Humanities and Social Sciences Letters
2025 Vol. 13, No. 3, pp. 916-929
ISSN(e): 2312-4318
ISSN(p): 2312-5659
DOI: 10.18488/73.v13i3.4318

Effect of internet access on food expenditure and nutrition of Indonesian agricultural households

Sri Ulfa Sentosa[1]
Alpon Satrianto[2+]
Urmatul Uska Akbar[3]
Dwirani Puspa Artha[4]
Ariusni[5]

[1,2,3,4,5]*Department of Economics, Faculty of Economics and Business, Universitas Negeri Padang, Indonesia.*
[1]*Email: sriulfasentosa@fe.unp.ac.id*
[2]*Email: alponsatrianto@fe.unp.ac.id*
[3]*Email: urmatulakbar@fe.unp.ac.id*
[4]*Email: dwiranipuspa@fe.unp.ac.id*
[5]*Email: ariusni77@fe.unp.ac.id*

(+ Corresponding author)

Article History
Received: 6 February 2025
Revised: 8 July 2025
Accepted: 15 July 2025
Published: 23 July 2025

Keywords
COVID-19 pandemic
Impact
Income
Micro and small industry.

ABSTRACT

The study analyses the direct and indirect effects of internet access on household food expenditure and nutrition using income as a mediating variable. Cross-sectional data from the March 2020 National Socio-Economic Survey by the Central Bureau of Statistics were used covering 127,672 agricultural households across 34 provinces in Indonesia. Information and Communication Technology (ICT) infrastructure development is employed as an instrumental variable to address the endogeneity of internet access. Data were analysed using the two stages least squares model and mediation regression. Findings indicate that internet access has a significant direct effect on household food expenditure and nutrition. Moreover, internet access indirectly influences these outcomes through its impact on household income. These results underscore the crucial role of ICT in improving the welfare of agricultural households by enhancing consumption patterns. Expanded ICT infrastructure facilitates better access to information on food prices, healthy consumption practices, and efficient shopping strategies which in turn boost household nutrition and food expenditure. This research has significant policy implications for strengthening ICT development and supporting the micro, small, and medium-scale food industry in Indonesia.

Contribution/Originality: This research examines the influence of internet usage on food expenditure as well as nutrition with farm household income as a mediating variable. There are still relatively few previous researchers studying this topic, especially in Indonesia.

1. INTRODUCTION

In Indonesia, Information and Communication Technology (ICT) development is experiencing positive developments. The ICT development index in 2020 amounted to 5.59 points, which increased by 0.27 points compared to 2019. This index continues to increase while the index in 2022 amounted to 5.85 points. During 2018 - 2022, there has been an increase of 0.78 points (Statistics Indonesia, 2022). The above ICT development affected the rise in internet penetration in 2018, 2020, and 2022 by 64.8%, 73.7 % , 77.01%, respectively (Indonesian Internet Service Providers Association, 2024). This data indicates that the number of Indonesians who use the Internet tends to increase every year. One of the groups of internet users is agricultural households.

Previous researchers have found various positive impacts of internet access on farmer households. Siaw, Jiang, Twumasi, and Agbenyo (2020) found that internet access makes it simpler for farmers to acquire agriculture details, capital, and the adoption of agricultural technology. Wang, Chen, and Du (2024) found that access to the internet dramatically raised farmers' involvement in professional cooperatives. The study of Na and Kang (2023) found that internet access has a significant and beneficial impact on increasing the use of fertilizers and pesticides.

Studies on the effects of internet use on farmers' household income have been conducted by many researchers (Wei, Liu, & Liu, 2023; Zhang, Sarkar, & Wang, 2021) who found that internet access has a positive and significant impact on agricultural and household income. All of the above positive impacts pertain to farming households as producers of agricultural products. In addition, research on the internet access's effects on the cost of food as well as the nutrition of farming households is still lacking.

Studies on the effects of internet usage on the expenditure and nutrition of rural dwellers have been conducted by many researchers. Cui, Zhao, Glauben, and Si (2024) conducted research in rural China and found that food spending and food quality are positively and significantly impacted by internet access. Ma, Nie, Zhang, and Renwick (2020) found that internet utilization has a substantial impact on rural household spending. Many studies have been carried out regarding the impact of internet usage on household nutrition. According to Cui et al. (2024) and Deng, Liu, Hong, and Liu's (2024) research in China, difficulties arise in generalizing research findings in different countries due to different socio-economic characteristics. In rural areas, people do various jobs. Ajibade, Amao, Sulaimon, Daud, and Omotoso (2024) found that occupation has a significant influence on food expenditure. This finding indicates that farming households will have different food expenditures compared to non-farming households.

The purpose of this research is to analyze internet access on food expenditure and nutrition of agricultural households in Indonesia. This study is essential because based on data (Burki, 2022), around 2 billion people in the world are at risk of malnutrition and face health poverty. In the agricultural sector, some risks and uncertainties cause agricultural households to face nutritional deficiencies. This study examined the effect of internet access on household food expenditure and nutrition. The study also examined the indirect effects of access to household food expenditure and nutrition through income.

Income affects internet access, namely the higher the income, the more internet access in the household (Kendall & Robin, 2020). Previous researchers found that internet access has a positive and significant effect on agricultural household income (Khan, Ray, Zhang, Osabuohien, & Ihtisham, 2022; Siaw et al., 2023). This indicates that there is a causality between the income of the household and internet usage. Internet access also affects the increase in consumption expenditure (Chunfang, Yifeng, & Suyun, 2023; Ma et al., 2020; Wu, Xu, Wang, Wang, & Zhu, 2025). Therefore, internet access has an important role in increasing household income and food expenses. Income has a favorable and noteworthy influence on household food production (Rashid, Sesabo, Lihawa, & Mkuna, 2024). The above findings indicate internet access on food expenditure either directly or indirectly or through household income.

The study of the impact of internet access on the cost of food in households is important in light of the recent development of online shopping. E-commerce is a sales activity through the Internet (Banda & Kassam, 2023). In particular, e-commerce has a favorable and noteworthy effect on increasing household food consumption (Luo XuBei, Wang Yue, & Zhang XiaoBo, 2019). E-commerce increases household consumption expenditure (Banda & Kassam, 2023). In addition, the rapid development of internet infrastructure has increased rural and urban residents' consumption of food and non-food (Chunfang et al., 2023; Ma et al., 2020).

Effects of the internet on household nutrition can be analyzed through the following mechanisms: First, internet access's direct impact on household nutrition. Internet use significantly increases the variety of family consumption in rural areas (Deng et al., 2024). Internet access leads to increased consumption of animal, aquatic, and dairy products (Cui et al., 2024). Internet use improves the nutrition of farming households (Twumasi et al.,

2021) and increases dietary knowledge, thereby improving food quality (Deng et al., 2024). Internet access significantly increases food nutrient intake, namely increasing the proportion of protein and fat intake. The percentage of carbs reaches 55-65, and a portion of it is fat, reaching 20-30% . The usage of the internet increased dramatically. The consumption of the primary nutrients (fat and protein) by people living in rural areas (Xue, Han, Elahi, Zhao, & Wang, 2021).

Second, using income mediation variables. Internet usage effects on improving nutrition' quality through household income variables (Cui et al., 2024). Based on income channels, there is heterogeneity in the effect of internet access on nutrition for energy, protein, and fat. Internet access improves nutritional status (Xue et al., 2021). The above findings indicate income's function as a mediating factor between internet access and household nutrition.

2. LITERATURE REVIEW

In developing nations, the use of the internet has various economic impacts which can be broadly grouped as follows: First the supply includes the effect of the internet on labour productivity, the effect of internet integration with other factors of production in increasing firm productivity, and the effect of the internet on increasing total factor productivity. Second, from the demand perspective, internet access reduces market and information access constraints (Hjort & Tian, 2021). With regard to the effect of the internet from the demand perspective, it is easy for companies to expand the market for the commodities produced (Satrianto & Ikhsan, 2023). E-commerce is a direct way to achieve firm goals (Hjort & Tian, 2021). E-commerce is an electronic platform where consumers and vendors meet in the exchange of goods and services (Moriset, 2020). Apart from being an exchange of goods and services, e-commerce also functions as the transmission of funds and data using an electronic platform via an internet connection (Chai, Holak, & Cole, 2021). E-commerce is an online purchasing activity using computers, tablets, cell phones, and laptops (Reardon, Tomatis, & Pedersen, 2020). E-commerce can be divided into non-food and food e-commerce. Food e-commerce has experienced rapid development since the COVID-19 pandemic (Reardon et al., 2020).

As food e-commerce has grown internationally, the study of the consequences of internet usage on household food and nutrition expenditure is closely related to the existence of e-commerce. E-commerce has several effects including 1) increasing trade and welfare of residents in cities and in remote areas, 2) reducing the negative effects of distance in trade and 3) eliminating fixed costs (Fan, Tang, Zhu, & Zou, 2018). Moreover, e-commerce has a substantial and favourable impact on real consumption in households, an increase in e-commerce marketing by one unit will increase real consumption by 0.72 % in the long run (Banda & Kassam, 2023). E-commerce is using the internet for marketing and has a major effect on population expenditure (Fan et al., 2018). The above findings indicate that internet marketing has an effect on consumption and consumer spending.

Several researchers have found a relationship between internet usage and household food expenditure. Ma et al. (2020) and Chunfang et al. (2023) in their study found that internet usage has a major impact on the cost of food for households. This result suggests that as internet usage increases, so does household food expenditure. The above findings suggest that internet usage has an immediate impact on household food expenses.

As presented at the beginning of this literature study, internet access also has an economic impact from the supply side or households as producers, namely in the form of productivity and total production factors, thereby increasing household income. Previous researchers, such as Siaw et al. (2020), W. Ma et al. (2020), and Wei et al. (2023) have found that internet use has a positive impact on overall household income. This increase in income is attributed to higher earnings from both farm and non-farm activities. Hong and Chang (2020) found that compared to homes without internet access, those with internet use earn more money. This increase in income is due to access to information on prices, production and technology. Zhang et al.'s(2021) study found that the more the utilization of Information and Internet Technology (IIT) increases, the more agricultural household income increases because

the use of IIT significantly increases the efficiency of sales channels which has an effect on increasing agricultural income. Hübler and Hartje (2016) have found that the utilization of smartphones has a beneficial effect on increasing rural household income.

Previous studies conducted by Venn, Dixon, Banwell, and Strazdins (2018), Eyasu (2020), Mulamba (2022) and Rashid et al. (2024) found that household income significantly determines food expenditure. This finding means that an increase in household income encourages households to increase food expenditure. Based on the above findings, internet use will have an indirect effect on food expenditure through the mediation of household income variables. Food expenditure determines food quality and nutritional intake; therefore, food expenditure determines household consumption patterns of quality food (Monsivais, Aggarwal, & Drewnowski, 2012).

The influence of internet usage on household nutrition will have direct effects and indirect effects, namely through the mediation of income. In terms of direct effects, utilizing the internet may increase knowledge about food so that consumer households can optimize the structure of food consumption (Ma & Jin, 2022). Twumasi et al. (2021) found that internet use significantly improved household food and nutrition. This means that the improvement of food and nutrition is in the form of quality food consumption. The study results of Ma and Jin (2022) also found that the use of the internet has a positive and significant effect on improving food quality consumption of rural households in the form of consumption of dairy products, fruits, egg commodities, vegetables, and a decrease in consumption of salt and oil products. The study results of Chen, Yang, and Hu (2022) found that the growth of the internet has an impact on the rise in consumption. The findings of Liu, Ren, Hong, Glauben, and Li (2025) assert that the internet usage has encouraged the development of sustainable food consumption, namely food consumption that is in accordance with the nutrients needed by households.

The effect of internet access on household nutrition can be analyzed through the mediation of income. This mechanism arises because internet access has a direct result on nutrition and an indirect effect through income (Cui et al., 2024). Muhammad, D'Souza, Meade, Micha, and Mozaffarian (2017) showed a decrease in nutrient intake in response to an increase in income but also a positive response to the effect of increased income on nutrient intake depending on the dietary requirements of the household. Thus, the effect of income on nutrient intake can vary by household. Improvements in household nutrition include increases in dietary diversity, increases in food knowledge, types of food preferences, and consumption of outside food (Ren, Li, & Wang, 2019). Household income determines the nutritional quality consumed, therefore households with low-income levels will buy food with low nutritional quality while households with high- income levels decide to buy food with high nutritional quality (French, Tangney, Crane, Wang, & Appelhans, 2019; Lin & Qi, 2023). The study of Lei, Zhai, and Bai (2021) found that increasing income has a substantial impact on household food demand and consumption of nutrients. Wen, Zhu, and Jia (2024) also found that rising income increases nutrient intake in rural areas. Wang, Hao, and Ma (2024) observed that a rise in overall household income considerably enhanced the rural elderly's dietary quality.

3. METHODS

The National Socio-Economic Survey (NSES) provided the cross-sectional data used in this study conducted by the Indonesian Central Bureau of Statistics (ICBS) during the March 2020 survey period. The sample size was 127,672 agricultural households from 34 provinces in Indonesia. NSES data covers socio-economic aspects and fulfilment of life needs in households, including data on food, education, health and employment opportunities collected periodically by ICBS. Data were collected using a questionnaire provided by statistics of Indonesia. Data were collected by survey officers who had been appointed by ICBS. The 2020 NSES questionnaire on internet access is in the form of a question on the use of the internet through computers, cell phones, laptops and so on) within the last 3 months. Two possible answers were provided, yes or no. The food expenditure questionnaire included questions relating to household food expenditure during the month. The nutrition questionnaire included questions on the amount of calories , protein, fat and carbohydrate intake per day of the respondent household.

3.1. Analysis Model

The influence of the internet on spending on food is given in Equation 1.

$$FEi = \alpha_0 + \alpha_1 Internet + \alpha_2 X_1 + \varepsilon_{i1} \quad (1)$$

FEi = Household food expenditure i, X_i is a vector of control variables, and e_i is a random error term. control variable (X_i) such as education (X_1), age (X_2), gender (X_3), marital status (X_4), food crops (X_5), access to credit (X_6), land ownership (X_7), city/rural (X_8).

Model analysis of the effect of internet access on household nutrition is given in Equation 2.

$$N_i = \beta_0 + \beta_1 Internet + \beta_2 X_i + \varepsilon_{i2} \quad (2)$$

Ni is household nutrition i, Xi is a random error term while ei is a vector of control variables. In the study, nutrients are categorized into calories, protein, fat, and carbohydrates.

3.2. Endogeneity Test

The internet variable potentially has endogeneity problems due to many factors that affect farmer households in accessing the internet including ICT infrastructure development, if infrastructure development in a region is better, the accessibility of internet use will be smooth (Chunfang et al., 2023). This study uses ICT infrastructure development as an instrumental variable (IV) in the endogeneity test. The endogeneity test findings are shown in Tables 1, 2 and 3.

Table 1. Endogeneity test results of food expenditure variables

Variables	Stage one	Stage two
C	14.29 **(0.000)	14.42 ***(0.000)
Internet	0.23 ***(0.000)	-0.62 ***(0.000)
R^2	0.02	-0.29
F-statistics	2989.70	219.35
Prob(F-statistic)	0.00	0.00
Durbin-Watson stat (DW)	1.82	1.83
J-statistic		0.00
Observations	127,672	

Note: ***, ** $P < 0.01$, P and $P < 0.05$.

Table 2. Nutrition variable endogeneity test results

Variables	Calories		Protein	
	Stage one	Stage two	Stage one	Stage two
C	7.65*** (0.00)	7.49*** (0.00)	4.03*** (0.00)	3.64*** (0.00)
Internet	0.03*** (0.00)	1.00*** (0.00)	0.09*** (0.00)	2.51*** (0.00)
R^2	0.00	-1.48	0.01	-5.84
F-statistic	160.86	1084.01	1026.46	1574.59
Prob(F- statistic)	0.00	0.00	0.00	0.00
DW	1.86	1.95	1.72	1.96
J-statistic		0.00		0.00
Obs.	127,672		127,672	

Note: ***, $P < 0.01$.

Tables 1, 2, and 3 can conclude that there is an endogeneity problem with the internet variable which can be indicated by 1) the difference in the internet coefficient from the first stage estimation to the second stage. 2) A very high F-statistic indicates that the IV used is very relevant. 3) J-statistic = 0 indicates that the IV used does not have over identification problems, so the instrument is valid. 4) Positive autocorrelation or DW value < 2, potentially has an endogeneity problem that needs to be addressed further.

Table 3. Endogeneity test results of fat and carbohydrate

Variables	Fat		Carbohydrate	
	Stage one	Stage two	Stage one	Stage two
C	3.80*** (0.00)	3.29*** (0.00)	5.79*** (0.00)	5.78*** (0.00)
Internet	0.16*** (0.00)	3.31*** (0.00)	-0.04*** (0.00)	0.07*** (0.00)
R^2	0.02	-6.26	0.00	-0.02
F-statistic	1963.54	1629.62	298.15	12.87
Prob(F-statistic)	0.00	0.00	0.00	0.00
DW	1.70	1.95	1.89	1.89
J-statistic		0.00		0.00
Obs.	127,672		127,672	

Note: ***, $P < 0.01$.

Considering the outcomes of the endogeneity test results, this study will use TSLS regression to estimate. 1) Internet usage's impact on food spending. 2) The effect of the internet on nutrition. The TSLS model can be used in case of variable endogeneity problems.

The equation for the determinants of the usage of the internet in rural households is given in Equation 3.

$$\text{internet}_i = \alpha_0 + \alpha_1 \text{LnIVICT} + \alpha_2 X_i + \varepsilon_i \quad (3)$$

Y is internet access. IVICT is the instrumental variable ICTs, Xi is an exogenous variable, α_0 is a constant, α_1 and α_2 regression coefficients, e_i is a random error term. Equation 4 presents the stage 2 TSLS equation model for food expenditure.

$$FE = \beta_0 + \beta_1 \widehat{\text{internet}} + \beta_2 X_i + \varepsilon_{i1} \quad (4)$$

FE is food expenditure; variable $\widehat{\text{internet}}$ is the estimation result at stage 1.

β_0 is a constant, β_1 and β_2 regression coefficients.

$\varepsilon_{i1}$is a random error term.

Equation 5 presents the TSLS simultaneous equation model stage 2 of the nutrition variable.

$$N_i = \partial_0 + \partial_1 \widehat{\text{internet}} + \partial_2 X_i + \varepsilon_{i2} \quad (5)$$

N_i is a nutrient consisting of calories, protein, fat, and carbohydrates. ∂_0 is a constant, ∂_1 dan ∂_2 regression coefficients, ε_{i2} is a random error term.

3.3. Regression Estimation Using Mediating Variables

Changes in variable X cause changes in variable Y through the following two paths: (1) the mediating variable M or indirect effect and (2) the path not through M or direct effect. Based on the above opinion, the estimated effect of internet access and food expenditure on farm household nutrition is through indirect and direct pathways. The mediation model used in this study is based on the framework proposed by Hayes (2013).

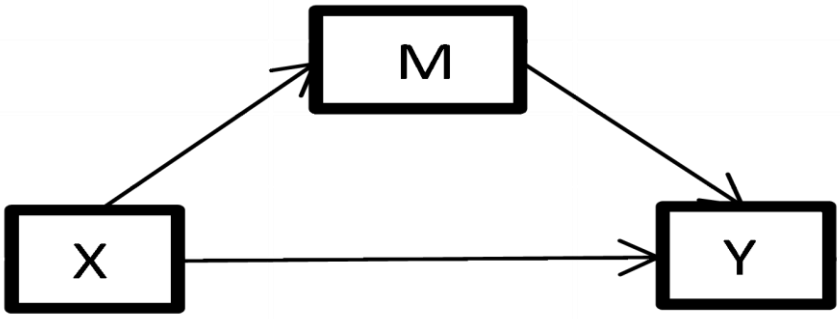

Figure 1. Conceptual diagram.

Source: Hayes (2013).

The conceptual diagram in Figure 1 shows that there is a direct effect of variable X on variable Y. In addition, there is also an indirect effect of variable X on Y with the mediation of variable M.

Based on the conceptual diagram above, the model of the equation for the effect of internet access on food expenditure is shown in Equation 6.

$$FE = \beta_0 + \beta_1 internet + \varepsilon_1 \quad (6)$$
$$Income = \beta_0 + \beta_1 internet + \varepsilon_2$$
$$FE = \beta_0 + \beta_1 internet + \beta_2 income + \varepsilon_3$$

Based on the conceptual diagram above, the impact of internet access using an equation model on nutrition is given in Equation 7.

$$N_i = \beta_0 + \beta_1 internet + \varepsilon_1 \quad (7)$$
$$Income = \beta_0 + \beta_1 internet + \varepsilon_2$$
$$N_i = \beta_0 + \beta_1 internet + \beta_2 income + \varepsilon_3$$

Income data is a proxy for total household expenditure because in the National Socioeconomic Survey, expenditure data is considered as an income proxy. In Table 4, the average food expenditure of sample farmer households amounted to US$ 1,928 calorie nutrition with a range of 2000-2650 kcal, protein nutrition per capita per day of 60.75g and fat nutrition of 50.83 g by the Ministry of Health of 50 g per capita per day. Carbohydrate nutrition amounted to 341.36 g per day. The proportion of families with farmers who use the Internet is 16.16% . The average education is not graduated from high school. The average age is 49.82 years. Gender is 89.44 % male, and marital status is 84.64%. The average family size is 4 people. On average, 43.15% of farmer households cultivate food crop commodities. Average credit access is 19.04%. The number of farmer households that own land is 82.05% , and an average of 15.16 reside in the city.

Table 4. Descriptive statistics of research variables

Variables	Variable definition	Mean	Std. dev
Food expenditure	Monthly household expenditure (USD)	1.93	1.13
Calories	Kilo calories (kcal) daily per capita	2.20	661.66
Protein	Gram (g) daily per capita	60.75	22.73
Fat	Gram (g) daily per capita	50.83	23.47
Carbohydrates	Gram (g) daily per capita	341.36	104.71
Internet access income	Yes = 1, 0 = no Monthly household income (USD)	0.16 14.85	0.37 0.58
Education	0= incomplete primary school, 1 = completed primary school, 2 = completed from junior high school, 3 = completed high school and 4= college graduate	1.22	1.12
Age	Years	49.82	12.83
Gender	1= male and 2 =female	0.89	0.31
Marital status	1 = married and 0 = other	0.85	0.36
Household size	People	3.84	1.73
Food crops	1= Food crops and 0 = other	0.43	0.50
Credit access	Yes = 1 and 0 = no	0.19	0.39
Land ownership	Yes = 1 and 0 = no	0.82	0.38
City	1 = city and 0 = other	0.15	0.36
Infrastructure development ICT	Scale index 0 – 10	5.02	0.68

4. RESULTS AND DISCUSSION

Table 5 presents the outcomes of the logistic regression estimation of the determinants of internet access in agricultural households in Indonesia. Internet access is the dependent variable. ICT infrastructure development is the IV, independent variables consist of education, age, gender, marital status, family size, food crops, access to credit, land ownership, and urban/rural location. The logistic estimation results show that the IV and all

independent variables except the marital status variable have a significant influence on internet access in agricultural households. This logistic regression estimation is the initial phase of the TSLS simultaneous analysis.

The results of the second stage estimation of food expenditure are shown in Table 5. The internet access variable has a regression coefficient of 0.18 and is significant at the 1 % level on household food expenditure. This coefficient value means that an increase in internet access by one unit will increase food expenditure by 0.18% . In other words, the more internet access increases, the more food expenditure of farm households increases. The internet access variable has a larger regression coefficient than the control variables. Control variables such as education, gender, marital status, family size, access to credit, land ownership, and urban/rural location have a substantial and favorable impact on food expenditure but the variables of age and food crop subsector have a negative and significant influence on household food expenditure.

Table 5. TSLS regression estimation results of the effect of internet access on food expenditure

Variables	First-stage internet access		Second stage Food expenditure (ln FE)
	Odds ratio	Z	
Internet access	-	-	0.18**(0.000)
ICTs infrastructure development	2.12*** (0.000)	48.96	-
Education	1.83*** (0.000)	80.59	0.05***(0.000)
Age	0.92***(0.000)	-90.99	-0.00***(0.000)
Gender	1.61 ***(0.000)	9.54	0.19***(0.000)
Marital status	1.05 (0.260)	1.13	0.05***(0.000)
Family size	0.90***(0.000)	-16.97	0.15***(0.000)
Food crops	0.70***(0.000)	-18.84	-0.09***(0.000)
Access to credit	1.51***(0.000)	20.43	0.09***(0.000)
Land ownership	1.18***(0.000)	7.34	0.01***(0.001)
City	1.72 ***(0.000)	23.96	0.03***(0.000)
C	0.05***(0.000)		13.60***(0.000)
Observations	127,672		
Log-likelihood	-42822.98		
LR statistic	27296.83		
Prob (LR statistic)	0.00		
Pseudo R^2	0.24		
R-squared			0.32
F-statistic			6022.72
Prob(F-statistic)			0.00

Note: ***, **, $P < 0.01$, and $P < 0.05$.

The results of the second stage TSLS regression estimation of the effect of internet access on household nutrition are presented in Table 6. The internet access variable has a positive and significant influence at the 1 percent level on household nutrition calories per capita per day. This finding indicates that an increase in internet access by one unit will increase calorie nutrition per capita per day by 0.04%. Thus, the more internet access increases, the higher the calorie intake per capita per day of the household.

The effect of control variables on household per capita daily calorie nutrition has positive and negative signs. The variables education, age, gender, credit access, and land ownership have a positive and significant effect on household per capita daily calorie nutrition. This finding indicates that the higher the education, age, gender, credit access, and land ownership, the higher the household per capita daily calorie nutrition. In contrast, marital status, numbers of family members, food crops, and location have a negative and significant influence on the calorie nutrition per capita per day of households. This finding indicates that the higher the marital status, number of family members, food crops and location, the lower the calorie nutrition per capita per day of the household.

The estimated effect of internet access on carbohydrate nutrition per capita per day has a regression coefficient of 0.001 and is significant at the 5 % level (see Table 6). This finding means that an increase in internet access by

one unit will increase carbohydrate nutrition per capita per day by 0.001% . In other words, the more internet access increases, the more households increase carbohydrate nutrition per capita per day.

The effect of control variables on carbohydrate nutrition has both negative and positive signs. The variables of education, marital status, family size, and city location have a negative effect on household daily per capita carbohydrate nutrition. This finding indicates that the higher the level of education, marital status, family size, and city, the lower the per capita carbohydrate nutrition per day of the household. On the other hand, gender, food crops, access to credit and land ownership have a positive sign. Therefore, an increase in these variables affects improving household daily per capita carbohydrate nutrition.

Table 6 shows that the coefficient estimate of the effect of internet access on fat nutrition per capita per day is positive and significant at the 1 percent level. The result of this study shows that an increase in internet access by one unit will significantly increase fat nutrition by 0.12% . Furthermore, the variables of education, age, gender, access to credit, and land ownership (control variables) have a positive and significant influence on fat nutrition per capita per day. An increase in education level, age, gender, access to credit, and land ownership increases the fat nutrition per capita per day of the household. However, marital status, family size, food crops, and urban location have a negative and significant influence on fat nutrition per capita per day of the household.

Table 6 Second stage TSLS regression estimation of the effect of internet access on household nutrition

Variables	Nutrition			
	ln calories	Ln carbohydrate	ln fat	ln protein
Internet access	0.04***	0.001**	0.12***	0.08***
	(0.00)	(0.02)	(0.00)	(0.00)
Education	0.01***	-0.001	0.04***	0.03***
	(0.00)	(0.13)	(0.00)	(0.00)
Age	0.002***	0.002***	0.003***	0.004***
	(0.00)	(0.00)	(0.00)	(0.00)
Gender	0.008**	0.01***	0.01	0.02***
	(0.03)	(0.00)	(0.16)	(0.00)
Marital status	-0.02***	-0.03***	-0.01**	-0.04***
	(0.00)	(0.00)	(0.01)	(0.00)
Family size	-0.07***	-0.06***	-0.10***	-0.08***
	(0.00)	(0.00)	(0.00)	(0.00)
Food crops	-0.02***	0.01***	-0.07***	-0.06***
	(0.00)	(0.00)	(0.00)	(0.00)
Access to credit	0.06***	0.03***	0.11***	0.09***
	(0.00)	(0.00)	(0.00)	(0.00)
Land ownership	0.02***	0.01***	0.06***	0.07***
	(0.000)	(0.00)	(0.00)	(0.00)
City	-0.006***	-0.07***	0.10***	0.06***
	(0.01)	(0.00)	(0.00)	(0.00)
C	7.79***	5.91***	3.95***	4.06***
	(0.00)	(0.00)	(0.00)	(0.00)
Observations	127,672			
R-squared	0.212	0.146	0.1825	0.205
F-statistic	3440.31	2182.38	2849.65	3283.09
Prob(F-statistic)	0.000	0.000	0.000	0.000

Note: ***, ** $P < 0.01$, and $P < 0.05$.

4.1. Direct Effects of Internet Access on Food Expenditure and Nutrition

The direct effect of internet access on food expenditure is positive and significant with a regression coefficient of 0.23 (see Table 7). An increase in internet access by one unit will have a direct effect on an increase in food expenditure by 0.23% . The direct effect of internet access was positive and significant at the level of 1 percent on calorie, protein, and fat nutrition with regression coefficients of 0.03, 0.09, and 0.16, respectively. These findings indicate that an increase in internet access by one unit significantly increases calorie nutrition by 0.03% , protein

nutrition by 0.09 % and fat nutrition by 0.16%. However, internet access has a significant direct effect of reducing carbohydrate nutrition by -0.04% .

Table 7. Direct effects of internet access on food expenditure and nutrition

Variables	FE	Calories	Protein	Fats	Carbohydrate
Internet	0.23***	0.03***	0.09***	0.16***	-0.04***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	4.62***	7.65***	4.03***	3.80***	5.79***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	127,672	127,672	127,672	127,672	127,672
f-statistic of the first-stage	2,989.70	160.86	1,026.46	1,963.54	298.16

Note: ***, $P < 0.01$.

Indirect effects of internet access on food expenditure and nutrition is given in Table 8. The direct effect of internet access on income is positive and significant at 1 %. An increase in internet access by one unit significantly increased the income of farmer households by 0.33 %. These findings show that the more internet access increases, the higher the income of agricultural households.

Table 8. Effects of internet access on food expenditure and nutrition with income mediation

Variables	Ln_income	FE	Calories	Protein	Fats	Carbohydrate
Internet	0.33***	-0.06***	-0.003***	0.05***	0.09***	-0.06***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ln_income	-	0.90***	0.09***	0.13***	0.18***	0.06***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	5.13***	0.03***	7.16***	3.37***	2.89***	5.48***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Observations	127,672	127,672	127,672	127,672	127,672	127,672

Note: ***, $P P < 0.01$.

The effect of internet access on food expenditure was negative and significant with a regression coefficient of 0.06 through increased income. Increasing internet access by one unit reduces food expenditure by 0.06% through increased revenue.

The effect of internet access with income mediation was negative and significantly decreased calorie and carbohydrate nutrition with coefficients of 0.003 and 0.06 respectively. These findings indicate that increasing internet access by one unit significantly decreases calorie and carbohydrate nutrition by 0.003 and 0.06 %, respectively. The indirect effects of internet access on protein and fat nutrition were positive and significant with coefficients of 0.05 and 0.09. The results of the study mean that the increase in internet access per unit increases protein and fat nutrition through an increase in agricultural household income.

The direct effect of internet access on the food expenditure of agricultural households in Indonesia is positive and significant with a p-value of < 0.001 (see Table 7). The results of this study indicate that the higher the internet access, the higher the food expenditure of agricultural households in Indonesia. The results of this study are in line with the findings of Cui et al. (2024) and Xue et al. (2021). Internet access increases household food expenditure.

The results of the study found that internet access has a significant effect on reducing food expenditure through an increase in income (see Table 8). Negative effects after including income-mediating variables in the regression analysis of the relationship between internet access and food expenditure must occur statistically (Acheampong, Erdiaw-Kwasie, & Abunyewah, 2021). This finding is relevant to the study by Wu et al. (2025). Income variables are mediators in the relationship between household consumption expenditure and internet access.

The effect of internet access on food expenditure will increase if control variables are used (Chunfang et al., 2023). The study found that education, gender, marital status, family size, access to credit, land ownership, and

urban/rural location have a favorable and noteworthy impact on food spending which is in line with the study of Wu et al. (2025). The food crop sub-sector variable has a detrimental and substantial impact on household food expenses. It is suspected that an increase in food crop agricultural products encourages farmer households to consume their agricultural products, thereby reducing food expenditure.

Based on the study results, all of the aforementioned control variables significantly influence on Indonesian farming households' food expenditures.. This finding supports the findings of previous researchers that demographic, geospatial, and socio-economic variables determine food expenditure (Damari & Kissinger, 2024).

Household food expenditure has a significant influence on nutrition, i.e., the more expenditure increases, the more household nutrition increases (Cui et al., 2024). The internet usage significantly and favorably affects on the nutrition (calories, protein, fat, and carbohydrates) of agricultural households in Indonesia (see Table 7). The results of this study are reinforced by the finding (see Table 8) that internet access directly has a favorable and noteworthy impact on calorie, protein, and fat nutrition but has a negative and significant influence on carbohydrate nutrition. This result shows that household nutrition is significantly impacted by internet availability. The results of this study are relevant to previous research that internet use improves the nutritional status of the population (Xue et al., 2021).

Nutritious food is reflected in its diversity and quality. In this regard, internet access can improve food diversity and quality (Cui et al., 2024; Twumasi et al., 2021). Internet as a tool to improve nutrition (Cui et al., 2024). The important role of the Internet in household nutritional quality is because internet access increases household knowledge of food, thereby improving food quality (Deng et al., 2024).

Internet access also has a significant and indirect effect on household nutrition through the mediation of income variables. This study shows that internet access has an impact on through income mediation that was positive and significantly improved protein and fat nutrition, suggesting that there were cases of partial mediation. However, the income-mediating effect significantly decreases calorie and carbohydrate nutrition, or there is a case of perfect mediation. This result is consistent with the investigation of Cui et al. (2024) that internet use improves nutrition through mediating income.

5. CONCLUSION

This study analyzes the direct and indirect effects of internet access with income mediation on food expenditure and nutrition of farmer households. The data in this study are cross-sectional data from the National Socio-Economic Survey (NSE) of the Central Statistics Agency (CSA) in March 2020. The sample size is 127,672 agricultural households from 34 provinces in Indonesia. In this study, the internet access variable is endogenous, so the research uses the TSLS model to estimate the effect of internet access on household food expenditure and nutrition. The results found that internet access has a positive and significant direct effect on household food expenditure and nutrition (calories, protein, fat, and carbohydrates). In addition, this study found that there are two indirect effects of internet access on farmers' household food expenditure. First, internet access has a significant effect on increasing food expenditure with income mediation. Second, internet access has a significant effect on reducing food expenditure through increased income or perfect mediation. This study also found two effects of the indirect effect of internet access on farmer household nutrition with income mediation. First, internet access has a significant indirect effect on reducing calorie and carbohydrate nutrition with income mediation (perfect mediation). Second, Internet access has a significant indirect effect on improving protein and fat nutrition with income mediation (partial mediation).

This study has contributed to the literature. First, the economics of agricultural and rural household nutrition, the results of this study strengthen the findings of previous studies related to the effects of internet access on agricultural household nutrition. Second, the impact of ICT on welfare. Internet access has various positive effects on the welfare of agricultural households, thus supporting the findings of previous studies. Third, agricultural

economics regarding consumption. Changes in household food consumption behavior are related to the development of the food industry.

Limitations of this study are as follows: first, the income data used in this study is a proxy for total expenditure due to the limited availability of National Socioeconomic Survey data. Second, this study only examined nutritional intake consisting of calories, protein, fat, and carbohydrates. Further researchers could use other nutritional measures, such as more complete food consumption.

Funding: This study received no specific financial support.
Institutional Review Board Statement: The Ethical Committee of the Universitas Negeri Padang, Indonesia has granted approval for this study on 27 August 2024 (Ref. No. 4156/UN35.15/TU/2024).
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: Conceptualization, definitions, empirical analysis, discussions, Sri Ulfa Sentosa (S.U.S.); data processing, data curation, Alpon Satrianto (A.S.); techniques analysis, conclusions, Urmatul Uska Akbar (U.U.A.); collecting of literature, project administration, validation, Dwirani Puspa Artha (D.P.A.); translation, grammar checking, study of literature, Ariusni (A). All authors have read and agreed to the published version of the manuscript.

REFERENCES

Acheampong, A. O., Erdiaw-Kwasie, M. O., & Abunyewah, M. (2021). Does energy accessibility improve human development? Evidence from energy-poor regions. *Energy Economics*, *96*, 105165. https://doi.org/10.1016/j.eneco.2021.105165

Ajibade, A., Amao, A., Sulaimon, O., Daud, S., & Omotoso, A. (2024). Economic survey of household expenditure pattern during COVID-19 pandemic in Ogun State, Nigeria. *International Journal of Agricultural Science and Food Technology*, *10*(2), 041-045. https://dx.doi.org/10.17352/2455-815X.000205

Banda, L. G., & Kassam, Z. Z. (2023). E-commerce and household consumption in the United States: An arrangement of convenience. *Cogent Business & Management*, *10*(3), 2275360. https://doi.org/10.1080/23311975.2023.2275360

Burki, T. (2022). Food security and nutrition in the world. *The Lancet Diabetes & Endocrinology*, *10*(9), 622. https://doi.org/10.1016/S2213-8587(22)00220-0

Chai, W., Holak, B., & Cole, B. (2021). *E-commerce*. Retrieved from https://www.techtarget.com/searchcio/definition/e-commerce

Chen, Y., Yang, W., & Hu, Y. (2022). Internet development, consumption upgrading and carbon emissions—an empirical study from China. *International Journal of Environmental Research and Public Health*, *20*(1), 265. https://doi.org/10.3390/ijerph20010265

Chunfang, Y., Yifeng, Z., & Suyun, W. (2023). The impact of the Internet on household consumption expenditure: An empirical study based on China Family Panel Studies data. *Economic Research-Ekonomska istraživanja*, *36*(3), 2150255. https://doi.org/10.1080/1331677X.2022.2150255

Cui, Y., Zhao, Q., Glauben, T., & Si, W. (2024). The impact of Internet access on household dietary quality: Evidence from rural China. *Journal of Integrative Agriculture*, *23*(2), 374-383. https://doi.org/10.1016/j.jia.2023.11.014

Damari, Y., & Kissinger, M. (2024). An integrated multiyear assessment framework of households' food consumption sustainability aspects. *Resources, Conservation and Recycling*, *204*, 107471.

Deng, Z., Liu, J., Hong, Y., & Liu, W. (2024). The effect of Internet use on nutritional intake and health outcomes: New evidence from rural China. *Frontiers in Nutrition*, *11*, 1364612. https://doi.org/10.3389/fnut.2024.1364612

Eyasu, A. M. (2020). Determinants of poverty in rural households: Evidence from North-Western Ethiopia. *Cogent food & agriculture*, *6*(1), 1823652. https://doi.org/10.1080/23311932.2020.1823652

Fan, J., Tang, L., Zhu, W., & Zou, B. (2018). The Alibaba effect: Spatial consumption inequality and the welfare gains from e-commerce. *Journal of International Economics*, *114*, 203-220. https://doi.org/10.1016/j.jinteco.2018.07.002

French, S. A., Tangney, C. C., Crane, M. M., Wang, Y., & Appelhans, B. M. (2019). Nutrition quality of food purchases varies by household income: The SHoPPER study. *BMC Public Health, 19*, 1-7. https://doi.org/10.1186/s12889-019-6546-2

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach* (1st ed.). New York: The Guilford Press.

Hjort, J., & Tian, L. (2021). The economic impact of internet connectivity in developing countries. *Annual Review of Economics, 17*. http://dx.doi.org/10.2139/ssrn.3964618

Hong, Y.-Z., & Chang, H.-H. (2020). Does digitalization affect the objective and subjective wellbeing of forestry farm households? Empirical evidence in Fujian Province of China. *Forest Policy and Economics, 118*, 102236. https://doi.org/10.1016/j.forpol.2020.102236

Hübler, M., & Hartje, R. (2016). Are smartphones smart for economic development? *Economics Letters, 141*, 130-133. http://dx.doi.org/10.1016/j.econlet.2016.02.001

Indonesian Internet Service Providers Association. (2024). *Number of Indonesian internet users reaches 221 million people*. Jakarta, Indonesia: Indonesian Internet Service Providers Association.

Kendall, S., & Robin, G. (2020). People in low-income households have less access to internet services. In (pp. 1–2). Washington, D.C: Evaluation, U.S. Department of Health and Human Services.

Khan, N., Ray, R. L., Zhang, S., Osabuohien, E., & Ihtisham, M. (2022). Influence of mobile phone and internet technology on income of rural farmers: Evidence from Khyber Pakhtunkhwa Province, Pakistan. *Technology in Society, 68*, 101866. https://doi.org/10.1016/j.techsoc.2022.101866

Lei, L., Zhai, S.-X., & Bai, J.-F. (2021). The dynamic impact of income and income distribution on food consumption among adults in rural China. *Journal of Integrative Agriculture, 20*(1), 330-342. https://doi.org/10.1016/s2095-3119(20)63239-7

Lin, X., & Qi, Y. (2023). Influence of consumption decisions of rural residents in the context of rapid urbanization: evidence from sichuan, China. *Sustainability, 15*(23), 16524. https://doi.org/10.3390/su152316524

Liu, J., Ren, Y., Hong, Y., Glauben, T., & Li, Q. (2025). Does Internet use help to achieve sustainable food consumption? Evidence from rural China. *Sustainable Futures*, 100466. https://doi.org/10.1016/j.sftr.2025.100466

Luo XuBei, L. X., Wang Yue, W. Y., & Zhang XiaoBo, Z. X. (2019). E-commerce development and household consumption growth in China. *Policy Research Working Paper, 8810*, 1–48. http://documents.worldbank.org/curated/en/146951554905409975

Ma, B., & Jin, X. (2022). Does internet use connect us to a healthy diet? Evidence from rural China. *Nutrients, 14*(13), 2630. https://doi.org/10.3390/nu14132630

Ma, W., Nie, P., Zhang, P., & Renwick, A. (2020). Impact of Internet use on economic well-being of rural households: Evidence from China. *Review of Development Economics, 24*(2), 503-523. https://doi.org/10.1111/rode.12645

Monsivais, P., Aggarwal, A., & Drewnowski, A. (2012). Are socio-economic disparities in diet quality explained by diet cost? *Journal of Epidemiology Community Health, 66*(6), 530-535. https://doi.org/10.1136/jech.2010.122333

Moriset, B. (2020). e-Business and e-commerce. *International Encyclopedia of Human Geography (Second Edition), 4*, 1-10. https://doi.org/10.1016/B978-0-08-102295-5.10044-7

Muhammad, A., D'Souza, A., Meade, B., Micha, R., & Mozaffarian, D. (2017). How income and food prices influence global dietary intakes by age and sex: Evidence from 164 countries. *BMJ Global Health, 2*(3), e000184. https://doi.org/10.1136/bmjgh-2016-000184

Mulamba, K. C. (2022). Relationship between households' share of food expenditure and income across South African districts: A multilevel regression analysis. *Humanities and Social Sciences Communications, 9*(1), 1-11. https://doi.org/10.1057/s41599-022-01454-4

Na, H., & Kang, J. (2023). Research on the impact of internet use on fertilizer and pesticide inputs: Empirical evidence from China. *Heliyon, 9*(10), e20816. https://doi.org/10.1016/j.heliyon.2023.e20816

Rashid, F. N., Sesabo, J. K., Lihawa, R. M., & Mkuna, E. (2024). Determinants of household food expenditure in Tanzania: Implications on food security. *Agriculture & Food Security*, *13*(1), 13. https://doi.org/10.1186/s40066-023-00462-0

Reardon, T., Tomatis, F., & Pedersen, E. (2020). Evolution of food e-commerce during the COVID-19 pandemic. Investment brief. Rome, FAO. https://doi.org/10.4060/cc3650en

Ren, Y., Li, H., & Wang, X. (2019). Family income and nutrition-related health: Evidence from food consumption in China. *Social Science & Medicine*, *232*, 58-76. https://doi.org/10.1016/j.socscimed.2019.04.016

Satrianto, A., & Ikhsan, A. (2023). The effect of information and communication technology on economic growth high-income countries. *Asian Economic and Financial Review*, *13*(9), 621–634. https://doi.org/10.55493/5002.v13i9.4824

Siaw, A., Jiang, Y., Twumasi, M. A., & Agbenyo, W. (2020). The impact of internet use on income: The case of rural Ghana. *Sustainability*, *12*(8), 3255. https://doi.org/10.3390/SU12083255

Siaw, A., Twumasi, M. A., Agbenyo, W., Ntiamoah, E. B., Amo-Ntim, G., & Jiang, Y. (2023). Empirical impact of financial service access on farmers income in Ghana. *Ciência Rural*, *53*, e20220345. https://doi.org/10.1590/0103-8478cr20220345

Statistics Indonesia. (2022). *Welfare indicators: A study on information and communication technology (ICT) and its impact on employment and income inequality*. Indonesia: Statistics Indonesia.

Twumasi, M. A., Jiang, Y., Asante, D., Addai, B., Akuamoah-Boateng, S., & Fosu, P. (2021). Internet use and farm households food and nutrition security nexus: The case of rural Ghana. *Technology in Society*, *65*, 101592. https://doi.org/10.1016/j.techsoc.2021.101592

Venn, D., Dixon, J., Banwell, C., & Strazdins, L. (2018). Social determinants of household food expenditure in Australia: The role of education, income, geography and time. *Public Health Nutrition*, *21*(5), 902-911. https://doi.org/10.1017/S1368980017003342

Wang, G., Hao, Y., & Ma, J. (2024). Family income level, income structure, and dietary imbalance of elderly households in rural China. *Foods*, *13*(2), 190. https://doi.org/10.3390/foods13020190

Wang, X., Chen, J., & Du, X. (2024). Understanding the impact of Internet access on farmers' willingness to participate in farmer professional cooperatives. *Agricultural Economics/Zemědělská Ekonomika*, *70*(7), 349–361. https://doi.org/10.17221/69/2024-agricecon

Wei, X., Liu, Y., & Liu, Y. (2023). Study on the impact of internet usage, aging on farm household income. *Sustainability*, *15*(19), 14324. https://doi.org/10.3390/su151914324

Wen, P., Zhu, N., & Jia, M. (2024). Changes in food consumption and nutrition intake of rural residents in central China. *Heliyon*, *10*(16), e36523. https://doi.org/10.1016/j.heliyon.2024.e36523

Wu, Y., Xu, G., Wang, X., Wang, S., & Zhu, W. (2025). The impact of internet use and life satisfaction on household consumption expenditure: Based on empirical data from Chinese surveys. *International Review of Economics & Finance*, *97*, 103767. https://doi.org/10.1016/j.iref.2024.103767

Xue, P., Han, X., Elahi, E., Zhao, Y., & Wang, X. (2021). Internet access and nutritional intake: Evidence from rural China. *Nutrients*, *13*(6), 1–15. https://doi.org/10.3390/nu13062015

Zhang, F., Sarkar, A., & Wang, H. (2021). Does internet and information technology help farmers to maximize profit: A cross-sectional study of apple farmers in Shandong, China. *Land*, *10*(4), 390. https://doi.org/10.3390/land10040390