wavelets are translated and dilated version of a finite length or fast decaying oscillating waveform, known as the mother wavelet. Therefore, the wavelet transforms are now widely being applied in many areas of Physics, Mathematics and Engineering. It is also being used in signal and image processing, climatology, human sexual response analysis, computer graphics, multifractal analysis and sparse coding [9-10]. In this paper, the milk products, fruits and vegetables intake data are spectrally analysed using Haar wavelet transforms and the results are discussed and compared with statistical results.

II. BASICS OF WAVELET TRANSFORMS

A wavelet refers to small waves for short time interval that can be dilated and translated.

Fig. 1. A wavelet

A wavelet function is defined as follows: -

$$\psi_{a,b}(x) = \frac{1}{\sqrt{a}}\psi\left(\frac{x-b}{a}\right) = T_b D_a$$

where a and b are two real numbers. If we select $a = 2^{-j}$ and $\frac{b}{a} = k$, a discrete wavelet is obtained as follows [11] -

$$\psi_{j,k}(x) = 2^{j/2}\psi(2^j x - k)$$

A multi resolution analysis (MRA) consists of a sequence $V_j: j \in \mathbb{Z}$ of closed subspaces of a space of square integrable function $L^2(\mathbb{R})$, satisfying the following properties [12-15]: -

1) $V_{j+1} \subset V_j : j \in \mathbb{Z}$
2) $\cap_{j\in\mathbb{Z}} V_j = \{0\}, \ \cup_{j\in\mathbb{Z}} = L^2(\mathbb{R})$
3) For every $L^2(\mathbb{R}), f(x) \in V_j \Rightarrow f(2x) \in V_{j+1}, \ \forall j \in \mathbb{Z}$
4) If $\phi(x) \in V_0$, then $\{\phi(x-k): k \in \mathbb{Z}\}$ is orthonormal basis of V_0.

Above properties imply a dilation equation as follows: -

$$\phi(x) = \sum_{k\in\mathbb{Z}} h_k \, \phi(2x-k)$$

where h_k is low pass filter and defined as follows: -

$$h_k = \left(\frac{1}{\sqrt{2}}\right)\int_{-\infty}^{\infty} \phi(x)\phi(2x-k)dx$$

And wavelet function,

$$\psi(x) = \sum_{k\in\mathbb{Z}} g_k \, \phi(2x-k)$$

where g_k is high pass filter and defined as follows: -

$$\beta_k = \left(\frac{1}{\sqrt{2}}\right)\int_{-\infty}^{\infty} \psi(x)\phi(2x-k)dx$$

Any space V_0 can be orthogonally decomposed in V_1 and W_1 subspaces and mathematically written as: -

$$V_0 = V_1 \oplus W_1$$

Similarly, we can write,

$$V_1 = V_2 \oplus W_2$$

In general,

$$V_j = V_{j+1} \oplus W_{j+1}$$

But,

$$V_{j+1} = V_{j+2} \oplus W_{j+2}$$

Therefore

$$V_j = W_{j+1} \oplus W_{j+2} \oplus V_{j+2}$$

$$V_j = W_{j+1} \oplus W_{j+2} \oplus W_{j+3} \oplus \ldots\ldots\ldots\ldots W_{j_0} \oplus V_{j_0}$$

III. RESEARCH METHODOLOGY

Any discrete signal or data f[n] can be described in space of square summable sequences $\ell^2(\mathbb{Z})$ as follows [16]: -

$$f[n] = \frac{1}{\sqrt{M}}\sum_k a[j+p,k]\phi_{j+p,k}[n] + \frac{1}{\sqrt{M}}\sum_{p=1}^{\infty}\sum_k d[j+p,k]\psi_{j+p,k}[n]$$

Here the discrete functions f[n], $\phi_{j+p,k}[n]$ and $\psi_{j+p,k}[n]$ are defined in interval $[0, M-1]$, totally M points. Here the sets $\{\phi_{j+p,k}[n]\}_{k\epsilon\mathbb{Z}}$ and $\{\psi_{j+p,k}[n]\}_{k\epsilon\mathbb{Z},p\epsilon\mathbb{Z}^+}$ are orthogonal to each other. The scaling and wavelet coefficients can be obtained by taking the inner product as follows: -

$$a[j+p,k] = \frac{1}{\sqrt{M}}\sum_n f[n]\,\phi_{j+p,k}[n]$$

$$d[j+p,k] = \frac{1}{\sqrt{M}}\sum_n f[n]\,\psi_{j+p,k}[n]$$

where $a[j+p,k]$ and $d[j+p,k]$ are called approximation and detail coefficients respectively. With help of low pass and high pass filters any data or signal is decomposed into approximation and detail coefficients respectively. The vector x is convolved with a low pass filter h for approximation and with a high pass filter g for detail. The coefficients at level $j+1$ are calculated from the coefficients at level j by dyadic decomposition called down sampling and denoted as 2 (Figure 2).

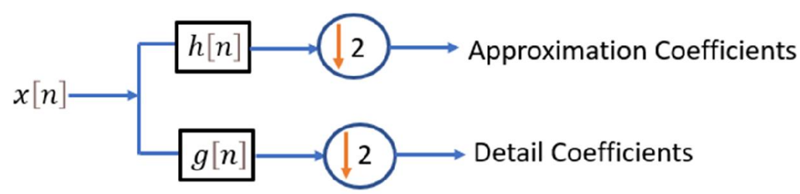

Fig. 2. Signal decomposition into approximation and detail coefficients at level 1

Proceeding with the same manner, approximation is again decomposed into approximation and detail coefficients of the next level (Figure 3) [17].

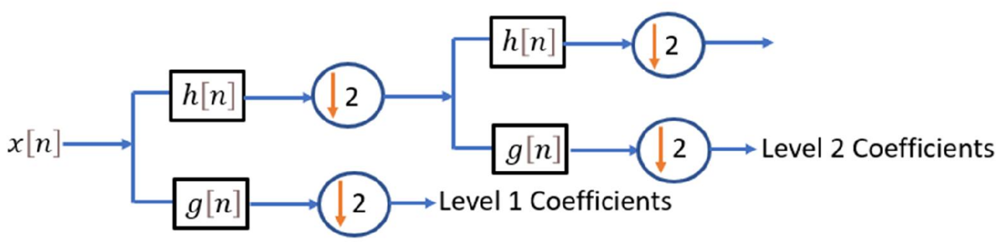

Fig. 3. Signal decomposition into approximation and detail coefficients up to level 2

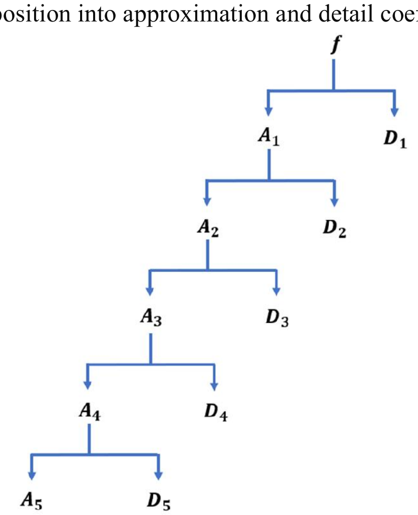

Fig. 4. Signal decomposition into approximation and details up to level 5

For the first level of decomposition, the data (function f) is expressed as follows [18]: -

$$f(1) = A_1 + D_1$$

For the second level of decomposition,

$$f(2) = A_2 + D_2 + D_1$$

Similarly,

$$f(3) = A_3 + D_3 + D_2 + D_1$$
$$f(4) = A_4 + D_4 + D_3 + D_2 + D_1$$
$$f(5) = A_5 + D_5 + D_4 + D_3 + D_2 + D_1$$

The milk products, fruits and vegetables index of India from Jan. 2013 to Aug. 2021 are takes as raw data. Wavelet transform is performed to analyse this data by using software dyadwaves. First of all, the best suitable wavelet is selected for this data, that is Haar wavelet. Using this Haar wavelet the data is transformed up to decomposition level 5. In this way an approximation corresponding to decomposition level 5 and five details corresponding to each decomposition levels are obtained. The approximation represents average behaviour or trend of the data while details represent differential behaviour or fluctuation in data corresponding to each decomposition level.

Skewness is a measure of lack of symmetry while Kurtosis is a measure of whether the data are flatness relative to a normal distribution [19]. Negative value of skewness indicates that the data is skewed to the left and positive value indicates that data is skewed to the right. Negative value of kurtosis indicates that the outlier character of given data is less extreme that expected from a normal distribution. Positive value of kurtosis indicates that the outlier character of given data is more extreme than expected from a normal distribution. Zero value of kurtosis indicates that the outlier character of given data is similar to what is expected from a normal distribution. Standard deviation indicates that how much the data points are spread out over a wider range of values. High value of standard deviation indicates highly spreading data from mean value. Correlation represents the degree of linear relationship between two data, functions, or signals. The positive value of correlation means they are linearly related with positive slope and medium value means that they are moderately related.

IV. RESULTS AND DISCUSSION

The milk products, fruits and vegetables index of India from January 2013 to August 2021 imported from website data.gov.in are taken as raw data or original signal. For detailed investigation of milk products, fruits and vegetables intake, the wavelet transforms of given data is performed using Haar wavelet up to decomposition level-5 by software dyadwaves and shown in Figure 5, 6 and 7 respectively.

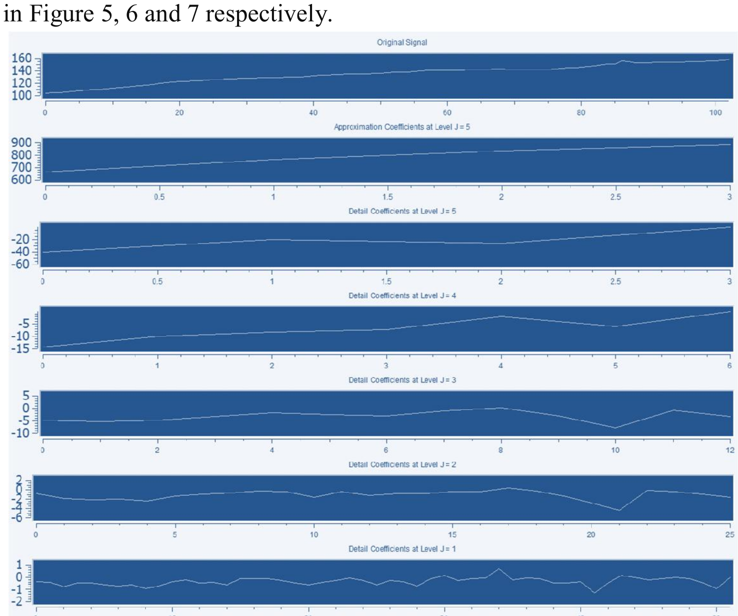

Fig. 5. Wavelet decomposition of Milk products from Jan. 2013 to Aug. 2021

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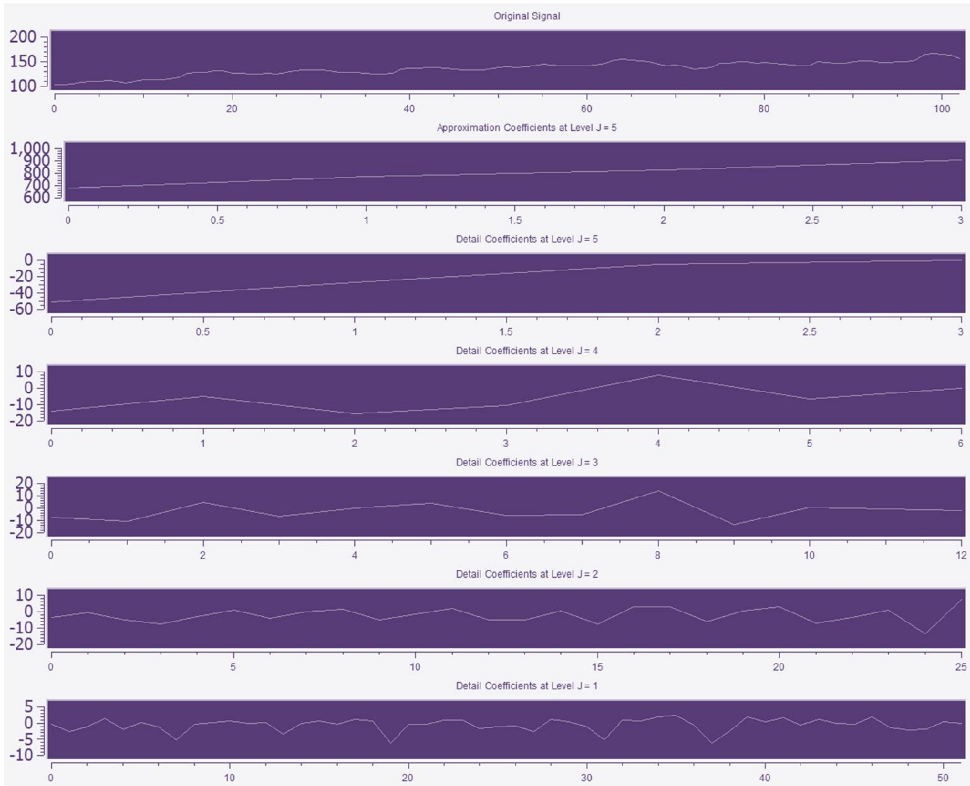

Fig. 6. wavelet decomposition of Fruits from Jan. 2013 to Aug. 2021

Fig. 7. Wavelet decomposition of Vegetables from Jan. 2013 to Aug. 2021

By discrete wavelet transforms, any original signal is decomposed into approximation and detail coefficients. Approximation represents average behaviour or trend of the signal, which represents the slowest part of a signal. In wavelet analysis term, it corresponds to the greatest scale value. As the scale increases, resolution decreases, producing a better estimate of unknown data. The detail represents the differential behaviour of the signal, which shows fluctuations or changes corresponding to each decomposition level. The approximation of milk products and fruits intake data reveals its continuous growth in India from Jan. 2013 to Aug. 2021, while the approximation of vegetables intake data reveals overall growth with decreasing trend in the same years. The details of milk products, fruits and vegetables intake for the same tenure reveals the fluctuations in time to time.

Table 1: Statistical Parameters

S.No.	Statistical Parameter	Milk products	Fruits	Vegetables
1	Skewness	-0.39707	-0.40446	0.78632
2	Kurtosis	-0.66795	-0.19574	1.328746
3	Standard deviation	14.46356	14.32287	24.99682
4	Correlation	0.944862 (MF)	0.47393 (FV)	0.544752 (MV)

Negative value of skewness for milk products and fruits intake indicates that the given data is skewed to the left, while positive value for vegetables indicates that given data is skewed to the right. Negative value of kurtosis for vegetables indicates that the outlier character of given data is less extreme that expected from a normal distribution. Positive value of kurtosis for vegetables indicates that the outlier character of given data is more extreme than expected from a normal distribution. High positive value of standard deviation for all milk products, fruits and vegetables intake indicates that the data points are highly spread out over a wider range of values from mean value. The high positive value of correlation between milk products and fruits means they are linearly related with positive slope, while medium positive value for milk products & vegetables and fruits & vegetables means that they are moderately related with positive slope.

V. CONCLUSION

The approximation obtained by wavelet transforms represents average behaviour of milk products and fruits intake in India from Jan. 2013 to Nov. 2021 shows continuous increasing trend, while vegetable intake shows overall growth with decreasing trend in recent years, while the details reveal the fluctuations in data corresponding to each decomposition level. The spectral analytical results using Haar wavelet transforms provide strong consistency with the statistical analytical results. By virtue of these results, we can say that spectral analysis using wavelet transforms provides a simple and accurate framework to investigate the milk products, fruits and vegetables intake in India.

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