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An Analysis of Factors Influencing African Indigenous Vegetable Farmers' Bargaining Power: A Case Study from Zambia

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ABSTRACT
Growing African Indigenous Vegetables (AIVs) is an innovative way to address poverty and malnutrition problems in Zambia. Farmers' bargaining power plays an important role in increasing AIV production and farmers' income. Based on 300 responses from Zambian AIV farmers, we defined AIV farmers' bargaining power and analyzed its benefits to farmers and the AIV industry. We used the ordered logistic regression model (OLRM) to analyze the influence of several factors that contribute to farmers' bargaining power, and then use the interpretative structural modeling (ISM) to analyze the relationship and hierarchical structure between the effects. Four key results and innovations arose from the analysis of the data. Growing African Indigenous Vegetables (AIVs) is an innovative way to address poverty and malnutrition problems in Zambia. Farmers' bargaining power plays an important role in increasing AIV production and farmers' income. Based on 300 responses from Zambian AIV farmers, we defined AIV farmers' bargaining power and analyzed its benefits to farmers and the AIV industry. We used the ordered logistic regression model (OLRM) to analyze the influence of several factors that contribute to farmers' bargaining power, and then use the interpretative structural modeling (ISM) to analyze the relationship and hierarchical structure between the effects. Four key results and innovations arose from the analysis of the data. First, we defined farmers' bargaining power through their self-reported bargaining power. Second, we found that the respondents' bargaining power was significantly influenced by seven variables: age, gender, education, main trading partners, awareness of AIV prices, and distance to the market from the farm. Second, the main trading partners and awareness of AIV prices are surface direct factors, gender, education and distance to the market from the farm are middle indirect relationships, and age, belong to any community are deep root factors. Last, farmers' bargaining power can be improved through education, especially women's education level, strengthening farmers' organization construction, altering some of the farmers' trading methods, and developing infrastructure.

Keywords: AIVs, Negotiating prices, Selling prices, Influencing factor analysis, Profitability

1. Introduction

Sub-Saharan Africa is the only region in the world where hunger is prevalent in over one-third of the population, and people have been threatened by low income and malnutrition for decades (Cumani & Rojas 2016). In Zambia, 60% of the population lives below the poverty line, and 42% are considered in extreme poverty (World Bank 2017). Because of poverty, many children suffer from micronutrient deficiency, and Zambia is one of the most nutritionally deficient countries in the world (Nkobole et al. 2016).

Increased production and consumption of African Indigenous Vegetables (AIVs) would help address problems related to nutrition and increase food supply and income for rural households (Mwadzingeni et al. 2021). In 2019, Africa produced 192.1 million tons of cassava, which feeds nearly 800 million people in West Africa. Yam production of 72.4 million tons is an important component of the region's economic development (Arumugam et al. 2022). Moreover, the AIVs such as amaranth, nightshade, African eggplant, jute mallow, and okra, can provide African people with nutrients (Yang et al. 2009; Byrnes et al. 2017; Gogo et al. 2017; Hoffman et al. 2018) and help reduce the number of nutrition-related diseases in Africa (Kamga et al. 2013; Weller et al. 2015). Additionally, except for the contributions made to food security, as a commercial product, AIVs have immense potential for creating employment opportunities and increasing household income in rural as well as peri-urban areas

(Gido et al. 2016), which is becoming a source of income for smallholder farmers in some regions such as Arumeru, Tanzania and Kiambu, and Kenya (Shackleton et al. 2010).

Despite AIVs' vital role in improving health and nutrition, their popularity in production is much lower than staple crops such as maize and even far less than European-introduced vegetables (Ayua et al. 2017; Weller et al. 2015; Chepkoech et al. 2023). Due to various restrictions, AIVs are in short supply, primarily neglected, and have in the past been considered "poor people's" plants (Muhanji et al. 2011). Some researchers conclude that the main reasons are that AIVs are prone to deterioration (Gogo et al. 2017) and the non-availability of improved seeds (Adebooye et al. 2005). While those factors contribute to current constraints, others argue that the most important constraint relates to market factors (Shackleton et al. 2010). By strengthening the value chain, the potential of AIVs as food can be unleashed and become a significant way to address Africa's food security and nutrition problems (Weller et al. 2015; Kansiime et al. 2018).

In many Sub-Saharan African countries, farmers' uncertainty about market prices is usually high, and traders may take advantage of farmers' ignorance of the market price and extract rent from them by offering very low prices for their products (Courtois & Subervie 2015). Bargaining power, as the ability of farmers to negotiate better conditions for the sale of their produce (including such factors as price, timing, quantity, and quality) (Gebert 2010), plays an important role in promoting farmers' market status (Falkowski et al. 2017). If a farmer has more bargaining power, she/he may earn more in the AIVs' selling market through improved farmers' selling prices, leading to increased farmers' income and market participation enthusiasm.

Previous studies have discussed the factors affecting bargaining power from different angles. Some works refer to production factors, such as farm size (Dries et al. 2009), the distance between a farm and its contractor (Falkowski 2012), farmers outside options (Vandeplas et al. 2013), and even the development and introduction of irrigation (Mwangi & Crewett 2019). Other studies have reported on power relations within the food supply chain and farmers' marketing decisions (Hingley 2005; Fischer et al. 2007; Leat & Revoredo-Giha 2008). Momanyi et al. (2015) thoroughly studied group marketing and concluded that group marketing can make full use of the advantages of production and sales clusters to improve bargaining power and obtain better sale prices. Handschuch and Wollni (2016) studied gender factors in price-fixing in western Kenya, and results show that female farmers may obtain higher selling prices when participating in a group. Additionally, other studies have focused on Market Information Services (MIS) (Courtois & Subervie 2015) and a streamlined and effective sales system (Bauhardt et al. 2015), finding that MIS can improve farmers' bargaining power and then increase their profits.

However, although there are many related studies, systematic research on the bargaining power of AIV farmers has not yet been reported. Therefore, in this paper, we address the following three questions: (1) Do Zambian farmers have enough bargaining power to sell AIVs? (2) If they obtain more bargaining power, what benefits would accompany that new position? (3) What are the factors that influence their bargaining power? What is the structure of the influencing factors?

2. Material and Methods

2.1. Sample selection

The analysis is based on the survey data gathered in Zambia, a landlocked country in south-central Africa where agriculture is predominantly dependent on rain-fed subsistence farming. The survey, which included 300 participating respondents, each involved in AIV small-scale production, was conducted in October and November of 2015. There were a total of five districts interviewed: Lusaka province (including Lusaka and Chongwe) and Chipata, Lundazi, Katete, and Petauke districts from Eastern Province (including 50 producers from Lusaka, 50 from Katete, 50 from Chipata, 75 from Lundazi, and 75 from Petauke). The interviewees were mostly farmers who belonged to ready-made cooperatives.

A structured questionnaire was used to collect information about the respondents' household demographics, land ownership, assets, labor allocation, vegetable production, marketing, access to financial capital, and constraints in AIV farming. The survey was conducted in English and the native provincial language. Along with the sixteen interviewers trained in questionnaire handling and the local languages (Bemba, Nyanja, etc.), data associates, district managers, and technology transfer officers in the eastern province conducted the survey. Numerators were trained to be engaged in such surveys; each completed the CITI (Collaborative Institutional Training Initiative) certificate, and each respondent agreed to be interviewed following proper protocols. The survey was designed to specifically collect data about nine AIVs, namely: amaranth, nightshade, spider plants, cowpea, jute mallow, kale, sweet potato leaves, orange sweet potato, and okra. These were the most popular AIVs reported in an earlier focus group and prior studies in these same geographical regions.

2.2. Extraction of influencing factors

Many factors influenced AIV farmers' bargaining power, including individual and family characteristics, production and organizational characteristics, and market characteristics (Shackleton et al. 2010; Muhanji et al. 2011; Krause et al. 2019; Vivas et al. 2022). The results of Arumugam et al. (2022) showed that older people have more bargaining power, men have more bargaining power, and more educated farmers have more bargaining power. Moreover, production and organization

characteristics also play an important role in influencing farmers' bargaining power. Some studies find that farmers who contact the market frequently and have benefited from the MIS program usually have more bargaining power (Courtois & Subervie 2015). Therefore, based on the above study, we selected three aspects of individual and family characteristics, production and organizational characteristics, and market characteristics to measure the factors influencing the bargaining power of AIV farmers. Among them, individual and family characteristics include age, gender, and education. Production and organizational characteristics include AIVs planting proportion, changing production costs, belong to any community. Market characteristics include main trading partners, nearest market meet frequency, awareness of AIVs prices, and distance to market from the farm (Table 1).

Table 1 – Variables definition and description

Category		*Variables*	*Symbol*	*Definition*	*Mean*	*SD*
Dependent variable		bargaining power	BP	1=full bargaining power 1/2=half bargaining power 1/3=one-third bargaining power 0=no bargaining power	0.702	0.342
Independent Variables	Individual and family characteristics	age	age	Actual age	45.370	13.025
		gender	gender	1=male; 0=female	0.790	0.408
		education	edu2	1=primary and below; 0=others	0.620	0.501
			edu3	1=secondary; 0=others	0.200	0.401
			edu4	1=college; 0=others	0.160	0.370
			edu5	1=university; 0=others	0.020	0.140
	Production and organizational characteristics	AIVs planting proportion	planting	AIVs planting area/total planting area	29.278	25.643
		changing production costs	cost_in	1=increased; 0=others	0.560	0.497
			cost_de	1=decreased; 0=others	0.110	0.318
		belong to any community	community	1=belong; 0=not	0.970	0.171
	Market characteristics	main trading partners	partner_con	1=Direct to consumers or roadside stands; 0=others	0.080	0.272
			partner_mar	1=Direct to supermarkets or retailers; 0=others	0.740	0.439
		nearest market meet frequency	market_daily	1=daily; 0=others	0.200	0.398
			market_twice	1=twice a week; 0=others	0.110	0.318
			market_thrice	1=thrice a week; 0=others	0.020	0.140
			market_weekly	1=weekly; 0=others	0.660	0.473
		awareness of AIVs prices	price	1=aware of AIVs prices before sale; 0=not	0.830	0.373
		distance to market from the farm	distance	Average distance of all AIVs	5.387	14.866

2.3. Method

This study is based on the ordinal logistic regression model (OLRM), which is typically used to solve cumulative approach problems. Generally, when the outcome represents an underlying continuous scale subdivided into several categories, the most adequate modeling framework is a cumulative approach (Fullerton 2009). The OLRM can be written as follows (Williams 2006):

$$P(Y_i > j) = g(X_i > \beta_j) = \left\{ exp(\alpha_j + X_i\beta_j) \Big/ 1 + [exp(\alpha_j + X_i\beta_j)] \right\} \quad (1)$$

In formula (1), j=1, 2,…, M-1, where M is the number of categories of the ordinal dependent variable. From the above, it can be determined that the probabilities that Y will take on each of the values 1, …, M are equal to

$$P(Y_i = 1) = 1 - g(X_i\beta_j) \quad (2)$$

$$P(Y_i = j) = g(X_i\beta_{j-1}) - g(X_i\beta_j) \quad (3)$$

$$P(Y_i = M) = g(X_i\beta_{M-1}) \quad (4)$$

When M=2, the model is equivalent to the logistic regression model. And, in this study, M=4. The identification of significant variables for each logit of Y is carried out by using a stepwise selection procedure. The decision to include a variable is based on the significance of the log-likelihood ratio of the estimation and the x^2 statistical test of the variables. After a variable is

included, it is tested to see whether the exclusion of a variable included at an earlier stage causes a significant decline in the log-likelihood. This process is terminated when the inclusion of an extra variable does not lead to a significant improvement in the model. The level of significance for acceptance and rejection in the stepwise selection is 0.01, 0.05, and 0.1, respectively.

3. Results and Discussion

3.1. Results of the survey

3.1.1. Bargaining power of the sample

In our research, in order to measure farmers' bargaining power more accurately, we used self-reported strength with one question: "Who fixed the price of AIVs?". As shown in Figure1, about 55% of respondents stated that they fixed the sale price on their own; 22% stated that the prices were fixed after negotiation; 4% stated that the price was fixed by the buyer; and 18% stated that the prices were fixed by a middleman or broker.

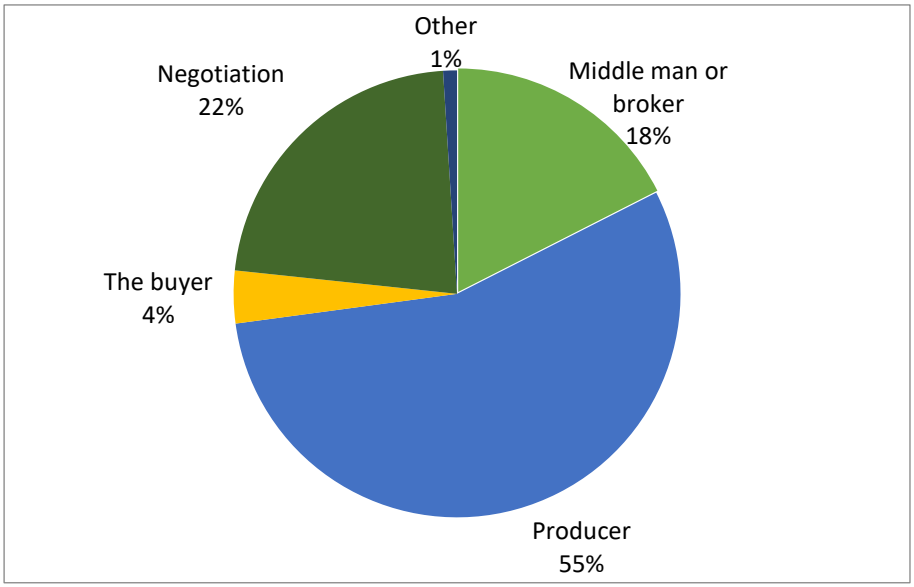


Figure 1 – Determination of sales prices for indigenous African vegetables (AIVs) by Zambian growers

Drawing on the studies of Ngenoh et al. (2019) and Arumugam et al. (2022), we categorized every respondent's bargaining power into four levels (Table 2). If the price was fixed by oneself, we considered he/she to have full bargaining power; if the price was fixed after negotiation, we thought she/he had half bargaining power; if it was fixed by a middleman or broker, we defined it as having one-third bargaining power; or if the price was fixed by the buyer or another, we thought he/she had no bargaining power.

Table 2 – Definition of different levels or categories of bargaining power

Level	*The price was fixed by?*	*Definition*	*Numerical value*
1	Oneself	full bargaining power	1
2	Negotiation	half bargaining power	1/2
3	Middleman or broker	one-third bargaining power	1/3
4	The buyer or another	no bargaining power	0

Second, if one's bargaining power belongs to levels 1 to 3, we asked her/him another question: "Have you had the opportunity to bargain for higher producer prices?" If the respondent replied "yes", we did not change her/his level; if her/his reply was "no", we marked it as the next level. Eventually, about 47% of respondents (141 respondents) had full bargaining power, 21% (63 respondents) had half bargaining power, 20% (60 respondents) had one-third bargaining power, and 12% (36 respondents) had no bargaining power.

3.1.2. Advantages of having bargaining power

For the farmers that grow AIVs, the more bargaining power one has, the higher the price she/he may obtain. For farmers with different bargaining powers, the AIVs prices' changing ratios in the past five years are different (Figure 2). About 67% of respondents with full bargaining power stated that their AIVs prices have increased in the past five years. The ratios for half-

bargaining power, one-third bargaining power, and no bargaining power were 46.15%, 41.18%, and 36.36%, respectively. The decreased AIV price ratios for different bargaining power farmers were 5.59%, 10.77%, 15.69%, and 18.18%, respectively.

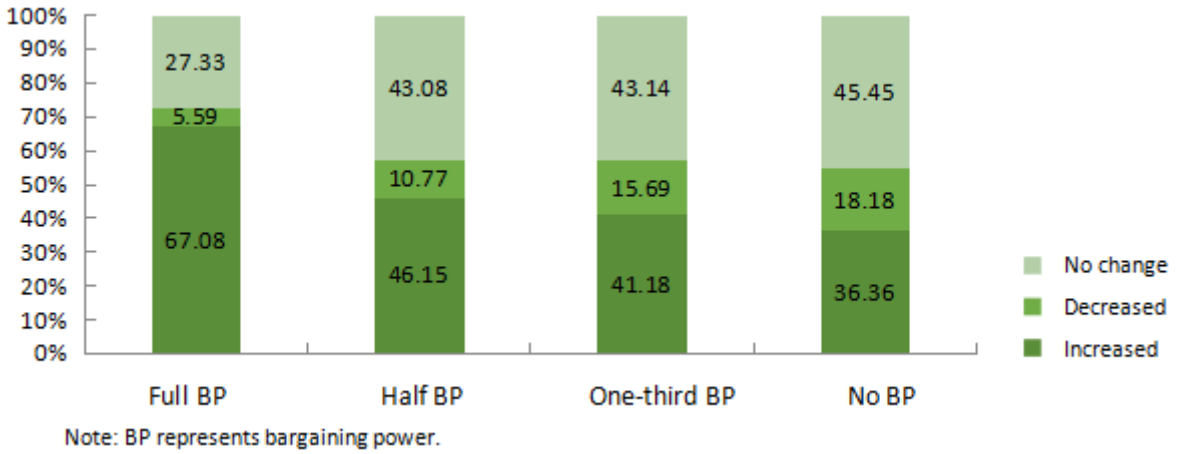


Figure 2 – AIVs prices' changing ratio of the last five years according to different bargaining power (%)

For farmers that grow African indigenous vegetables, the more bargaining power one has, the faster she/he can get the payment. As shown in Figure 3, about 85% of respondents stated that they got paid at the time of selling the AIVs. The average ratios for half bargaining power farmers were 85%, while one-third bargaining power, and no bargaining power for farmers were 78%, and 57%, respectively.

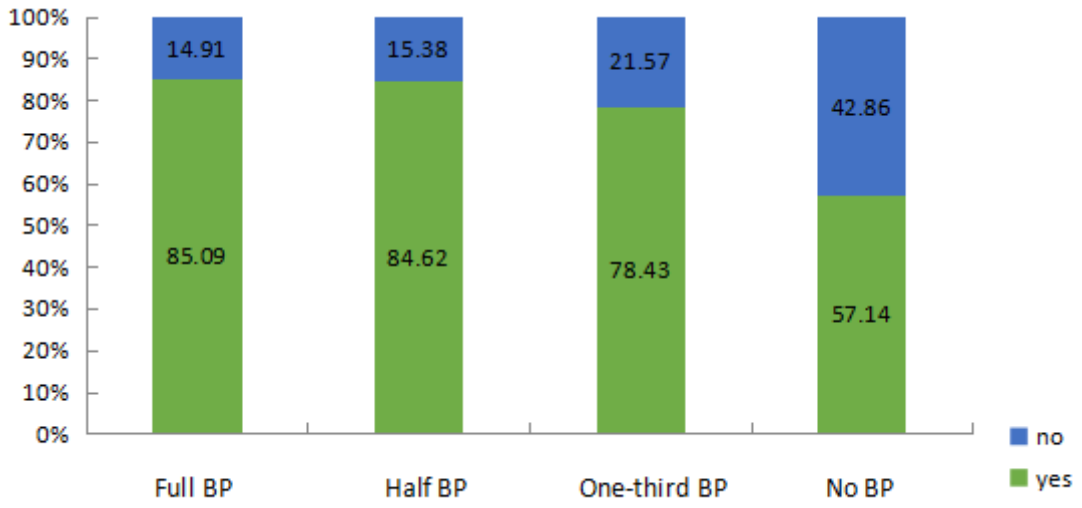


Figure 3 – The ratio of "whether you get paid at the time of selling the AIVs" (%)

For farmers that grow African indigenous vegetables, the more bargaining power one has, the more income one gets from the sale of African indigenous vegetables. About 24% of respondents with full bargaining power (39 respondents) selected "sale of AIVs" as the main source of household income (Figure 4) and the ratios of respondents with half bargaining power, one-third bargaining power, and no bargaining power who selected "sale of AIVs" as the main source of household income were only 21%, 5%, and 13%, respectively.

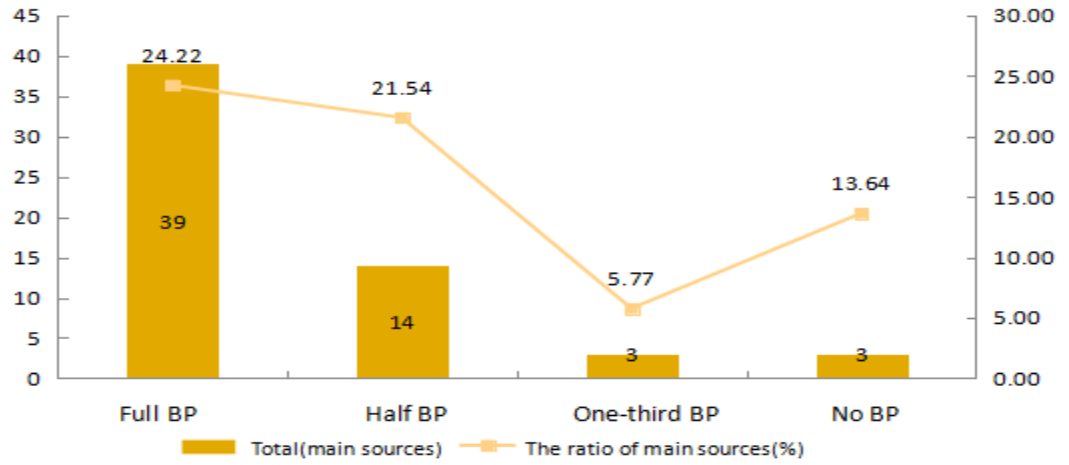


Figure 4 – The number and ratio that select "Sale of AIVs" as the main source of household income

We next analyzed the ratio of one respondent's AIV income to her/his total income. The average ratio of the respondents with full bargaining power was 27%, which meant 27% of their income was from the sales of AIVs. The figures for half bargaining power, one-third bargaining power, and no bargaining power were only 10%, 14%, and 9%, much lower than 27% (Figure 5).

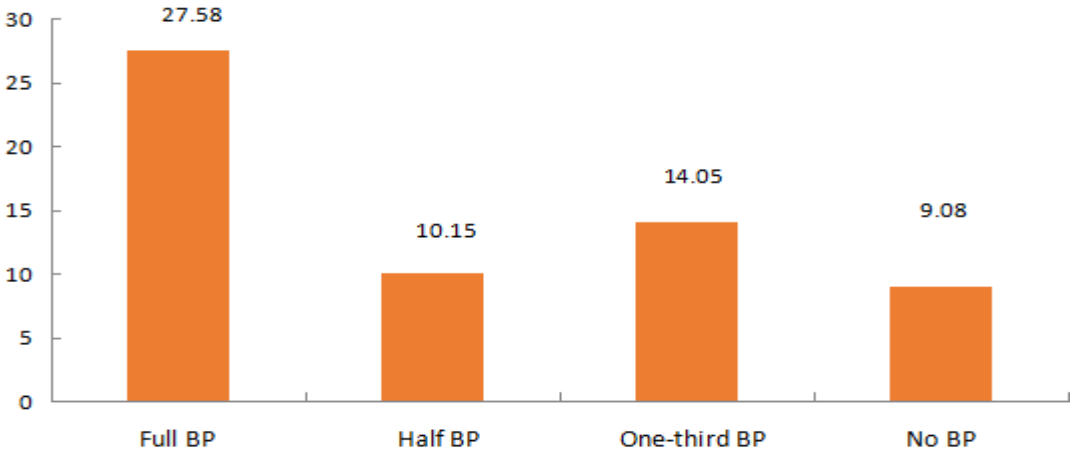


Figure 5 – The ratio of AIVs income to total income (%)

For the African indigenous vegetable industry, once farmers have higher bargaining power, they are willing to grow more African indigenous vegetables, which will further promote the African indigenous vegetable market's development. Researchers who analyzed the relationship between bargaining power proxies and coffee output found that with coffee, there was a significant negative correlation (Lim et al. 2007). In contrast, with our survey on AIVs, we found that the average planting area of farmers who had full bargaining power was greater than those who had partial bargaining power or no bargaining power (Figure 6).

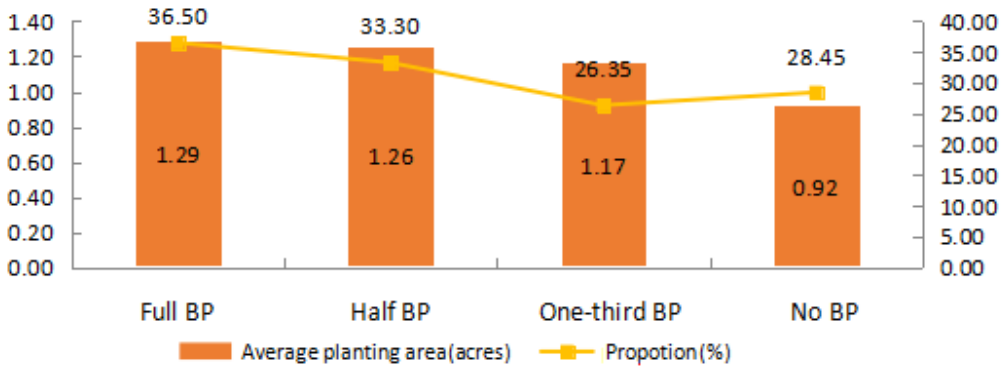


Figure 6 – Average AIVs planting area and its proportion according to different bargaining powers

Overall, the analysis indicates that bargaining power plays an important role in raising agricultural product prices, increasing farmers' income, and promoting industrial development. We further analyze the empirical results.

3.2. Results of empirical analysis

3.2.1. Model fitting information and parallel lines test

The statistical package SPSS 23.0 is used for carrying out the OLRM analysis. First, we performed a multi-collinearity test. We found that the variable "nearest market meet frequency" failed the multi-collinearity test and therefore dropped that variable and then performed the same test on other variables. Then, we ran the model again. The model fitting information shows the significant value of the model is less than 0.01 through the chi-square test, indicating that it passed the test at 1% significance (Table 3). That is, the results indicate that all the independent variables collectively significantly contribute to the change in the dependent variable. The x^2 in parallel lines test is 18.520, p=0.231>0.05, so it passes the test of the parallel line and can be analyzed by OLRM.

Table 3 – Model fitting information and parallel lines test

Type of test	*Model*	*-2 Log Likelihood*	x^2	*Df*	*Sig.*
Model fitting information	Intercept only	696.452			
	Final	648.127	48.325	14	0.000
Parallel lines test	Null Hypothesis	648.127			
	General	466.607	18.520	28	0.231

The regression results are reported in Table 4. B is the coefficient of variables, and Exp(B) is the odds ratio (OR). The results show that seven variables pass the test of significance. They are age, gender, education, main trading partners, being aware of AIVs prices, belonging to a group/community, and distance to market from the farm.

Table 4 – Regression results of OLRM

Variable	*B*	*S.E.*	*95% Confidence Interval*		*Wald* x^2	*Exp(B)*	*95% Confidence Interval of Exp(B)*	
			lower limit	*Upper limit*			*lower limit*	*Upper limit*
[BP=.00]	4.08	1.86	0.45	7.72	4.84	59.14	1.56	22 41.31
[BP=.33]	5.60	1.86	1.96	9.24	9.09	270.62	7.10	10 311.77
[BP=.50]	6.73	1.87	3.07	10.39	12.97	837.89	21.50	32 660.85
Gender	-0.68**	0.28	-1.23	-0.13	5.85	0.51	0.29	0.88
Age	0.04***	0.01	0.02	0.06	12.66	1.04	1.02	1.06
Edu1	1.43***	0.43	0.59	2.27	11.18	4.19	1.81	9.70
Edu2	1.11**	0.47	0.18	2.03	5.48	3.02	1.20	7.62
Edu3	1.41***	0.49	0.45	2.38	8.19	4.11	1.56	10.82
Edu4	1.45	1.01	-0.54	3.43	2.04	4.25	0.58	30.97
Cost_in	-0.09	0.26	-0.59	0.42	0.12	0.92	0.55	1.51
Cost_de	-0.12	0.40	-0.91	0.67	0.09	0.89	0.41	1.95
Community	-0.70**	0.67	-2.00	0.61	1.10	0.50	0.14	1.83
Partner_con	1.22***	0.39	0.45	1.98	9.78	3.38	1.58	7.24
Partner_mar	1.61***	0.52	0.59	2.63	9.49	4.99	1.80	13.89
Price	-0.66**	0.33	-1.30	-0.02	4.08	0.52	0.27	0.98
Planting	-0.01	0.01	-0.02	0.01	1.66	0.99	0.98	1.00
Distance	-0.02**	0.01	-0.03	-0.01	5.77	0.98	0.97	1.00
Cox & Snell R^2	0.15							
Nagelkerke R^2	0.17							

Notes: ** and *** are statistically significant at 5% and 1%, respectively

(1) Individual and family characteristics influence

A farmer's age has a significant influence on their bargaining power. Its OR is 1.036, indicating that if one farmer's age increases by one year, the odds of having more bargaining power will increase by a factor of 1.036. For a female, the odds of having more bargaining power are 0.507 times as large as the odds for a male. This is consistent with many previous studies (Breda, 2015; Lenjiso et al. 2016; Lim et al. 2007). In comparison with no education, primary education, secondary education, and college education are significant at 0.05 levels, which means good education is helpful to improve farmers' bargaining power, and their odds of having more bargaining power are about 4.2 times, 3.0 times, and 4.1 times, respectively, that of farmers who have no education. This is a key finding to use in capacity training, education, and awareness programs for growers.

(2) Production and organizational characteristics' influences

There are three variables in production and organizational characteristics, including AIVs planting proportion, changing production costs, and belonging to any community. For a farmer who did not take part in a community, the odds of having more bargaining power are only 0.497 times higher than for farmers who participated in a community.

(3) Market characteristics' influences

Awareness of AIVs' prices and distance to market from the farm do have significant influences on farmers' bargaining power (Table 4). Information was found to play a vital role in increasing farmers' bargaining power. The farmers who knew the AIV price before the sale created a psychological expectation of the price and were reluctant to bargain. The odds of it are about twice that of the farmers who are not. This is also in line with the findings that were previously reported (Draganska et al. 2010). The distance to the market from the farm is significant at the 0.05 level. This can explain why there are large differences in bargaining power among the five districts (Table 5). Differences between the reported bargaining powers between districts as observed may in part be due to growers having a shorter distance from farm to market. Delayed infrastructure construction may also lead to lower prices for rural households (Bumbangi et al. 2016; Sinyangwe et al. 2016). There are three main trading partners for farmers: direct to consumers or roadside stands; direct to supermarkets or retailers; or direct to brokers or wholesalers. Take the last as a reference; the other two main trading partners are significant in influencing farmers' bargaining power. The farmers who sell their products direct to consumers, roadside stands, supermarkets, or retailers are more likely to have high bargaining power; the odds of this are about 3.4 and 4.9 times higher than those who sell directly to brokers or wholesalers.

Table 5 – Bargaining power and distance to market in each of the five districts in Zambia

Districts	*Lusaka*	*Lundazi*	*Chipata*	*Petauke*	*Katete*
Respondents with Full BP	35	25	6	35	45
Respondents with Half BP	11	0	42	8	3
Respondents with One-third BP	2	24	1	0	0
Respondents with No BP	2	1	1	7	2
Average BP	0.82	0.55	0.55	0.73	0.93
Distance to market from the farm	2.11	12.49	6.98	2.59	0.62

3.3. Prediction success of the model

We use the cross-tabulation of bargaining power and predicted response category to test the prediction success of the model (Table 6). The correct predictions of no bargaining power, 1/3 bargaining power, 1/2 bargaining power, and full bargaining power are 5, 32, 33, and 143, respectively. So, the prediction success of the model is (5+32+33+143)/300=71%.

Table 6 – Bargaining power and predicted response category cross-tabulation

Variable			*Predicted response category*				*Total*
			No BP	*1/3 BP*	*1/2 BP*	*Full BP*	
BP	No BP	Count	5	1	0	16	22
		% within BP	22.7%	4.5%	0.0%	72.8%	100.0%
	1/3 BP	Count	0	32	7	13	52
		% within BP	0.0%	61.5%	13.4%	25.0%	100.0%
	1/2 BP	Count	0	6	33	26	65
		% within BP	0.0%	9.2%	50.8%	40%	100.0%
	Full BP	Count	1	7	10	143	161
		% within BP	0.6%	4.3%	6.2%	88.8%	100.0%
Total		Count	6	46	50	198	300
		% within BP	2.0%	15.3%	16.7%	66.0%	100.0%

3.4. Further analysis

Although the OLRM can be used to calculate and identify the factors influencing the bargaining power of AIVs and their degree of influence, it cannot effectively reflect the underlying and process elements of the model. Therefore, the next step of this paper is to use the ISM model to analyze the correlation and hierarchy among the factors influencing the bargaining power of AIVs in order to identify the root factors affecting the quality of employment. Drawing on Roson et al. (2015), the specific steps of the analysis are as follows :

3.4.1. Determine the relevant factors

According to the estimated results of OLRM, seven factors affect the bargaining power of AIVs. Through the integration of the above factors, the influence of African indigenous vegetable farmers bargaining power ISM (interpretative structural modeling) has seven factors: F_1 on behalf of gender, F_2 on behalf of age, F_3 on behalf of education, F_4 on behalf of community, F_5 on behalf of the main trading partners, F_6 on behalf of farmers price, F_7 on behalf of the distance to market from the farm.

3.4.2. Establish adjacency matrix

After consulting five African experts engaged in agriculture-related research to conduct simple inferential statistics on the data in this paper, and after in-depth discussions and judgments based on relevant literature, the logical relationships between variables were determined and the adjacency matrix A was established. The adjacency matrix in Table 7 describes the relationships between the elements in the system, where "1" indicates row factors have direct or indirect influence on column factors, and "0" means no influence.

Table 7 – Adjacency matrix A

	F_1	F_2	F_3	F_4	F_5	F_6	F_7
F_1	1	0	0	0	1	1	0
F_2	0	1	1	0	0	0	0
F_3	0	0	1	0	1	1	0
F_4	0	0	0	1	1	0	1
F_5	0	0	0	0	1	1	0
F_6	0	0	0	0	1	1	0
F_7	0	0	0	0	1	0	1

3.4.3. Establish achievable matrix

As shown in Table 8, we use Matlab 7.0 to obtain the achievable matrix M of the adjacency matrix A by using formula (5), where I denotes the unit matrix and the Boolean operator is used for the power operation of the matrix.

$$M = (A + I)^{+1} = (A + I) \neq (A + I)^{-1} \neq (A + I)^2 \neq (A + I) \quad (5)$$

Table 8 – Achievable matrix M

	F_1	F_2	F_3	F_4	F_5	F_6	F_7
F_1	1	0	0	0	1	1	0
F_2	0	1	1	0	1	1	0
F_3	0	0	1	0	1	1	0
F_4	0	0	0	1	1	1	1
F_5	0	0	0	0	1	1	0
F_6	0	0	0	0	1	1	0
F_7	0	0	0	0	1	1	1

3.4.4. Determine the hierarchy between factors

$M(F_i) \cap N(F_i) = M(F_i)$ is the hierarchical decomposition of factors and extraction based on conditions. $M(F_i)$ represents the set of all factors in the accessible matrix M that can be reached from factor F_i. $N(F_i)$ represents the set of factors in the accessible matrix M of accessible factor F_i. According to the accessible matrix M and the above conditions, the accessible sets and advance sets of the factors are shown in Table 8. In this study, by calculation, the $L_1 = \{F_5, F_6\}$. The elements of F_5 and F_6 in the original accessible matrix M are extracted to obtain a new matrix, then and so on, and finally, $L_2 = \{F_1, F_3, F_7\}$ and $L_3 = \{F_2, F_4\}$. Thus, the goal of performing a hierarchical decomposition of the accessible matrix M is achieved (Table 9).

Table 9 – Reachable set, antecedent set and its intersection

	$M(F_i)$	$N(F_i)$	$M(F_i) \cap N(F_i)$
F_1	1, 5, 6	1	1
F_2	2, 3, 5, 6	2	2
F_3	3, 5, 6	2, 3	3
F_4	4, 5, 6, 7	4	4
F_5	5, 6	1, 2, 3, 4, 5, 6, 7	5, 6
F_6	5, 6	1, 2, 3, 4, 5, 6, 7	5, 6
F_7	5, 6, 7	4, 7	7

3.4.5. Establish an explanatory structural model

According to the hierarchical structure among the factors, the factors at the same level are represented by boxes in the same position. Based on the logical relationship between the factors, each factor was connected with a directed line segment to obtain the correlation and hierarchy among the factors influencing the bargaining power of AIVs farmers. As shown in Table 7, age and community play a deep-rooted role in the bargaining power of AIVs farmers. Gender, education and distance to market are key connecting variables at the intermediate level. Awareness of AIVs prices and marketing partners are direct causes at the superficial level such as influencing the bargaining power of AIVs farmers.

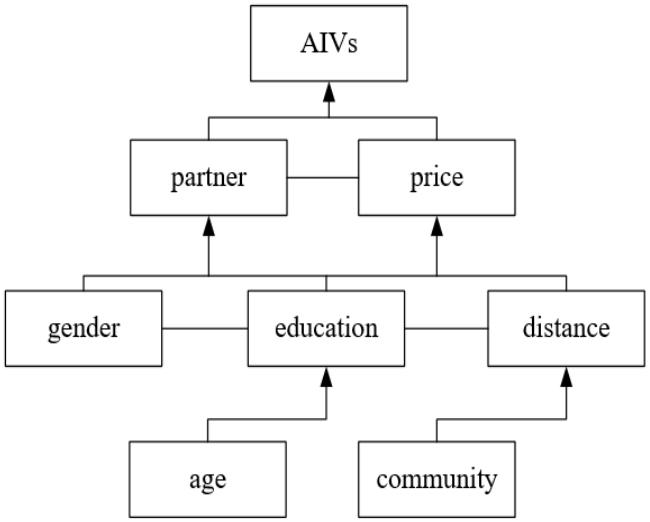


Figure 7 – The correlation relationship and the hierarchical structure of the influencing factors

4. Conclusions

Based on data obtained from a field study in Zambia, a landlocked country in south-central Africa, this paper investigates the bargaining power of 300 vegetable farmers in five states of Zambia. The bargaining power of AIV farmers and the factors influencing them were studied through a Logistic-ISM model and the following conclusions were drawn:

First, we defined farmers' bargaining power through their self-reported bargaining power. We found that bargaining power has played an important role in obtaining higher prices, getting faster payment, getting more income from AIV sales, and expanding AIV planting areas for farmers. The promotion production and power expand the scope of higher interests, enhances vegetable farmers' ability to manage risks, unleashes the potential of vegetable production, and facilitates the transformation and upgrading of the vegetable industry. This, in turn, increases the income of AIVs farmers.

Second, we used OLRM to analyze the influence of several factors that contribute to farmers' bargaining power. Results indicated that respondents' bargaining power is significantly influenced by seven variables: age, gender, education, main trading partners, awareness of AIVs prices, belonging to a group/community, and distance to the market from the farm. Among them, education, age, and major trading partners had a positive effect on the bargaining power of farmers. Gender, community, awareness of AIVs prices, and distance to market from the farm had a negative effect on the bargaining power of farmers. Further analysis of interactions of the seven significant influencing factors using ISM revealed that the age and community attributes of farmers are the deep root factors that affect the bargaining power of AIVs farmers. Gender, education and distance to market from the farm were the three intermediate level factors. Awareness of AIVs prices and marketing partners were the direct factors influencing the bargaining power of AIV farmers.

Finally, it is important to note that the farmers' bargaining power can be improved by improving farmers' education, strengthening farmers' organization construction, altering some of the farmers' trading methods, and developing infrastructure. To improve the bargaining power of AIVs farmers in the market, several measures can be taken. Firstly, by improving their education and training, farmers can better utilize various policies and negotiate more effectively. Secondly, strengthening their organizational structure can reduce costs and increase bargaining power. Thirdly, changing their trading methods and increasing sales concentration can lead to long-term benefits. Finally, developing infrastructure can expand their trading range and improve their bargaining power. Moreover, this provides a clear path for future studies to incorporate such training and education for smallholder farmers as part of a larger best practices approach. These findings should be considered by international and national public policy programs that continually seek to reduce poverty and strengthen market access for smallholder farmers.

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References

Adebooye O C, Ajayi S A, Baidu-Forson J J & Opabode J T (2005). Seed constraint to cultivation and productivity of African indigenous leafy vegetables. *African Journal of Biotechnology* 4(13): 1480-1484

Arumugam S, Govindasamy R, Simon J E, Van Wyk E & Ozkan B (2022). Market outlet choices for African Indigenous Vegetables (AIVs): a socio-economic analysis of farmers in Zambia. *Agricultural and Food Economics* 10(1): 28

Ayua E, Mugalavai V, Simon J, Weller S, Obura P & Nyabinda N (2017). Comparison of a mixed modes solar dryer to a direct mode solar dryer for African indigenous vegetable and chili processing. *Journal of Food Processing and Preservation* 41(6): 7

Bauhardt C, Brückner M & Caglar G (2015). *Understanding consumer behaviour: the social embeddedness of food practices.* Paper presented at the 143rd Joint EAAE/AAEA Seminar, March 25-27, 2015, Naples, Italy

Breda T (2015). Firms' rents, workers' bargaining power and the union wage premium. *Economic Journal* 125(589): 1616-1652

Bumbangi N F, Muma J B, Choongo K, Mukanga M, Velu M R, Veldman F, Hatloy A & Mapatano M A (2016). Occurrence and factors associated with aflatoxin contamination of raw peanuts from Lusaka district's markets, Zambia. *Food Control* 68: 291-296

Byrnes D R, Dinssa F F, Weller S C & Simon J E (2017). Elemental micronutrient content and horticultural performance of various vegetable Amaranth genotypes. *Journal of the American Society for Horticultural* 142(4): 265-271

Chepkoech W, Stoeber S, Kurgat B K, Bett H K, Mungai N W & Lotze-Campen H (2023). What drives diversity in climate change adaptation strategies for African indigenous vegetable production in Kenya? *Economic Analysis and Policy* 77: 716-728

Courtois P & Subervie J (2015). Farmer Bargaining Power and Market Information Services. *American Journal of Agricultural Economics*, 97(3): 953-977

Cumani M & Rojas O (2016). Characterization of the agricultural drought prone areas on a global scale. *Food and Agriculture Organization of the United Nations*. http://www.fao.org/3/a-i5764e.pdf

Dries L, Germenji E, Noev N & Swinnen J F M (2009). Farmers, Vertical Coordination, and the Restructuring of Dairy Supply Chains in Central and Eastern Europe. *World Development* 37(11): 1742-1758

Falkowski J (2012). Dairy supply chain modernisation in Poland: what about those not keeping pace? *European Review of Agricultural Economics* 39(3): 397-415

Falkowski J, Malak-Rawlikowska A & Milczarek-Andrzejewska D (2017). Farmers' self-reported bargaining power and price heterogeneity Evidence from the dairy supply chain. *British Food Journal* 119(8): 1672-1686

Fischer C, Gonzalez M A, Henchion M & Leat P (2007). Trust and economic relationships in selected European agrifood chains. *Acta Agriculturae Scandinavica, Section C — Food Economics* 4(1): 40-48

Fullerton, A. S. (2009). A Conceptual Framework for Ordered Logistic Regression Models. *Sociological Methods & Research* 38(2): 306-347

Gebert R (2010). Farmer Bargaining Power in the Lao PDR: Possibilities and Pitfalls. *Joint Sub-Working Group on Farmers and Agribusiness & Helvetas*

Gido E O, Bett H K & Bokelmann W (2016). Importance of African Indigenous Vegetables in Food Systems. *African Journal of Horticultural Science* 10: 7-7

Gogo E, Opiyo A, Ulrichs C & Huyskens-Keil S (2017). Nutritional and economic postharvest loss analysis of African indigenous leafy vegetables along the supply chain in Kenya. *Postharvest Biology and Technology*, 130: 39-47

Handschuch, C. and M. Wollni (2016). Traditional Food Crop Marketing in Sub-Saharan Africa: Does Gender Matter? *Journal of Development Studies* 52(3): 343-359

Hingley M K (2005). Power imbalanced relationships: cases from UK fresh food supply. *International Journal of Retail & Distribution Management* 33(8): 551-569

Hoffman D, Merchant E, Byrnes D & Simon J E (2018). Preventing micronutrient deficiencies using African Indigenous vegetables in Kenya and Zambia. *Sight and Life* 32(2): 177-181

Kamga R T, Kouamé C, AtanganaA, Chagomoka T & Ndango R (2013). Nutritional evaluation of five African indigenous vegetables. *Journal of Horticultural Research* 21(1): 99-106

Kansiime M K, Karanja D K, Alokit C & Ochieng J (2018). Derived demand for African indigenous vegetable seed: implications for farmer-seed entrepreneurship development. *International Food and Agribusiness Management Review* 21(6): 723-739

Krause H, Fasse A & Grote U (2019). Welfare and food security effects of commercializing African indigenous vegetables in Kenya. *Cogent Food & Agriculture 5*(1)

Leat P & Revoredo-Giha C (2008). Building collaborative agri-food supply chains. *British Food Journal* 110(4-5): 395-411

Lenjiso B M, Smits J & Ruben R (2016). Transforming Gender Relations through the Market: Smallholder Milk Market Participation and Women's Intra-household Bargaining Power in Ethiopia. *Journal of Development Studies* 52(7): 1002-1018

Lim S S, Winter-Nelson A & Arends-Kuenning M (2007). Household bargaining power and agricultural supply response: Evidence from Ethiopian coffee growers. *World Development* 35(7): 1204-1220

Momanyi D, Lagat K & Ayuya O I (2015). Determinants of smallholder African indigenous leafy vegetables farmers' market participation behaviour in Nyamira County, Kenya. *J. Econ. Sustain* 16: 212-217

Muhanji G, Roothaert R L, Webo C & Stanley M (2011). African indigenous vegetable enterprises and market access for small-scale farmers in East Africa. *International Journal of Agricultural Sustainability* 9(1): 194-202

Mwadzingeni L, Afari-Sefa V, Shimelis H, N'Danikou S, Figlan S, Depenbusch L, Derera J (2021). Unpacking the value of traditional African vegetables for food and nutrition security. *Food Security* 13(5): 1215-1226

Mwangi J K & Crewett W (2019). The impact of irrigation on small-scale African indigenous vegetable growers' market access in peri-urban Kenya. *Agricultural Water Management* 212: 295-305

Ngenoh E, Kurgat B K, Bett H K, Kebede S W & Bokelmann W (2019). Determinants of the competitiveness of smallholder African indigenous vegetable farmers in high-value agro-food chains in Kenya: A multivariate profit regression analysis. *Agricultural and Food Economics* 7(1): 2

Nkobole N, Hussein A & Prinsloo G (2016). Metabolomics profile of wild versus cultivated South African indigenous/traditional African leafy vegetables. *South African Journal of Botany* 103(339)

Roson R & Hubert F (2015). Bargaining Power and Value Sharing in Distribution Networks: A Cooperative Game Theory Approach. *Networks & Spatial Economics* 15(1): 71-87

Shackleton C, Paumgarten F, Mthembu T, Ernst L, Pasquini M & Pichop G (2010). Production of and trade in African indigenous vegetables in the urban and peri-urban areas of Durban, South Africa. *Development Southern Africa* 27(3): 291-308

Sinyangwe D M, Mbewe B & Sijumbila G (2016). Determination of dichlorvos residue levels in vegetables sold in Lusaka, Zambia. *The Pan African Medical Journal* 23(113)

Vandeplas A, Minten B & Swinnen J (2013). Multinationals vs. Cooperatives: The Income and Efficiency Effects of Supply Chain Governance in India. *Journal of Agricultural Economics* 64(1): 217-244

Vivas J, Kim M K, Takagi C & Kirimi L (2022). Adopting African Indigenous Vegetables: A Dynamic Panel Analysis of Smallholders in Kenya. *Journal of Agricultural and Resource Economics*, *48*(1)

Weller S C, Van Wyk E & Simon J E (2015). Sustainable production for more resilient food production systems: case study of African indigenous vegetables in eastern Africa. *Acta Horticulture* 1102(1102): 289-298

Williams R (2006). Generalized ordered logit/partial proportional odds models for ordinal dependent variables. *Stata Journal* 6(1): 58-82

World Bank (2017). The World Bank in Zambia. http://www.worldbank.org/en/country/zambia/ overview.

Yang R Y, Wu W J & Oluoch M (2009). Are African Indigenous vegetables nutritious? evaluation and comparison of nutritional values among indigenous, adapted, and exotic vegetables in tropical Africa. *Annals of Nutrition and Metabolism* 55: 170-171

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