EXAMINING THE DEMAND FOR VEGETABLES IN PAKISTAN: EVIDENCE FROM LINEAR APPROXIMATE ALMOST IDEAL DEMAND SYSTEM

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ABSTRACT

In agricultural economics, food demand is given top priority as food helps meet individuals' basic needs to sustain life. Therefore, it is of paramount importance to understand consumer behavior regarding the food demand. In this paper, we estimate own price, cross price and expenditure elasticity's of vegetables consumption in Pakistan because of their importance in daily nutrition intake of this country. To achieve the above objective, we apply linear approximate almost ideal demand system (LA-AIDS) model and latest available data from the Household Integrated Economic Survey (HIES) of Pakistan for the period 2018-19 is utilized. Total sample size in the data is 24809 households based on 1802 rural and urban primary sampling units (PSUs). The result reveals that the uncompensated and compensated own price elasticity's for all vegetables are negative and less than unity for overall Pakistan and hence categorized as necessities. The uncompensated cross price elasticity of demand for vegetables having positive sign indicates that these are substitutes while other commodities having negative sign exhibits complementary for overall Pakistan. The compensated cross price elasticity of vegetables in overall Pakistan as well as rural and urban regions have positive signs indicating that these are substitutes. Expenditure elasticity's of vegetables in Pakistan are positive revealing that these are regarded as normal goods. As all the estimated own price elasticity's of vegetables are inelastic in nature so any change in the prices will result in huge expenditures on vegetables by the consumers. Therefore, price stabilization policies need to be devised to safeguard the food insecure segments

of the society. Government also needs to provide income earing opportunities for enhancing the purchasing power of consumers to afford the required quantity and better quality of vegetables.

Keywords: *Vegetables, Marshallian, Hessian, Expenditure Elasticity's, LA/AIDS, Pakistan.*

INTRODUCTION

Food is scientifically and biologically proved to be a crucial component for a human body (Rehman et al., 2022: Mehmood et al., 2022). It is required for daily performance by the human body and necessary for the development and growth. The world has gone through many stages like the old era of down sized and old technology towards new technology and the industrial era to provide food and services. A sufficient amount of food is required daily for existence and act by the body (Taran et al., 2022: Khan et al., 2022). The quality, quantity and nature of the food has changed over the time period but yet still many are unable to get access to it. The deficiency of food and nutrition results in ill health and less productivity capability with an increase of medical expenses, thus harming the overall national growth (Mehmood et al., 2021). Therefore, it is important for the governments and policymakers in the developing countries to concentrate on the food consumption habits of their citizens (Ayub et al., 2021).

Making different choices for food is very complex which are determined by different factors i.e. Social, cultural and economic variables. The income of the family and prices of food commodities play a vital role in it (Shah *et al*., 2021). The economic aspects seemed to have a critical effect on the intake of fruits and vegetables (Shahzad et al., 2021). Many studies have revealed that diets having much amount of fruits and vegetables are more luxurious than diets that had less amount of fruits and vegetables (Ayub *et al*., 2020: Khan et al., 2020). Economic restrictions which are mostly confronted by the low income earning people favor diets which are more energy dense and have less ingestion of fruits and vegetables because of the higher rate of handled sugars, oils, fats and processed cereals (Mehmood *et al*., 2020; Mehmood *et al*., 2018).

Majority of malnourished people (780 out of 795 million) live in the developing countries. Growth and expansion of a country is concerned with the consumption patterns in such a manner that it deals with the wellbeing for those that are making purchase of various consuming heads (World Bank, 2005 and FAO, 2015). Pakistan is also facing a similar problem of malnutrition. It is the 5th most populous country, having the 9th largest labor force in the entire world and has an annual population growth rate of 1.80 percent. The probable population in 2020 is 215.25 million [Government of Pakistan (GoP), 2020]. Over the last several decades, the agricultural sector of Pakistan has undergone through substantial changes. For example, forms of land usage, utilization of inputs, cropping system, the system of marketing and also the financial system closely related with agriculture have changed in significant ways. Changes in the technology of agriculture like the wide spread use of high yielding crop varieties has raised many problems in the environment such as decreasing the water table and soil productivity (Jalil and Khan, 2018). Since the beginning of independence, Pakistan has seen provincially unstable economic growth and this unstable economic growth has noteworthy effect on the current consumption patterns. Pakistan has accomplished noteworthy development either by importing edible food products or by the resident production. Yet still the problem of food shortage is faced by the country and still unable to provide food for its population (FAO, 2011).

In this country, there are still continued differences in consumption among the income groups in rural and urban areas. Out of the total expenditure, the major expenditure is of food which is 80.42%. However, there has been a decrease in the total expenditures for both the rural and urban areas, 45.01% in 2011-12 and 43.63% in 2013-2014. The main portion of food consumption expenditure is on vegetables, sugar, vegetable ghee, milk and wheat having a share of 54.75% out of 80.42%. The poorest spend a large amount (65.63%) of their total expenditure on milk, vegetable ghee, wheat, sugar and vegetables when compared to the rich which spend 58.54% on fruits, mutton, vegetables, wheat, milk, beef and sugar etc. showing that all possess dissimilar preferences for food consumption expenditures when compared with others (GoP, 2015).

For analysis of food consumption, empirical studies mostly use household survey data. The prices almost remain the same as dissimilar households face similar market circumstances throughout the survey time period (Islam and Siwar, 2005). Certain policies are made by the government regarding the production and consumption choices like that of declaring subsidy, imposing taxes and fixing the production targets. These governmental policies have a great impact on consumers, producers and traders as well, though diverse stakeholder's respond differently to such decisions (Chaudhary, *et al*., 1999). For Pakistan, the issue is very topical.

The empirical research on the consumption patterns of food gives clear indication for the consumer's responsiveness towards change in price and expenditure which is very beneficial for designing food policies for a country. Estimating the prices and also income elasticities of different food groups would be helpful in setting directed prices and also in designing subsidy and tax policies (Haq *et al.*, 2008). The elasticities of demand for a certain country provides treasured evidence for the policy analysts to understand the growth patterns of the national food consumption. Elasticities of a certain country are prejudiced by the income level achieved and also by the quantities of food consumption which is done by the consumers. It is very important that the complete demand elasticities are estimated because they are very much beneficial to obtain the price elasticities and also for getting consistent estimations of income (expenditures) elasticities.

Because of the importance of determining food consumption patterns, many researchers have used a variety of econometric methods on different types of data to understand the association between income of the consumer and food consumption patterns in different countries (Deaton and Muelbauer, 1980a and Kakhki, *et al.* 2010). A single equation model was used in most of the research which is not only unfitting and unreliable but also lacking the benefit of system approach (Barten, 1977). In order to prevent inappropriateness and irregularity, many economists had developed and used method of equation approaches for estimating the demand elasticities. Stone (1954), Barten (1977), Deaton and Muellbauer (1980b) best described the superiority over a single equation.

Vegetables are cherished in terms of nutrients and are very much important in the developing countries particularly the South Asian Counties which have vegetable dietetic habits. The poor and developing countries have greater consumption and growth of vegetables because of having vegetables as their main food necessity. Pakistan, being an Asian developing country, most of its rural and urban population rely on vegetables, which is a savoring food because of its nutritious importance such as Iron, Protein, Calcium etc. (Memon, 2013). The analysis will allow us to provide precise analysis of demand interrelationship among these different vegetable products and thus we will be able to know the structural differences in demand for disaggregated vegetables (Brester, 1996).

In this study, we will estimate the elasticities of vegetables in Pakistan using a demand system approach, which will enable us to recognize the behavior of the household consumption. As there is a change in income of households living in Pakistan, some are eager to recompense extra for quality and quantity of food while others are only to pay less for food due to low income. This study adds to literature e.g., it adds to our knowledge because this is a new study which concentrates on the consumption patterns of the consumer by estimating own prices, cross prices and the expenditure elasticities of vegetables. The estimation of own price elasticities, cross price and expenditure elasticities is very much important and beneficial for the policy makers to make policies according to the consumption of the consumers for vegetables.

Many studies in Pakistan have been conducted with regards to the food consumption such as that of Malik *et al*., (2015), Haider and Zaidi (2017), Jalil and Khan (2018) and Ullah *et al*., (2018) etc. However, a detailed and a specific study on vegetables specifically has not been done in Pakistan. Different models have been used for the estimation of food consumption patterns like that of double log demand model (Altson *et al*., 2002), linear expenditures system (developed by Stone 1954), rotterdam system (developed by Theil 1965 and Barten 1966), indirect translog model (developed by Christensen, Jorgenson and Lau in 1975), Quadratic Expenditure System (developed by Pollak, Wales and Howe in 1979) and also the AIDS model (developed by Muellbauer and Deaton, 1980). In this study, Almost Ideal Demand System (AIDS) will be used because of the advantages it has over other models. When stone price index is added to the almost ideal demand system than it becomes Linear Approximated Alost Ideal Demand System (LA/AIDS). We try to identify and estimate own price, cross price and expenditure elasticities of vegetables consumption in Pakistan and suggest policy prescriptions based on the findings for vegetables consumption for this country. The study is organized as follows: section 2 presents description of methodology and data, third section provides the result and fourth section finally concludes.

2.0 DATA AND METHODOLOGY

2.1 Study Area

As there are different consumption patterns in different areas of the country, so the study is conducted for all the regions. The total area of Pakistan is 796,096 km square. According to the census of 2017, Pakistan had a population of 207.775 million out of which 132.190 million were living in the rural areas and 75.585 million in the urban areas. The probable population in 2019 was 211.17 million and in 2020 was 215.25 million. Pakistan has a total of four provinces, Baluchistan, Punjab, Sindh and Khyber Pakhtunkhwa (KPK). The province of KPK has a total population of 35.525 million, Punjab has a total population of 110.012 million, Sindh has a total population of 47.886 million and Baluchistan has a total population of 12.344 million (GoP, 2017; GoP, 2019; GoP, 2021). All these provinces have individuals living in either urban areas or rural areas. Both the rural and urban areas in all the provinces of Pakistan have different cultures, traditions, lifestyle patterns, consumption patterns etc. As Pakistan is an agriculture country so most of its population live in the rural areas and depend upon agriculture for their income source and survival while in urban areas most depend upon businesses, jobs, investments for their income and survival. The consumption of food (vegetables) are different in both the cases of rural and urban parts in all the provinces of Pakistan. As there is an income inequality between the rural and the urban people so there is a difference in amount of food consumed, quality of food consumed, and changes in the expenditure on food when there is a change in the income level of both the rural and urban population.

2.2 Data description

Following the work of Haq *et al*. (2011), Haider and Zaidi (2018), Jalil and Khan (2018), Fayaz *et al*. (2014), Ullah *et al*. (2016), among others, this study utilized Household Integrated Economic Survey (HIES) of Pakistan, dispensed by the Pakistan Bureau of Statistics (PBS). To get appropriate and consistent estimation in the constraint of inconsistency that happens amongst the key population individualities, the PBS had taken a sample size of 24809 households for the time period of 2018-19. The research utilizes data from the Pakistan Social and Living Standards Measurements (PSLM) and Household Integrated Economic Survey (HIES).

2.3 Methodology

The double-log demand model was a popular model when it came to equations having single models. It is useful in interpreting the model appropriately. The issue with that of the double-log demand model was that only the restriction of homogeneity is imposed and is not able to satisfy other restrictions (Altson *et al*., 2002). The much old-style and perhaps the finest form of the

Engle's curve is the linear one which is called Linear Expenditure System (LES). Initially LES was developed by Richard Stone in the year 1954. The advantage of LES was that it was good in estimating cross price elasticities but was not that much great when it came to estimation of income elasticities (Dybczak *et al*., 2010; Astoy, 2019).Theil (1965) and Barten (1966) developed the Rotterdam System (RS). As the Rotterdam System being linear in parameters so was easy to estimate. The disadvantage of Rotterdam system was that the coefficients were not able to be constant unless all the expenditures elasticities were 1 and all the own price elasticities were -1 (Mountain, 1988).

Christensen, Jorgenson and Lau developed The Indirect Translog System in 1975. The advantage that Indirect Translog System had over the previous demand systems was its flexible functional form but the disadvantage was that it was not great in the estimation of income and cross price elasticities (Rizov *et al*., 2014).The Quadratic Expenditure System (QES) was developed by Howe, Pollak and Wales in 1979. QES was good in the estimation of income and cross price elasticities. The problem with QES is that when estimating the cross price elasticities, the results of QES changes with the number of commodities in different situations (Meyer *et al*., 2011).

In much of the past literature and studies done on demand systems/equations, the specification of a functional form has always been an initial point. The function or functional form act as a second order approximation to any arbitrary direct or an indirect utility function, or more rarely a cost (expenditure) function. For example, like that of Christensen, Jorgenson and Lau in 1975 used second order approximation. On the other hand first order approximation can be used in the demand functions like that of Theil, 1965 and Barten 1966, (developed the Rotterdam System). Generally, these approaches will be followed, not in arbitrary preference but a specific class of preferences which are the theorems by that of Deaton and Muellbauer (1975, 1976) which allows specific aggregation over the consumer. The representation of the market demand system as if they were the outcome of the consumer's decision. These preferences made are known as PIGLOG class and are represented by cost (expenditure) function which are required to acquire a necessary utility level at prices which are given. The function is represented by $c(u, p)$, where "u" is utility, "p" is the vector prices (Deaton and Muellbauer, 1980b). The PIGLOG class is defined as; $ln\ c\ (u, p) = a\ (p) + up\ (p)$ (1)

Taking functional form of *a(p)* and *b(p)* in such a way that the resulting cost function has a flexible functional form, having enough parameters so that at any point its derivates can be equal to those of an arbitrary cost function. Taking;

$$a(p) = \alpha_0 + \sum_{k=1}^{n} \quad a_k \, ln \, ln \, p_k \, + \frac{1}{2} \sum_{k=1}^{n} \quad \sum_{i=1}^{n} \quad \gamma_{ki} \, ln \, ln \, p_k ln p_i \qquad (2)$$

$$b(p) = \beta \Pi_{k=1}^{n} p_k^{\beta k} \qquad (3)$$

a_k, β_k and γ_{ki^*}, the above-mentioned parameters which needs to be estimated.

For each commodity or a group of commodities, the expenditure share function can be derived from differentiating an expenditure function which takes the form or the AIDS cost function which takes the form of:

$$ln \, ln \, c(u,p) \; = \alpha_0 \Sigma_{k=1}^{n} \alpha_k \, ln \, ln \, p_k \; + \frac{1}{2} \Sigma_{k=1}^{n} \Sigma_{i=1}^{n} \gamma_{k_i}^{*} \, ln \, ln \, p_k ln p_i + u \beta_0 \, \Pi_{k=1}^{n} p_k^{\beta k} \qquad (4)$$

Where $ln \, ln \, c(u,p)$ is the expenditure function of the utility u. When applying shepherd's lemma, the Hicksian demand function is obtained. Price is well-defined by overturning cost function which actually is the indirect function of utility. The total extent of the utility relies on the total expenditure. By replacing the indirect utility function in Hicksain demand function, in the share of budget, the Marshallian demand function is achieved.

$$w_i = \alpha_i + \Sigma_i \gamma_{ij} \, ln \, ln \, p_j \; + \beta_{i ln} \left(\frac{x}{p} \right) + u_i \qquad (5)$$

Where:

w_i is the budget share of good i, α_i , β_i,

γ_{ij} = required parameters that have to be estimated,

p_j = price of good j,

x = total expenditures,

β_i signifies the changes in *i* due to the changes in price and expenditure, x/p is the real expenditure,

P = aggregate price index and is well-defined by:

$$ln\, ln\, P = \alpha_0 + \sum_{i=1}^{n} \alpha_i\, ln\, ln\, p_i + \frac{1}{2} \sum_{i}^{n} \sum_{i}^{n} \gamma_{ij}\, lnP_i\, lnPj \quad (6)$$

Where:

$$\gamma_{ij} = \frac{1}{2}\left(\gamma_{ij}^{*} + \gamma_{ji}^{*}\right) = \gamma_{ij} \text{ for goods i, j.} \quad (7)$$

α_0 and α_i , the parameters that are required to be estimated.

Following restrictions have to be executed for theoretical consistency:

Adding-up:

$$\sum_{i=1}^{n} \alpha_i = 1 \qquad \sum_{i=1}^{n} \beta_i = 0 \sum_{i=1}^{n} \gamma ij = 0$$

Homogeneity:

$$\sum_{i=1}^{n} \gamma ij = 0$$

Symmetry is satisfied for goods *i* and *j* when:

$$\gamma_{ij} = \gamma_{ji}$$

Applying the price index in equation (6), the association concerning that the prices of food and price index is non-linear, resulting in a multifaceted non-linear system. It was suggested by Deaton and Muellbauer (1980b) that if the price index (P) in equation (6) is replaced by price index of stone (P*), the relationship between prices of food and the price index would become linearized.

$$lnP^{*} = \Sigma_j w_j lnpj \quad (8)$$

When the stone price index is combined with the AIDS model then it becomes LA/AIDS. The LA/AIDS model having the stone price index is as follows:

$$w_i = \alpha_i^{*} + \Sigma_i \gamma_{ij}\, ln\, ln\, p_j + \beta_{i ln}\left(\frac{x}{p^{*}}\right) + \mu_i^{*} \quad (9)$$

Where:

$\alpha_i^* = \alpha_i - \beta_i\alpha_i$ and $\mu_i^* = u_i - \beta_i u_i$ (10)

As mentioned in many research studies e.g., Moschini (1995); Asche and Wessells (1997); Altson, Foster and Green (1994) and stated that when stone price is used than it will lead to unit measurement error. If simple mean is used instead of prices than the issue of unit measurement can be resolved. As recommended by Moschini (1995), by using laspeyres price index the issue of unit measurement error can be resolved. A log linear analogue is obtained by replacing *wi* in equation (8) by $\underline{w_i}$. Hence, Laspeyres price index develops to a geometrically average of prices.

$$ln\, ln\left(P^L\right) = \Sigma_i \underline{w}_i\, ln\, ln\,(P_i) \quad (11)$$

Where $\underline{w_i}$ represents the mean budget share. By combining equation (11) with equation (9) which yields LA/AIDS model having Laspeyres Price Index as below:

$$w_i = a^{**} + \Sigma_j\gamma_{ij}\, ln\, ln\left(P_j\right) + \beta i\left(ln(x) - \Sigma_j \underline{w}_j\, ln\, ln\left(P_j\right)\right) + \mu_i^{**}$$
(12)

Where:

$$a^{**} = \alpha_i - \beta_i\left(\alpha_o - \Sigma_j \underline{w}_j\, ln\, ln\left(\underline{P}_j\right)\right) \quad (13)$$

By applying the association proposed by Pollak and Wales (1978, 1981), equation (5) is improved with household socioeconomic characteristics which are as follows:

$$D^i = \sum_{r=1}^{N} \delta_{ir}\eta_r$$

Whereas δ_{ir} is the vector of parameters and η_r is a matrix of socio-economic variables. The socioeconomic characteristics are included in equation (5) which is as follows:

$$w_i = \alpha_i^{***} + \Sigma_k\delta_{ik}\eta_k + \Sigma_j\gamma ij ln\left(p_j\right) + \beta_i\left(ln\, ln\,(x) - \Sigma_j \underline{w}_j ln\left(p_j\right)\right) + \mu^{***} \quad (14)$$

Where:

$\alpha_i^{***} = \alpha_i^{**} - \Sigma_i \delta_{ik} \eta_k$

The complete demand system which uses dummy and also demographic variable quantity is as the same as a single equation model. Adding-up restriction which involves:

$\Sigma_i \alpha^{***} = 1$ and $\Sigma_i \delta_{ik} = 0$ $k = 1, \ldots \ldots \ldots, m$ = (number of demographic and other dummy variables)

Following the work of Green and Alston (1990), Han and Wahl (1998), Aziz *et al*., (2011), Haq *et al*., (2011), Jalil and Khan (2018), Ullah *et al*., (2018), taking derivation of equation (9) with respect to ln(x), the elasticities for expenditure can be obtained which are as follows:

$$e_i = 1 + \left(\frac{1}{\omega_i}\right)\left(\frac{\partial w_i}{\partial ln(x)}\right) = 1 + \left(\frac{\beta_i}{wi}\right) \qquad (15)$$

When taking derivative with respect to *ln* (*pj*), the uncompensated own price elasticity which is (j=1) and the cross price elasticity which is $(j \neq i)$, $e_{ij}^{LA/AIDS}$ becomes;

$$e_{ij}^{LA/AIDS} = -\ \partial ij \left(\frac{1}{\omega_i}\right)\left(\frac{\partial w_i}{p_j}\right) = \partial ij + \left(\frac{\gamma_{ij}}{\underline{w}_i}\right) - \left(\frac{\beta_i}{wi}\right)\underline{w}_j \qquad (16)$$

Where ∂ij is Kronecker delta that is 1 if i = j otherwise 0.The compensated price elasticities $s_{ij}^{LA/AIDS}$ becomes as follows;

$$s_{ij}^{LA/AIDS} = e_{ij} + e_i w_j = -\ \delta_{ij} + \left(\frac{\gamma_{ij}}{\underline{w_i}}\right) + \underline{w_i} \qquad \forall i, j = 1, \ldots \ldots \ldots, \text{n} \qquad (17)$$

3.0 RESULTS AND DISCUSSION

The following section presents results from the analysis of the data and discussion of the estimated results. Results of LA/AIDS model in which uncompensated as well as compensated (own price and cross price) and expenditure elasticities of vegetables consumption for overall Pakistan are depicted and discussed.

3.1 Descriptive statistics

First we present some descriptive statistics. Table 1 reveals that there is significant difference in the size of households amongst rural, urban regions and provinces as well.

Table 1 Average household size by province and region, 2018-19.

Area	2015-16	2018-19
Baluchistan	7.84	8.12
KP including merged areas	---	7.52
KP excluding merged areas	7.34	7.41
Sindh	6.22	6.23
Punjab	6.04	5.78
Rural	6.47	6.40
Urban	6.03	5.97
Total	6.31	6.24

Source: HIES report 2018-19

3.2 Uncompensated, compensated (own price and cross price) and expenditure elasticities

3.2.1 Uncompensated (Marshallian) own price elasticities

The own price elasticity of a good is anticipated to have a negative sign, conferring to the economic theory which indicates a downward sloping demand curve. The price elasticities represents the response of the consumer towards the changes in prices of goods or commodities. To examine the welfare effect of change in price, compensated and uncompensated own prices elasticities of demand were computed. Own prices elasticities shown in table 2 for all vegetables had an appropriate sign required which was negative. The resulted estimates suggested that the households were not much responsive to the changes in the price level of vegetables. The own price elasticity of vegetables ranged from 0.23 to 0.72. The estimated own price elasticities by Ullah *et al*. (2018); Aziz *et al*. (2011); Awal *et al*. (2008) and Akbay *et al*. (2007) for vegetables were 0.583, 0.290, 0.408 and 0.856. The estimated own price elasticity for potato (-0.3235), onion (-0.3931), tomato (-0.5156), cabbage, cauliflower (-0.2510), bitter gourd, lady finger, brinjal, cucumber (-0.4382), tinda, pumpkin, bottle gourd (-0.3056), turnip, radish, carrot (-0.3536), peas, moongra (-0.3394), turai, arvi, green pepper (-0.1652), garlic (-0.2320) and others (-0.7242) respectively.

3.2.2 Uncompensated (Marshallian) Cross price elasticities

Table 2 shows the uncompensated cross prices elasticities of vegetables in all over Pakistan indicating substitution, complement and supplement relations among all the vegetable commodities that are significant and insignificant. When there is a change in the disposable income of a household whether it may be either positive or negative, most of the households would first decide on the percentage change of how much to be spent or cut on savings and expenditures. Positive and significant cross price elasticity specifies that the commodity is a substitute. Negative and significant cross price elasticity shows that the commodity is a complement. Negative and insignificant cross price elasticity designates that the commodity is a supplement.

The uncompensated cross price elasticities of potato with respect to prices of onion (-0.0448), cabbage, cauliflower (-0.0334), bitter gourd, lady finger, brinjal, cucumber (-0.1412), tinda, pumpkin, bottle gourd (-0.0687), turnip, radish, carrot (-0.0376), peas, moongra (-0.0562), turai, arvi, green papper (-0.0513), garlic (-0.0324) and others (-0.0175) have a negative sign and p-value lower than 0.05 indicating that these are complements. Potato with respect to prices of tomato (0.0032) has a positive sign which shows the direction towards substitutes but has a significance level greater than 0.05.

The uncompensated cross price elasticities of onion with respect to prices of bitter gourd, lady finger, brinjal, cucumber (0.0307) has a positive sign and having a significance level less than 0.05 indicating that it is a substitute. The elasticity of onion with respect to prices of tomato (-0.048), cabbage, cauliflower (-0.0729), tinda, pumpkin, bottle gourd (-0.0476), turnip, radish, carrot (-0.0482), peas, moongra (-0.0742), turai, arvi, green papper (-0.0481), garlic (-0.0482) and others (-0.0071) have a negative sign and having a significance level of less than 0.05 indicating that these are complements.

The elasticity of tomato with regards to the prices of others (0.0190) has a positive sign and having a significance level less than 0.05 indicating that it is a substitute. The uncompensated cross price elasticities of tomato with respect to prices of cabbage, cauliflower (-0.0571), bitter gourd, lady finger, brinjal, cucumber (-0.1295), tinda, pumpkin, bottle gourd (-0.0834), turnip, radish, carrot (-0.0592), peas, moongra (-0.0208), turai, arvi, green papper (-0.0630), garlic (-

0.0076) have a negative sign and having a significance level of less than 0.05 indicating that these are complements.

The elasticity of cabbage, cauliflower with respect to prices of garlic (0.0087) has a positive sign and having a significance level less than 0.05 indicating that it is a substitute. The uncompensated cross price elasticities of cabbage, cauliflower with respect to prices of bitter gourd, lady finger, brinjal, cucumber (-0.0815), tinda, pumpkin, bottle gourd (-0.0036), turnip, radish, carrot (-0.0004), peas, moongra (-0.0241) turai, arvi, green papper (-0.0058) and others (-0.0185) have a negative sign and having a significance level of less than 0.05 indicating that these are complements.

The uncompensated cross price elasticities of bitter gourd, lady finger, brinjal, cucumber with respect to prices of tinda, pumpkin, bottle gourd (0.0648), peas, moongra (0.0110), turai, arvi, green papper (0.0836) and garlic (0.0470) has a positive sign and having a significance level less than 0.05 indicating that these are substitutes. The uncompensated cross price elasticities of bitter gourd, lady finger, brinjal, cucumber with respect to prices of turnip, radish, carrot (-0.0231) has a negative sign and having a significance level of less than 0.05 indicating that these are complements. The uncompensated cross price elasticities of bitter gourd, lady finger, brinjal, cucumber with respect to prices of others (-0.0028) has a negative sign and a significance level greater than 0.05 indicating that it is a supplement.

The uncompensated cross price elasticities of tinda, pumpkin, bottle gourd with respect to prices of turai, arvi, green papper (0.0070) has a positive sign and having a significance level less than 0.05 indicating that it is a substitute. The uncompensated cross price elasticities of tinda, pumpkin, bottle gourd with respect to prices of turnip, radish, carrot (-0.0315), peas, moongra (-0.0259) and others (-0.0192) have a negative sign and having a significance level of less than 0.05 indicating that these are complements. The uncompensated cross price elasticities of tinda, pumpkin, bottle gourd with respect to prices of garlic (0.0067) has a positive which shows the direction towards substitutes but has a significance level greater than 0.05.

The uncompensated cross price elasticities of turnip, radish, carrot with respect to prices of peas, moongra (0.0985) and others (0.0669) have a positive sign and having a significance level less than 0.05 indicating that these are substitutes. The uncompensated cross price elasticities of turnip, radish, carrot with respect to prices of turai, arvi, green papper (-0.0327) and garlic (-0.0212) have a negative sign and having a significance level of less than 0.05 indicating that these are complements.

The uncompensated cross price elasticities of peas, moongra as to the prices of garlic (0 .0124) and others (0.0604) have a positive sign and having a significance level less than 0.05 indicating that these are substitutes. The uncompensated cross price elasticities of peas, moongra with in regards to the prices of turai, arvi, green papper (-0.0401) have a negative sign and having a significance level less than 0.05 indicating that it is a complement.

The uncompensated cross price elasticities of turai, arvi, green papper with respect to prices of garlic (-0.0633) and others (-0.0654) have a negative sign and having a significance level of less than 0.05 indicating that these are complements. The uncompensated cross price elasticities of garlic regarding the price of others (0.0088) has a positive sign which shows the direction towards substitutes but has a significance level greater than 0.05.

Table 2: Uncompensated (Marshallian) Own and Cross Price Elasticities

Variables (p-value)	Potato	Onion	Tomato	Cabbage, Cauliflower	Bitter gourd, lady finger, brinjal, cucumber	Tinda, pumpkin, bottle gourd	Turnip, radish, carrot	Peas, moongra	Turai, arvi, green pepper	Garlic	Others
Potato	**-0.3235**	-0.0448	0.0032	-0.0334	-0.1412	-0.0687	-0.0376	-0.0562	-0.0513	-0.0324	-0.0175
	(0.000)	(0.000)	(0.476)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Onion		**-0.3931**	-0.0483	-0.0729	0.0307	-0.0476	-0.0482	-0.0742	-0.0481	-0.0482	-0.0071
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tomato			**-0.5156**	-0.0571	-0.1295	-0.0834	-0.0592	-0.0208	-0.0630	-0.0076	0.0190
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.037)	(0.000)
Cabbage, Cauliflower				**-0.2510**	-0.0815	-0.0036	-0.0004	-0.0241	-0.0058	0.0087	-0.0185
				(0.000)	(0.000)	(0.412)	(0.931)	(0.000)	(0.090)	(0.071)	(0.000)
Bitter Gourd, Lady finger, Brinjal, Cucumber					**-0.4382**	0.0648	-0.0231	0.0110	0.0836	0.0470	-0.0028
					(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.542)
Tinda, Pumpkin, Bottle Gourd						**-0.3056**	-0.0315	-0.0259	0.0070	0.0067	-0.0192
						(0.000)	(0.000)	(0.000)	(0.041)	(0.167)	(0.000)
Turnip, Radish, Carrot							**-0.3536**	0.0985	-0.0327	-0.0212	0.06692
							(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Peas, Moongra								**-0.3394**	-0.0401	0 .0124	0.06042
								(0.000)	(0.000)	(0.008)	(0.000)
Turai, Arvi, Green papper									**-0.1652**	-0.0633	-0.0654
									(0.000)	(0.000)	(0.000)
Garlic										**-0.2320**	0.0088
										(0.000)	(0.293)
Others											**-0.7242**
											(0.000)

Source: Authors' estimates using HIES data, 2018-19

3.3 Compensated, compensated (own price and cross price) and expenditure elasticities

3.3.1 Uncompensated (Marshallian) own price elasticities

The Hicksian own price elasticity of individual vegetable commodities have a negative sign, ranging from 0.11 to 0.62. The estimated own price elasticities by Ullah *et al*. (2018); Aziz *et al*. (2011) and Awal *et al*. (2008) for vegetables were 0.584, 0.265 and 0.571 respectively. The compensated own price elasticities of vegetables, potato (-0.1582), onion (-0.2421), tomato (-0.3721), cabbage, cauliflower (-0.1907**),** bitter gourd, lady finger, brinjal, cucumber (-0.3296), tinda, pumpkin, bottle gourd **(**-0.2420), turnip, radish, carrot (-0.2907), peas, moongra (-0.2816), turai, arvi, green papper (-0.1141), garlic (-0.1798) and others (-0.6262) were inelastic, respectively as shown in table 3.

3.3.2 Un Compensated (Hicksian) Cross price elasticities

Like that of uncompensated cross price elasticities, the compensated own price elasticities are all statistically significant and can be seen in table 3. Almost all the compensated cross price elasticities have positive signs but a few have negative signs. The positive sign shows that the vegetable commodities are substitutes while the negative sign shows that they are complements. The compensated cross price elasticities of potato as to the prices of onion (0.1206), tomato (0.1686), cabbage, cauliflower (0.1319), bitter gourd, lady finger, brinjal, cucumber (0.0242), tinda, pumpkin, bottle gourd (0.0967), turnip, radish, carrot (0.1277), peas, moongra (0.1091), turai, arvi, green papper (0.1141), garlic (0.1329) and other (0.1478) have a positive sign and having a significance level less than 0.05 indicating that these are substitutes.

The compensated cross price elasticities of onion with respect to the price of tomato (0.1026), cabbage, cauliflower (0.0780), bitter gourd, lady finger, brinjal, cucumber (0.1816), tinda, pumpkin, bottle gourd (0.1033), turnip, radish, carrot (0.0767), peas, moongra (0.1028), turai, arvi, green papper (0.1027), garlic (0.1027) and other (0.1438) with respect to the price of have a positive sign and having a significance level less than 0.05 indicating that these are substitutes.

The compensated cross price elasticities of tomato with respect to the price of cabbage, cauliflower (0.0864), bitter gourd, lady finger, brinjal, cucumber (0.0140), tinda, pumpkin, bottle gourd (0.0601), turnip, radish, carrot (0.0843), peas, moongra (0.1227), turai, arvi, green papper

(0.0805), garlic (0.1360) and other (0.1625) with respect to the price of have a positive sign and having a significance level less than 0.05 indicating that these are substitutes.

The compensated cross price elasticities of cabbage cauliflower with respect to the prices of tinda, pumpkin, bottle gourd (0.0567), turnip, radish, carrot (0.0600), peas, moongra (0.0362), turai, arvi, green papper (0.0545), garlic (0.691) and other (0.0419) the compensated cross price elasticities of cabbage cauliflower with respect to the price of bitter gourd, lady finger, brinjal, cucumber (-0.0211) has have a negative sign and having a significance level of less than 0.05 indicating that it is a complement.

The compensated cross price elasticities of bitter gourd, lady finger, brinjal, cucumber with respect to the price of tinda, pumpkin, bottle gourd (0.1734), turnip, radish, carrot (0.0856), peas, moongra (0.1196), turai, arvi, green papper (0.1923), garlic (0.1556) and other (0.1058) with respect to the price of have a positive sign and having a significance level less than 0.05 indicating that these are substitutes.

The compensated cross price elasticities of tinda, pumpkin, bottle gourd with respect to the price of turnip, radish, carrot (0.0321), peas, moongra (0.0377), turai, arvi, green papper (0.0706), garlic (0.0702) and other (0.0444) have a positive sign and having a significance level less than 0.05 indicating that these are substitutes.

The compensated cross price elasticities of turnip, radish, carrot with respect to the price of peas, moongra (0.1615), turai, arvi, green papper (0.0302), garlic (0.0417) and other (0.1299) have a positive sign and having a significance level less than 0.05 indicating that these are substitutes.

The compensated cross price elasticities of peas, moongra with respect to the price turai, arvi, green papper (0.0177), garlic (0.0703) and other (0.1182) have a positive sign and having a significance level less than 0.05 indicating that these are substitutes.

The compensated cross price elasticities of turai, arvi, green papper with respect to the price of garlic (-0.0122) and other (-0.0144) have a negative sign and having a significance level less than 0.05 indicating that these are complements. The compensated cross price elasticities of garlic in regards with the price of others (0.0611) has a positive sign and having a significance level less than 0.05 indicating that it is a substitute.

Table 3: Compensated (Hicksian) Own and Cross Price Elasticities

Variables (p-value)	Potato	Onion	Tomato	Cabbage, Cauliflower	Bitter gourd, lady finger, brinjal, cucumber	Tinda, pumpkin, bottle gourd	Turnip, radish, carrot	Peas, moongra	Turai, arvi, green pepper	Garlic	Others
Potato	**-0.1582** (0.000)	0.1206 (0.000)	0.1686 (0.000)	0.1319 (0.000)	0.0242 (0.000)	0.0967 (0.000)	0.1277 (0.000)	0.1091 (0.000)	0 .1141 (0.000)	0.1329 (0.000)	0 .1478 (0.000)
Onion		**-0.2421** (0.000)	0.1026 (0.000)	0.0780 (0.000)	0.1816 (0.000)	0.1033 (0.000)	0.1027 (0.000)	0 .0767 (0.000)	0.1028 (0.000)	0.1027 (0.000)	0.1438 (0.000)
Tomato			**-0.3721** (0.000)	0.0864 (0.000)	0.0140 (0.009)	0.0601 (0.000)	0.0843 (0.000)	0.1227 (0.000)	0.0805 (0.000)	0.1360 (0.000)	0.1625 (0.000)
Cabbage, Cauliflower				**-0.1907** (0.000)	-0.0211 (0.001)	0.0567 (0.000)	0.0600 (0.000)	0.0362 (0.000)	0.0545 (0.000)	0.0691 (0.000)	0.0419 (0.000)
Bitter Gourd, Lady finger, Brinjal, Cucumber					**-0.3296** (0.000)	0.1734 (0.000)	0.0856 (0.000)	0.1196 (0.000)	0.1923 (0.000)	0.1556 (0.000)	0.1058 (0.000)
Tinda, Pumpkin, Bottle Gourd						**-0.2420** (0.000)	0.0321 (0.000)	0.0377 (0.000)	0.0706 (0.000)	0.0702 (0.000)	0.0444 (0.000)
Turnip, Radish, Carrot							**-0.2907** (0.000)	0.1615 (0.000)	0.0302 (0.000)	0.0417 (0.000)	0.1299 (0.000)
Peas, Moongra								**-0.2816** (0.000)	0.0177 (0.000)	0.0703 (0.000)	0.1182 (0.000)
Turai, Arvi, Green papper									**-0.1141** (0.000)	-0.0122 (0.012)	-0.0144 (0.003)
Garlic										**-0.1798** (0.000)	0.0611 (0.000)
Others											**-0.6262** (0.000)

Source: Authors' estimates using HIES data, 2018-19.

3.4 Expenditure elasticities

Households living in Pakistan devote their own incomes on many substances to obtain a certain utility level. The expenditure elasticities estimated for vegetables provides valuable information about the level of consumption of the consumer. It is clear in table 6 that the expenditure elasticity of all individual vegetable commodities were positive (as per expectations) and also having a significance level of 99% and giving the suggestion that all vegetable commodities are recognized as essential commodities based upon the resulting expenditure elasticities from the analysis of the data. The vegetable commodities, potato (0.9239), onion (0.9157), cabbage, cauliflower (0.6577), bitter gourd, lady finger, brinjal, cucumber (0.6485), tinda, pumpkin, bottle gourd (0.6488), turnip, radish, carrot (0.6873), peas, moongra (0.6907), turai, arvi, green papper **(**0.6775) and garlic (0.9111) are considered as necessities based on their expenditure elasticities.

Table 6: Expenditure elasticities

Variables	**Coef.**	**Std. Err.**	**Z**	**P > |z|**	**[95% Conf. Interval]**	
Potato	0.9239	0.0022	429.13	0.000	0.9196	0.9281
Onion	0.9157	0.0019	488.3	0.000	0.9121	0.9194
Tomato	1.0175	0.0024	414.84	0.000	1.0127	1.0224
Cabbage, Cauliflower	0.6577	0.0020	321.24	0.000	0.6537	0.6618
Bitter Gourd, Lady finger, Brinjal, Cucumber	0.6485	0.0022	296.4	0.000	0.6442	0.6528
Tinda, Pumpkin, Bottle Gourd	0.6488	0.0020	328.32	0.000	0.644908	0.6526
Turnip, Radish, Carrot	0.6873	0.0025	276.17	0.000	0.6824	0.6922
Peas, Moongra	0.6907	0.0023	295.62	0.000	0.6861	0.6953
Turai, Arvi, Green papper	0.6775	0.0021	312.87	0.000	0.6730	0.6814
Garlic	0.9111	0.0035	256.78	0.000	0.9040	0.9179
Others	1.0530	0.0046	230.33	0.000	1.0440	1.0619

Source: Authors' estimates using HIES data, 2018-19.

Tomato (1.0175) and others (1.0530) are reported to be luxurious items based on their expenditure elasticities. As per expectations, these vegetable commodities will experience an increase in their demand when the income level of the consumers increases. The estimated expenditure elasticities by Ullah *et al*. (2018), Aziz *et al*. (2011), Awal *et al*. (2008) and Akbay *et al*. (2007) for vegetables were 0.77, 0.764, 0.58 and 0.907, respectively.

4. SUMMARY, CONCLUSION AND RECOMMENDATIONS

In agricultural economics, food demand is given top priority as food helps meet individuals' basic needs to sustain life (Ullah, 2018). Therefore, it is of paramount importance to understand consumer behavior regarding the food demand. Here, in this paper, we have analyzed how prices and income (expenditure) affect Pakistani people's demand for different vegetable varieties, enabling which us to recognize the behavior of the household consumption. We have applied Linear approximate almost ideal demand system (LA-AIDS) model proposed by Deaton and Muellbauer (1980). The research findings provide us some interesting insights. The uncompensated own price elasticity of demand in overall Pakistan for all the vegetables were less than unity, classifying them as necessities. The uncompensated cross price elasticity of demand revealed that most of the vegetable commodities were not sensitive to the change in prices of other vegetable commodities. The estimated expenditure elasticities of all vegetable commodities were positive which indicates that these were normal goods and the demand of these vegetables will increase with the increase in the income of the household. The expenditure elasticities of tomato and other were more than unitary and were categorized as luxury goods.

Limitations of the study

The study is not without limitations. Although we have applied LA-AIDS model, this model, even with corrected elasticities, can perform badly while recovering the time varying elasticities compared to Rotterdam model as has been found by Barnett and Kanyama (2013). Therefore, these limitations should be kept in mind while performing such analysis and future research may try to overcome such issues. We have also excluded two variables from the study due to having a smaller number of observations, lemon having 3536 observations and canned vegetables having 113 observations. Future research can overcome these limitations if the data becomes available. Also, several other covariates such as that of climate change, migration of the household members can be incorporated in the model to provide interesting insights.

REFERENCES

Ahmed, S. 2011. Does Economic Geography Matter for Pakistan? A Spatial Exploratory Analysis of Income and Educational Inequalities. The Pakistan Development Review, 929-953

Alston, M.A., J.A. Chalfant and N. Piggott. 2002. Estimating and testing the compensated double log demand model. App. Eco., 34(9): 1177-1186.

Anwar, T. 2009. Measuring inequality of consumption and opportunities in Pakistan 2001-02 and 2004-05. Pak. Eco. Soc. Rev., 47(2):157-181.

Awal, M.A., S.A. Sabur and M.I.A. Mia. 2007. Estimation of vegetable demand elasticities in Bangladesh: Application of almost ideal demand system model. Bangladesh J. Agric. Econ. 31(1): 35-60.

Ayub, Q., Khan, S.M., Hussain, I., Gurmani, A.R., Naveed, K., Mehmood, A., Ali, S., Ahmad, T., Haq, N.U. and Hussain, A., 2021. Mitigating the adverse effects of NaCl salinity on pod yield and ionic attributes of okra plants by silicon and gibberellic acid application. *Italus Hortus*, *28*, p.59. https://doi.org/10.26353/j.itahort/2021.1.5973

Ayub, Q., Khan, S.M., Hussain, I., Naveed, K., Ali, S., Mehmood, A., Khan, M.J., Haq, N.U. and Shehzad, Q., 2021. Responses of different okra (Abelmoschus esculentus) cultivars to water deficit conditions. *Journal of Horticultural Sciences*, *16*(1), pp.53-63. https://jhs.iihr.res.in/index.php/jhs/article/view/1099

Ayub, Q., Mehmood, A., Hayat, U., Shahzad, Q. and Ahmad, S., 2020. 7. Effect of salinity on physiological and biochemical attributes of different Brinjal (Solanum melongena L.)

cultivars. *Pure and Applied Biology (PAB)*, *9*(4), pp.2190-2198. . http://dx.doi.org/10.19045/bspab.2020.90234

Ayuba, Q., Khana, S.M., Mehmoodb, A., Haqc, N.U., Alia, S., Ahmadd, T., Ayuba, M.U., Hassaana, M., Hayata, U. and Shoukata, M.F., 2020. Enhancement of Physiological and Biochemical Attributes of Okra by Application of Salicylic Acid under Drought Stress. *Journal of Horticultural Science and Technology*, *3*(4), pp.113-119. https://doi.org/10.46653/jhst2034113

Aziz, B., K. Mudassar., Z Iqbal and I. Hussain. 2011. Estimation of food demand elasticates in Pakistan: An application of almost ideal demand system. Forman J. Eco. Stu. 7: 1-24

Chaudhary, M.A., A. Eatzaz., A.A. Burki and M.A. Khan. 1999. Income and price elasticities of agricultural, industrial and energy products by sector and income groups of Pakistan, QUES Research Report for Planning Commission, Government of Pakistan.

Deaton, A. and J. Muellbauer. 1980a. Economics and consumer behavior, Cambridge university press, Cambridge.

Deaton, A. and J. Muellbauer. 1980b. An almost ideal demand system. American Econ. Rev. 70:312-326. DOI: 10.26717/BJSTR.2018.05.001265

Dybczak, K., P. Tóth and D. Voňka. 2010. Effects of price shocks to consumer demand. Estimating the quaids demand system on Czech household budget survey data. Czech National Bank. Working paper series 8, 33-58.

FAO, 2011. Food and agriculture organization of the United States.

FAO, 2015. The state of food insecurity in the world. Rome: FAO.

Fayaz. M., A. U. Jan and D. Jan. 2014. Quality Elasticity of vegetable Consumption in Pakistan: A comparison of Urban and Rural Households. Sarhad J. Agric., 30(4): 451-458

Government of Pakistan. 2015. Household Integrated Economic Survey. Pakistan Bureau of Statistics, Islamabad.

Government of Pakistan. 2020. Household Integrated Economic Survey. Pakistan Bureau of Statistics, Islamabad.

Green, R. and J.M. Alston. 1990. Elasticities in AIDS Models. American J. Agric. Eco., 72(2):442-445.

Haider, A. and M. Zaidi. 2017. Food consumption patterns and nutrition disparity in Pakistan. 833-893. https://mpra.ub.uni-muenchen.de/83522/1/MPRA_paper_83522.pdf

Han, T. and T.I. Wahl. 1998. China's rural household demand for fruit and vegetables. J. Agric. Appl. Econ., 30(1): 141-150.

Haq, Z., H. Nazli and K. Meilke. 2008. Implications of high food prices for poverty in Pakistan. Agric. Econ., 39: 477–484.

Islam, A. and C. Siwar. 2005. Impact of the financial crises on expenditure patterns in Malaysia: Special reference on low-income households. Journal of Economic Research, 10:145-173.

Jalil, A. and H. Khan. 2018. Consumption Patterns and Demand Elasticities of Selected Horticulture Products in Pakistan. Policy and Institutional Reforms to Improve Horticultural Markets in Pakistan. WORKING PAPER 04/18

Kakhki, M.D., N. Shahnoushi and F. Rezapour. 2010. An experimental comparison between demand systems of major food groups in urban economics. American J. Appl. Sci., 7(8): 1164-1167.

Kamal, A.A., Rahman, T.U. and Khan, A., Identification, adaptability, phytochemical and nutritional potential of Slender amaranth: A review. *Journal of Xi'an Shiyou University, Natural Sciences Edition*, 18(9): 517-545.

Kearney, J. 2010. Food consumption trends and drivers. Phil. Trans. R. Soc. B., 365(1554):2793-2807. doi:10.1098/rstb.2010.0149

Khan, M.J., Ayub, Q., Hussain, I., Mehmood, A., Arif, N., Mehmood, S., Shehzad, Q., Khalid, S. and Haq, N.U., 2020. Responses of persimmon (Diospyros kaki) fruits to different fruit coatings during postharvest storage at ambient temperature. *Journal of Pure and Applied*

Agriculture, *5*(3), pp.26-32. https://jpaa.aiou.edu.pk/wp-content/uploads/2020/10/JPAA_2020_5_3_26-32.pdf

Malik, S.J., H. Nazli and E. Whitney. 2015. Food consumption patterns and implications for poverty reduction in Pakistan. The Pak. Develop. Rev., 30(4): 651-670

Mehmood, A., Naveed, K., Ayub, Q., Alamri, S., Siddiqui, M.H., Wu, C., Wang, D., Saud, S., Banout, J., Danish, S. and Datta, R., 2021. Exploring the potential of moringa leaf extract as bio stimulant for improving yield and quality of black cumin oil. *Scientific Reports*, *11*(1), pp.1-10. https://doi.org/10.1038/s41598-021-03617-w

Mehmood, A., Naveed, K., Azeem, K., Khan, A., Ali, N. and Khan, S.M., 2018. 10. Sowing time and nitrogen application methods impact on production traits of Kalonji (Nigella sativa L.). *Pure and Applied Biology (PAB)*, *7*(2), pp.476-485. http://dx.doi.org/10.19045/bspab.2018.70060

Mehmood, A., Naveed, K., Jadoon, N., Ayub, Q., Hussain, M. and Hassaan, M., 2021. Phytochemical screening and antibacterial efficacy of black cumin (Nigella sativa L.) seeds. *FUUAST Journal of Biology*, *11*(1), pp.23-28. https://fuuastjb.org/index.php/fuuastjb/article/download/592/433

Mehmood, A., Naveed, K., Khan, S.U., Haq, N.U., Shokat, M.F., Iqbal, M., Ali, R., Nisar, S., Ahmad, J., Rehman, A.U. and Ur, S., Phytochemical screening, antioxidants properties and antibacterial efficacy of moringa leaves. *Journal of Xi'an Shiyou University, Natural Sciences Edition*, 18(10): 59-70. https://www.xisdxjxsu.asia/V18I10-06.pdf

Mehmood, S., Ayub, Q., Khan, S.M., Arif, N., Khan, M.J., Mehmood, A., Shahzad, Q., ul Haq, N., Tanoli, M.T.Z. and Ayub, M.U., 2020. Responses of Fig Cuttings (Ficus Carica) to Different Sowing Dates and Potting Media under Agro-Climatic Conditions of Haripur. *RADS Journal of Biological Research & Applied Sciences*, *11*(2), pp.112-119. https://doi.org/10.37962/jbas.v11i2.268

Memon, N. A. 2013. Vegetable Exports from Pakistan. Available on: http://www.foodjournal.pk/Jan-Feb-2013/PDF-Jan-Feb-2013/Exclusive-article-Dr- Noor.pdf

Meyer, S., X. Yu and D. Abler. 2011. Comparison of several demand systems. Department of Agricultural Economics and Rural Sociology, Pennsylvania State University, 207 Armsby Building, University Park, PA 16802, USA.

Mountain, D.C. 1988. The Rotterdam model: An approximation in variable space. Econometrica: Journal of Econometric Society, 56(2):477-484.

Rehman, A.U., Mehmood, A., Naveed, K., Haq, N.U., Ali, S., Ahmed, J., Rehman, S.U., Shoukat, M.F., Ayub, A., Usman, M. and Nisar, S., Integrated effect of nitrogen and sulphur levels on productive traits and quality of black cumin (Nigella Sativa L.). *Journal of Xi'an Shiyou University, Natural Sciences Edition,* 18(10): 38-58. https://www.xisdxjxsu.asia/viewarticle.php?aid=1269

Rizov, M., A. Cupak and J. Pokrivcak. 2014. Food security and household consumption patterns in Slovakia. LICOS Discussion Paper, No. 360.

Shah, S.U., Ayub, Q., Hussain, I., Khan, S.K., Ali, S., Khan, M.A., Haq, N., Mehmood, A., Khan, T. and Brahmi, N.C., 2021. Effect of different growing media on survival and growth of Grape (Vitus Vinifera) cuttings. *J Adv Nutri Sci Technol*, *1*, pp.117-124.

Shahzad, Q., Sammi, S., Mehmood, A., Naveed, K., Azeem, K., Ahmed Ayub, M.H., Hussain, M., Ayub, Q. and Shokat, O., 2020. 43. Phytochemical analysis and antimicrobial activity of adhatoda vasica leaves. *Pure and Applied Biology (PAB)*, *9*(2), pp.1654-1661. http://dx.doi.org/10.19045/bspab.2020.90174

Taran, S.N.U., Ali, S.A., Haq, N.U., Faraz, A., Ali, S. And Rahman, T.U., Antioxidant and antimicrobail activities, proximate analysis and nutrient composition of eight selected edible weeds of Peshawar region. *Journal of Xi'an Shiyou University, Natural Sciences Edition,* 18(9): 517-545. https://www.xisdxjxsu.asia/viewarticle.php?aid=1224