



Article

Proposed Changes in Polish Agricultural Products Consumption Structure for 2030 Based on Data from 2008–2018

Anna Kuczuk ^{1,*}  and Katarzyna Widera ² ¹ Faculty of Mechanical Engineering, Opole University of Technology, 45-758 Opole, Poland² Faculty of Economics and Management, Opole University of Technology, 45-758 Opole, Poland; k.widera@po.edu.pl

* Correspondence: a.kuczuk@po.edu.pl

Abstract: The type of acquired food products is a derivative of various factors which depend both on economic aspects and consumer awareness. The purpose of this article is to present possible scenarios of changes in Polish agricultural products consumption structure in 2030 which may be due to increased consumer awareness and a transition to a more sustainable consumption. Suggested scenarios took into account both the supply side of Polish agricultural consumer products and the demand for such products. This study is based on data retrieved from FAOSTAT and Poland's Central Statistical Office. We demonstrated that domestic agricultural production is capable of supplying Poland's population with a sufficient amount of high-energy food products and proteins. Moreover, suggested scenarios anticipating reduced consumption of selected types of meat and cereals should not cause energy or protein deficiency. Total available energy (kcal/cap/day) in a scenario with reduced intake of selected animal and plant products (+/−75% scenario) could be 4141 while maintaining a balanced proportion of energy derived from protein (14.5%), animal proteins (48%) and an increase in the share of energy from plant production.

Keywords: food supply; food consumption forecast; domestic food; sustainable food consumption; Poland



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1. Introduction

Pretty [1] (p. 3) points to the problem of the need to change food consumption, writing: “Something is wrong with our agricultural and food systems. (. . .) hundreds of millions of people remain hungry and malnourished. Further hundreds of millions eat too much, or the wrong sorts of food, and it is making them ill”. This phenomenon is present in almost every country, including Poland, where the conventional system of agriculture dominates with food overproduction and overconsumption. As reported by Vermeir et al. [2], food preferences, choices and eating habits are notoriously hard to change. They are a central aspect of people's lifestyles and their sociocultural environment. However, the transition to more sustainable schemes of food consumption seems to be a necessity in environmental, economic and public health terms [3].

The type of acquired food products is a derivative of various factors which depend both on economic factors and consumer awareness. Likewise, the quality of purchased food, a concept variously defined [4–6], could be determined by consumers' environmental awareness, the environment in which food is produced, and their health. Kearney [7] argues that food consumption is affected differently by multiple factors, including availability or choice. They may depend on geographical factors, demographics, disposable income, socioeconomic status, urbanization, globalization, marketing, religion, culture and, last but not least, consumer attitudes. The latter may involve preference for domestically-produced, locally-grown, minimally-processed, vegetarian products or products with quality certificates. The consumers of those types of products are often characterized by the so-called ‘consumer patriotism’ or even eco-consumption [8]. In terms of consumers' health

and respect for the natural environment, the optimum approach would be to purchase eco-farming products. Numerous studies suggest that those products offer superior nutritional value [9–12]. Considering the fact that agriculture in its conventional form is still dominant, both in Poland and globally [13], we may expect that in the nearest future organic food will not be available to the majority of the human population.

Our article focuses on sustainable food consumption, which we define as a consistent supply of products crucial to satisfy the nutritional needs of the human body, but first and foremost products of exclusively domestic origin. In addition, we suggest that the proportion of plant products in the nutritional structure should be increased. At the same time, we do not deviate from commonly applied concepts concerning sustainable consumption. According to the FAO [14] (p. 7), sustainable food consumption is defined as: “*diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources*”. Other authors [15] also argue that sustainable food consumption should be based on wider availability of organic products but also increased access to regionally-produced food in supermarkets or diners, reduced meat consumption and a lower intake of junk food and unhealthy drinks in general.

The purpose of the present article is to present possible change scenarios with regard to the consumption structure of Polish agricultural products in the year 2030. We assume that the changes may result from increased consumer awareness leading to the transition to a more sustainable diet, involving mainly changes in the structure of consumed animal products. We argue that such a diet should only include domestic food, with a higher proportion of plant products as well as a reduction in selected animal products. A question asked in this study is also whether exclusively domestic agricultural production is capable of providing Poland’s population with a sufficient supply of products of high nutritional quality by satisfying energy and protein requirements. Our analysis is restricted to agricultural products and based on an assumption that they are intended for the domestic market only.

A base year was designed with the use of elements of descriptive statistics according to statistical data on Polish agricultural production for the years 2008–2018. The base year served as a departure point for the analysis of scenarios for 2030. Suggested scenarios took into account the supply side of Polish agricultural consumer products. We also established the demand for products, defined as the level of human energy requirement in kilocalories (kcal). The study is based on data retrieved from FAOSTAT and Poland’s Central Statistical Office.

The following parts of the article include: theoretical reference to the problem of food production and consumption in Poland, applied methods and calculations, as well as the results and their discussion.

2. Theoretical Background—Chosen Aspects of Food Production, Structure and Quantity of Consumed Food Products in Poland

In the period from 2008 to 2018, a departure point for developing possible scenarios, the consumption of selected food products in households rose on average from 38.11 (in 2008) to 31.84 kg/cap/month (in 2018). This also translates into a change in each product’s share in the entire consumption structure discussed here. Vegetables, bread, cereal products and meat products had the largest relative proportions in the diet (Figure 1). At the same time, from 2008 to 2018, there was a slight decrease in the proportion of vegetables (by 2.7%) and bread and cereals (by 2.3%) in the entire consumption structure. A change in the diet and consumer preferences due to health considerations could be of significance for the latter category. Admittedly, the amount of meat consumed fell from 5.6 to 5.2 kg/cap/month, yet the share of meat in overall consumption in the years 2008 to 2018 rose by 1.6%. In comparison to those quantities, in 2018 Poles ate on average 5.48 kg/cap/month of bread and cereal products, 3.75 kg/cap/month of fruits and 7.92 kg/caps/month of vegetables [16,17].

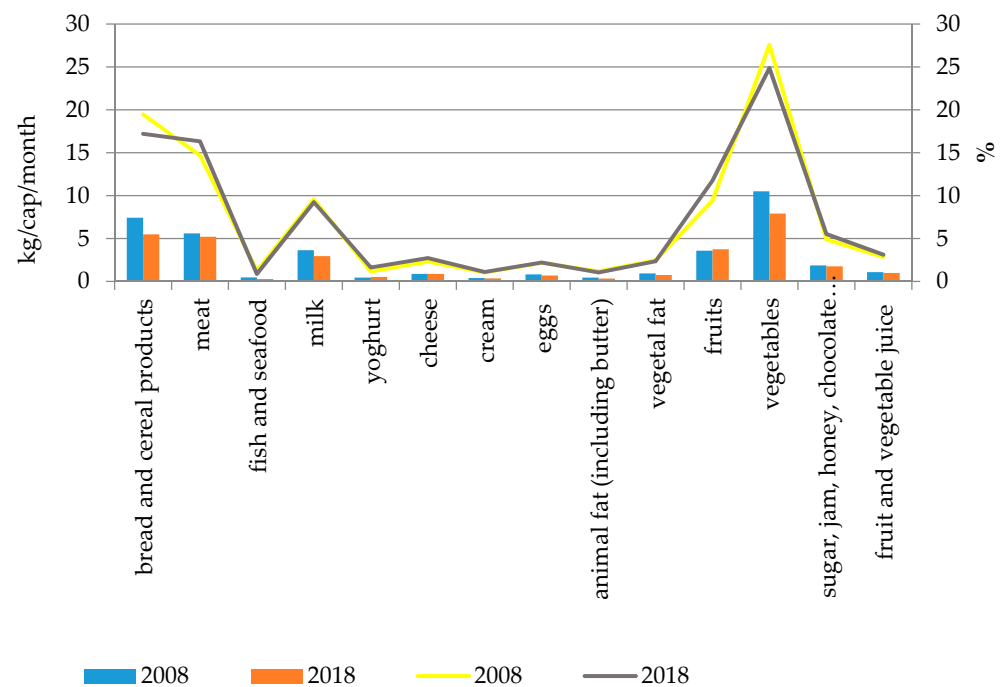


Figure 1. Changes in the amounts and structure of monthly consumption of selected food products in Polish households between 2008 and 2018. Source: Authors' own work based on [16,17].

Poland's population favors pork, which can be explained by tradition, dietary habits and taste preferences. In addition, the energy value of pork is another factor which contributes to its high consumption [18]. On the basis of production volume for meat in Poland, treated as domestic supply, Figure 2 shows its changes for pork, beef and poultry. A dominant share of pork and fowl is visible, with a clearly smaller proportion of beef, which, e.g., in 1990 was produced in quantities almost twice as large as those of poultry (19.11 for beef and 8.72 kg/cap/year for poultry) [19].

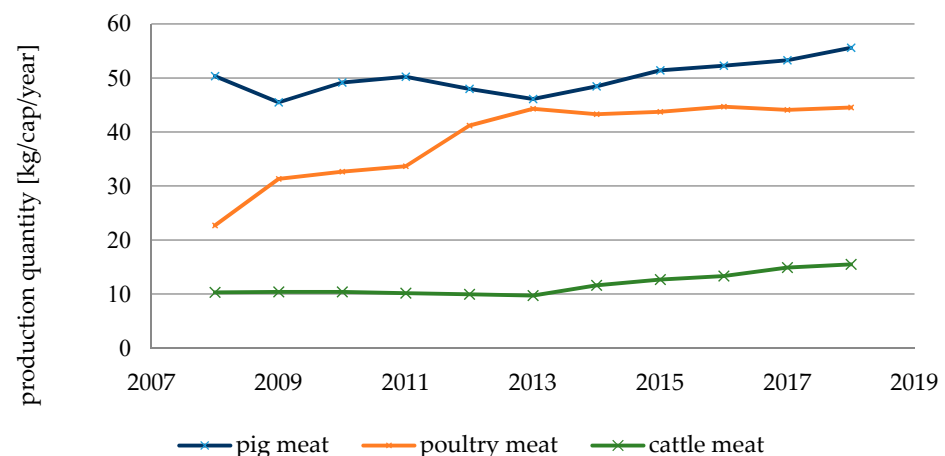


Figure 2. Changes in the production of various meat types in Poland from 2008–2018. Source: Authors' own work based on [19].

If we compare the amount of energy which can be supplied by plant and animal products of Polish origin, a dominant proportion of the former is apparent, although the share of energy provided together with animal products is increasing. The authors' calculations based on the Central Statistical Office of Poland [20,21] indicate that in the base year (as an average in the years 2008–2018) the production of plants grown (crops,

leguminous plants, vegetables, fruits etc.) which could be allocated for consumption (less any required feed and seeds for sowing) was capable of providing an average total of 4697 kcal/cap/day of energy and 93 g/cap/day of protein. Animal products (meat, milk and other) analyzed on the basis of available statistical data from FAOSTAT [19] were capable of providing, on average, 1419 kcal/cap/day of energy and as much as 125 g/cap/day of protein (see Figure 3). This means that the supply of domestic plant production could meet the entire nutritional demand of the human body. Theoretically, this means it is a possibility to make quite a radical change in diet and a significant reduction in the consumption of animal products.

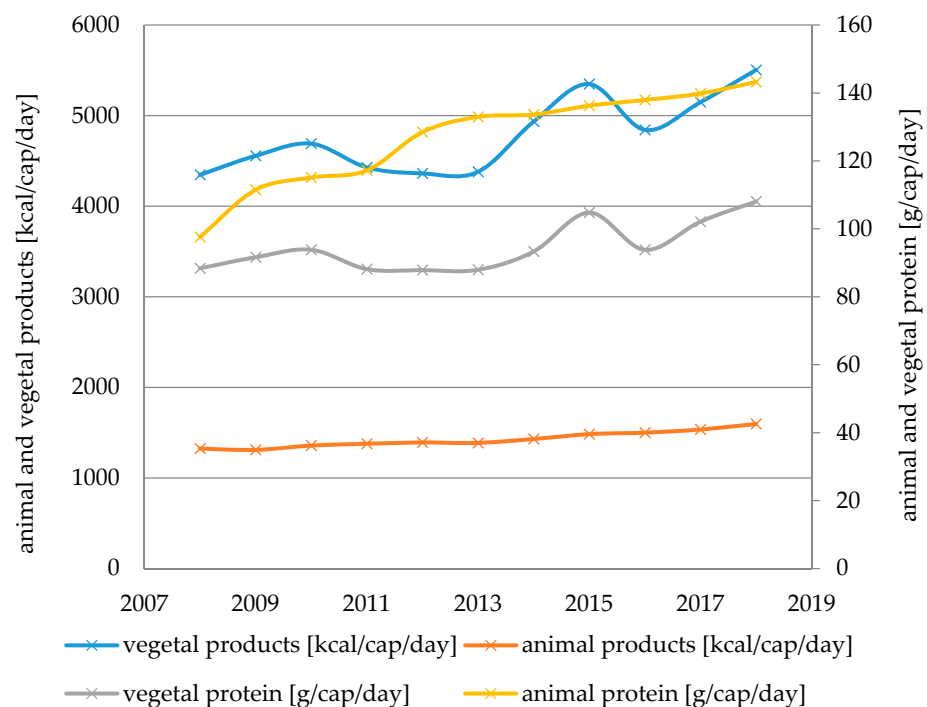


Figure 3. Daily amount of energy and protein supplied with plant and animal products of Polish origin from 2008–2018. Source: Authors' own work based on: [19–21].

As demonstrated by data in Figure 3, the supply of plant products to a significant extent may also guarantee the daily protein requirement. Any protein deficiencies which may appear due to the reduction in meat consumption could be compensated, e.g., by increased production and consumption of broad bean plants. Our calculations demonstrate that in the base year the share of domestic animal products in the entire supply of protein from domestic agricultural production was as much as 57% (more information in Section 4.1). In comparison, according to Schader et al. [22], the global amount of this ratio was 34% for the base year, being the average for the years 2005–2009. However, the authors of the study took into consideration countries in which malnutrition and low meat consumption is a factor.

The average proportion of protein-related energy to total energy from agricultural consumer products for the base year analyzed in our study was 14.5%. Polish standards assume that 10–20% is a proportion of energy from proteins suitable for children, adolescents and adults [23]. Consequently, the supply of Polish domestic products meets this criterion for the base year.

However, it should be noted that animal products remain the main source of protein in the human diet [24–26]. The higher nutritional value of various types of meat is a subject of popular debate. It transpires that the role of meat as a source of protein, especially red meat, is not so clear cut as, e.g., pork contains more available proteins, mineral salts and vitamin B than beef. On the other hand, beef is considered leaner, richer in essential amino

acids and recommended for people with cardiovascular conditions or high cholesterol levels. Nonetheless, it is believed that a change in meat consumption structure is necessary, especially a reduction in the intake of red meat in favor of white meat, including poultry [18]. Rabbit meat, which in terms of fat and cholesterol content is a product which could compete with fowl or red meat, also deserves more attention [27,28] but, like turkey meat, its production in Poland is very low.

Generally, meat consumption rose in the years 2008–2018 and such a tendency is likely to be maintained in the future. Still, the growth is accelerated mostly by white meat, particularly fowl, the importance of which is increasing, both globally [29] and in Poland.

Polish food products are generally considered products of high quality [30,31], with consumers tending to associate quality with not only with sensory appeal but also with health benefits. However, available data [13] suggest that in 2018 an average of only EUR 7 per person was spent in Poland on the best quality food—organic food. In Poland, this may be due to the still underdeveloped organic food market, as well as the prices of such products, more than consumers' awareness. Local, traditional products, purchased at the farm gate, still constitute only a small percentage of food consumed.

3. Materials and Methods

Our analysis uses available FAOSTAT data and information from the Central Statistical Office of Poland. The temporal scope of the study corresponds to the years from 2008 to 2018, and the forecast horizon is the year 2030. Data values for the base year and multiplier values for future years were calculated on the basis of time series from 2008–2018. The first step involved a “construction” of the value of a specific feature for the base year as a mean value from the years 2008–2018. The nature of data constituting a time series made it necessary to apply an adequate numerical characteristic from descriptive statistics. Therefore, the value of each feature for the base year was determined by means of a geometric mean given in Equation (1):

$$\bar{x}_{base\ year} = \sqrt[k]{x_t \cdot x_{t+1} \cdot \dots \cdot x_{t+k-1}} \quad (1)$$

where:

x_t —feature value X for the year t , e.g., X —pork supply in g/cap/day, kcal/cap/day,

k —number of analyzed years on which the base year is calculated,

t —the first year on the basis of which the value for the base year is calculated, in the present case $t = 2008$, and $k = 11$.

Mean value of the feature X calculated by means of Equation (1) (e.g., pork supply in g/cap/day) for the base year demonstrates its average level over the analyzed period, i.e., 2008–2018. It is the so-called base value of the feature; a departure point for forecasting the feature's value X for 2030. When the values of all features for the base year had been calculated, we started searching for a descriptive statistics tool which would best capture the value's change tendency from 2008–2018. Initially, an attempt was made to apply the trend function to determine the changes in the values of the feature in real time. Since no features showed any tendency or a statistically significant tendency, index methods were ultimately used to study the dynamics of changes in feature values from 2008–2018. The resulting value was referred to as a multiplier. The multiplier for a specific feature was calculated in two steps. First, chain indexes (I) were determined for the feature analyzed from 2008–2018 according to Equation (2):

$$I_{t+1/t} = \frac{x_{t+1}}{x_t} \quad (2)$$

Next, in order to capture change tendencies, the mean rate of change in the feature's value, i.e., geometric mean from chain indexes was used, and this formula, given in (3), determines the multiplier for feature X :

$$\text{multiplier} = \sqrt[k-1]{x_{t+1/t} \cdot x_{t+2/t+1} \cdot \dots \cdot x_{t+k-1/t+k-2}} \quad (3)$$

The geometric mean given in Equation (3) shows what the tendency was for changes in the feature in the analyzed years, from 2008 to 2018. Taking into account the duration of the period in the analysis, a value greater than one suggests an increase, on average, and the value smaller than one suggests a decrease in feature X . The multipliers calculated in this way were subsequently used in forecasting values of features in a future year, i.e., 2030, for which change scenarios were designed. In order to estimate the value of each feature in 2030, constancy of change trends determined for 2008–2018 was assumed.

Proposed projections of scenarios of changes in the values of features in 2030 assumed the constancy of trends indicated by the multiplier and: (a) no adjustment/change in the value of a feature, (b) a change in the value of a feature involving an increase/decrease by $\pm 25\%$, (c) a change in the value of a feature involving an increase/decrease by $\pm 50\%$, (d) a change in the value of a feature involving an increase/decrease by $\pm 75\%$. Four suggested projections of scenarios described in (a) to (d) were presented in relative values—grams of a given product, kilocalories and protein grams per capita per day. Feature values X for 2030 were adjusted for population based on population forecasts prepared by the Central Statistical Office of Poland [32]. From now on, they will be referred to as features X from adjusted 2030.

As noted above our analysis focuses only on domestic agricultural product manufacturing capabilities (excluding fish production) of providing food for the population of Poland. We demonstrated how many kilocalories and protein may be supplied to consumers and how their quantities will change along with a change in the consumption structure. Taking into account the important issue of food losses and food waste, and using information provided by Schader et al. [22], and the FAO Report on food wastage, [33], we expect losses to correspond to 30–40% of the total food supply (TFS), and we allowed for such losses in our analyses. For the base year and proposed change scenarios, we assumed a 40% loss resulting from food wastage. In our problem analysis assumptions, we assume that TFS (kcal/cap/day) is given by Equation (4):

$$TFS_{kcal/cap/day} = (1 + \alpha) \cdot \sum_{i=1}^6 SAP_i + (1 - \alpha) \cdot \sum_{i=7}^{12} UNSAP_i + (1 - \alpha) \cdot \sum_{i=13}^{14} UNSCP_i + \sum_{i=15}^{18} SCP_i \quad (4)$$

where:

α —percentage of change assumed in scenarios in (a) to (d),

i —number of the product,

SAP —sustainable animal products, the supply of which we increase,

SCP —sustainable crop products, the supply of which remains unchanged,

$UNSAp$ —unsustainable animal products, the supply of which we reduce,

$UNSCP$ —unsustainable crop products, the supply of which we reduce.

Assuming 40% food wastage, the borderline inequality to satisfy total food demand (TFD) is expressed by Equation (5):

$$TFD_{kcal/cap/day} \geq (1-40\%) \cdot TFS_{kcal/cap/day} \quad (5)$$

Available statistical data used in this study included:

- (a) Poland's population from 2008–2018 (population by sex and age group, n.d.) and forecasts for 2030 [32].
- (b) Sowing, yield and harvest for consumer plants such as: wheat, rye, barley, oats, buckwheat, seed maize, consumer leguminous plants, sugar beets, canola, other oleaginous plants (such as sunflower), cabbage, onion, carrot, beetroot, cucumbers,

tomatoes, cauliflower, other root vegetables (various in total), apples, pears, plums, strawberries, raspberries, other (including chokeberry, highbush blueberry, hazelnuts, grapes), cherries, sweet cherries, other (including apricot, peaches, walnuts); triticale, crop mixtures, portions of barley, maize for seeds, and potatoes used specifically for livestock feed [20,21].

- (c) Sowing, yield and harvest of plants used specifically for livestock feed [20,21].
- (d) The headcount of farm animals as of the start and the end of the calendar year [34], on the basis of which a rough calculation of demand for livestock feed was performed with the use of sample demand standards for feed specified in [35].
- (e) The production volume of animal products including eggs, cow's milk, goat's milk, sheep's milk, beef, pork, chicken meat, duck meat, turkey meat, gees and guinea-fowl meat (classified together), rabbit meat, sheep meat, edible beef offal, edible pork offal, and honey [19]. Our analysis does not include horse meat due to the fact that it is exported. Energy value of animal production was calculated for raw products.
- (f) Energy value of certain plant products such as vegetables, fruits, potatoes, leguminous plants, was provided for raw products. Calculations for cereals, sugar beets and oleaginous plants were performed on the basis of the energy value of products in the form in which they are directly consumed, e.g., flour, groats, sugar, oil. Calculations for such products used data from [36].
- (g) Energy and protein content for each product was determined according to [37].
- (h) Energy requirement of the human body was calculated according to age categories proposed by [23], as well as taking into account detailed population data in these categories [38].

Considering that the amount of kilocalories and protein generated in the domestic economy exceeds the requirements of the population, the proposed scenarios feature modifications in the consumption of animal products. We suggest a reduction in the consumption of red meat (pork, beef and their edible offal) and certain poultry products (chicken meat), as well as cow's milk by 25%, 50% and 75%. At the same time we assume an increased consumption of turkey, duck, goose, rabbit and sheep meat, and honey (also by 25%, 50% and 75%). We consider these types of products the most beneficial ones in terms of nutritive value [28,39]. For plant products, we recommend reduced consumption of wheat (flour) as a product with the greatest content of gluten [40] and sugar (from sugar beets). Other products in our analysis remain at the same level.

4. Results and Discussion

4.1. Satisfying Nutritional Needs and Changes in the Consumption Structure in the Proposed Scenarios for 2030

Tables 1–4 below, and Figure 4a,b show an overview of results calculated for proposed scenarios for the year 2030. Data in Tables 1 and 2 and Figure 4a,b provide information on the amount of domestic plant and animal products (gram, kcal, gram of protein) for the base year and change scenarios in 2030.

Table 1. Daily available food categories for the base year and scenario changes in 2030—animal products.

Animal Product	Base Year			2030 Adjusted			+/- 25%			+/- 50%			+/- 75%		
	g	kcal	g protein	g	kcal	g protein	g	kcal	g protein	g	kcal	g protein	g	kcal	g protein
eggs	42	58	5	49	68	6	61	85	8	74	102	9	86	119	11
cow milk	816	427	28	967	507	32	725	380	24	363	253	16	242	127	8
goat and sheep milk	1	0.7	0.04	0.4	0.3	0.01	0.5	0.3	0.02	1	0.4	0.02	1	0.5	0.02
cattle meat	32	51	6	53	85	10	40	64	8	20	43	5	13	21	3
chicken meat	91	184	61	215	434	143	161	325	107	81	217	71	54	108	36
duck, goose and turkey meat	13	23	2	24	43	4	30	54	5	36	64	6	42	75	8
pig meat	137	464	21	157	534	24	118	400	18	59	267	12	39	133	6
rabbit meat	0.2	0.3	0.04	0.2	0.4	0.1	0.3	0.5	0.1	0.4	0.5	0.1	0.4	0.6	0.1
sheep meat	0.1	0.2	0.01	0.1	0.10	0.01	0.1	0.1	0.01	0.1	0.2	0.01	0.1	0.2	0.02
beef and pork edible offal	9	12	2	14	19	3	11	14	2	5	9	1	4	5	1
animal edible fat	23	194	0.6	27	223	0.6	20	167	0.5	10	111	0.3	7	56	0.2
honey	1	4	0.003	2	7	0.01	3	8	0.01	3	10	0.01	4	12	0.01
Total animal products	1165	1419	125	1508	1920	223	1169	1499	173	651	1078	122	490	657	72

Source: Authors' own work.

Table 2. Daily available food categories for the base year and scenario changes in 2030—plant products.

Plant Product	Base Year			2030 Adjusted			+/- 25%			+/- 50%			+/- 75%		
	cap/day														
	g	kcal	g protein	g	kcal	g protein	g	kcal	g protein	g	kcal	g protein	g	kcal	g protein
wheat flour	527	1772	48	572	1921	74	429	1441	55	214	961	37	143	480	18
other cereal and legume products (flour, groats, grains)	409	1352	30	502	1675	44	502	1675	44	502	1675	44	502	1675	44
other industrial plants such as vegetable oil	65	572		88	635		88	635		88	635		88	635	
sugar beets such as sugar	117	475		215	871		161	654		108	436		54	218	0
vegetables total including potatoes	777	396	13	825	293	11.9	825	293	11.9	825	293	12	825	293	12
fruits total	272	130	2	309	182	2.2	309	182	2.2	309	182	2	309	182	2
Total plant products	2168	4697	93	2511	5578	132	2315	4880	114	2046	4182	95	1921	3483	77

Source: Authors' own work.

Table 3. Chosen measures and indicators for the base year and scenario changes in 2030.

	Base Year			2030 Adjusted			+/- 25%			+/- 50%			+/- 75%		
	cap/day														
	g	kcal	g protein	g	kcal	g protein	g	kcal	g protein	g	kcal	g protein	g	kcal	g protein
TFS	3333	6116	218	4019	7497	355	3483	6379	286	2697	5260	217	2412	4141	148
40% food wastage		3670	131		4498	213		3827	172		3156	130		2485	89
animal energy/total energy (%)		23			26			23			20			16	
animal protein/total protein (%)			57			63			60			56			48
protein energy		886			1441			1161			881			601	
protein energy/total energy (%)		14.5			19.2			18.2			16.8			14.5	
TFD		2572			2608			2608			2608			2608	

Source: Authors' own work

Table 4. Comparison of changes in the consumption structure: base year vs. scenarios for 2030.

Product	Product g/cap/day				kcal/cap/day				Proteins g/cap/day			
	Base Year	+/-25%	+/-50%	+/-75%	Base Year	+/-25%	+/-50%	+/-75%	Base Year	+/-25%	+/-50%	+/-75%
(1); SAP; eggs	1.26%	0.38%	1.23%	1.95%	0.95%	0.36%	0.95%	1.86%	2.40%	0.28%	1.83%	4.84%
(7); UNSAP; cow milk	24.47%	-5.13%	-12.23%	-15.44%	6.99%	-1.13%	-2.27%	-4.01%	12.64%	-4.19%	-5.22%	-7.20%
(2); SAP; goat and sheep milk	0.03%	-0.02%	-0.01%	-0.01%	0.01%	-0.01%	0.00%	0.00%	0.02%	-0.01%	-0.01%	0.00%
(8); UNSAP; cattle meat	0.95%	0.10%	-0.28%	-0.46%	0.84%	0.15%	-0.04%	-0.34%	2.86%	-0.14%	-0.47%	-1.11%
(9); UNSAP; chicken meat	2.74%	1.56%	-0.02%	-0.73%	3.01%	2.00%	1.03%	-0.46%	27.77%	9.61%	5.06%	-3.72%
(3); SAP; duck, goose and turkey meat	0.38%	0.42%	0.83%	1.18%	0.37%	0.45%	0.82%	1.39%	1.00%	0.89%	1.99%	4.10%
(10); UNSAP; pig meat	4.11%	-0.96%	-2.11%	-2.64%	7.59%	-1.41%	-2.61%	-4.45%	9.60%	-3.28%	-4.05%	-5.54%
(4); SAP; rabbit meat	0.01%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%	0.01%	0.02%	0.00%	0.01%	0.04%
(5); SAP; sheep meat	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
(11); UNSAP; beef and pork edible offal	0.28%	0.00%	-0.10%	-0.15%	0.20%	0.01%	-0.03%	-0.09%	0.78%	-0.10%	-0.18%	-0.34%
(12); UNSAP; animal edible fat	0.69%	-0.16%	-0.36%	-0.44%	3.17%	-0.59%	-1.09%	-1.86%	0.25%	-0.09%	-0.11%	-0.15%
(6); SAP; honey	0.03%	0.04%	0.07%	0.10%	0.06%	0.07%	0.13%	0.22%	0.00%	0.00%	0.00%	0.01%
(13); UNSCP; wheat flour	15.82%	-4.38%	-8.58%	-10.48%	28.97%	-6.75%	-11.07%	-17.66%	21.84%	-2.50%	-4.85%	-9.39%
(15); SCP; other: flour, groats, grains	12.28%	1.13%	4.69%	6.49%	22.11%	3.72%	9.11%	17.34%	13.94%	1.49%	6.38%	15.83%
(16); SCP; other industrial plants such as vegetable oil	1.94%	0.41%	1.04%	1.35%	9.35%	0.44%	2.48%	5.60%				
(14); UNSCP; sugar beets such as sugar	3.52%	0.79%	0.11%	-1.51%	7.77%	2.31%	0.35%	-2.64%				
(17); SCP; vegetables total incl. potatoes	23.32%	-1.32%	4.52%	7.49%	6.47%	-1.96%	-1.01%	0.42%	6.12%	-1.96%	-0.64%	1.90%
(18); SCP; fruits total	8.17%	0.07%	2.26%	3.38%	2.13%	0.69%	1.27%	2.17%	0.77%	0.01%	0.25%	0.73%

Source: Authors' own work.

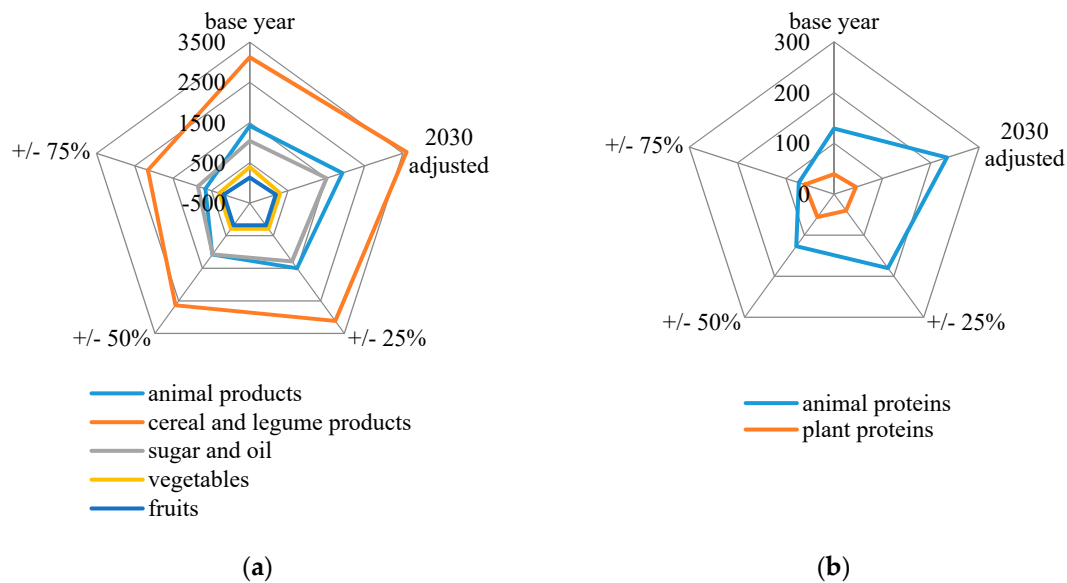


Figure 4. Changes in available: (a) kcal/cap/day in animal and plant products in base year and year 2030 scenarios; (b) protein g/cap/day in animal and plant products in base year and year 2030 scenarios. Source: Authors' own work.

These data provided the basis for the calculation of the indicators and TFS included in Table 3, giving the opportunity to compare the supply side with the demand side (demand for kcal/person/day), according to Equation (5). Data reveal a change in the supply (and thus potential changes in the consumption structure) of analyzed products, their energy value and protein content. According to our estimate, total supply of energy (TFS) from Polish agricultural production which can be allocated for consumption (with no food wastage expected) was 6116 kcal/cap/day (in the base year). Such a high amount was adjusted by 40% wastage in the food supply chain, resulting in a drop in available energy down to 3670 kcal/cap/day. What remains is still a substantial quantity offering considerable capabilities of satisfying human caloric demands, with domestic products alone. Should change trends in the volume of agricultural production remain at the same level as demonstrated by multiplier values for individual features X in the base year, in 2030 the supply of kilocalories for the Polish population may equal as much as 7497 kcal/cap/day (Table 3). Meanwhile, the energy requirement (TFD) for the Polish population calculated by the authors of this study, by age categories, was 2572 kcal/cap/day for the base year, and 2608 kcal/cap/day for 2030, adjusted according to the population forecast. We also expect that in consecutive proposed change scenarios the energy requirement will remain on the same level.

Based on calculations adjusted for 2030, we gradually reduce the supply of products included in our assumptions. Total available energy changes as follows: 6379 (+/- 25%), 5260 (+/- 50%) and 4141 kcal/cap/day (+/- 75%). Thus, the last scenario shows still a considerable surplus of available kcal/cap/day. Considering 40% wastage, we obtain 2485 kcal/cap/day. Only this value approaches the demand for energy derived from food calculated by the authors of this study. Obviously, our intention here is not to promote food wastage, but the phenomenon should nevertheless be kept in mind. Food is wasted at every stage of the food supply chain and for various reasons, which are largely dependent on local conditions in each country [33].

Animal protein is slightly predominant in terms of available quantity (Table 3, Figure 4b). According to other available data, animal products on average provide 34% of proteins worldwide [22]. However, there are countries in which the ratio reaches even 60–70% [41]. In our study, a slightly higher proportion of animal protein in the base year (57%) drops to

48% in the last scenario. Calculated indicators also demonstrate that in the last scenario the proportion of energy supplied with plant products rises to 84%.

In each of the analyzed cases the amount of energy supplied from protein is contained within standards defined for the population of Poland (10–20%). However, the last scenario seems the optimum one, also since it fulfills our expectations: using only the supply of domestic products in food consumption; a radical reduction in the amount of consumed red meat, chicken meat, edible pork and beef offal, as well as cow's milk, wheat and sugar—at the same time ensuring a sufficient amount of energy and protein, and calculated indicators remain within normal range. The last scenario also shows a big difference between TFS (4141 kcal/cap/day) and TFD (2608 kcal/cap/day), amounting to 1533 kcal/cap/day. However, taking into account present food wastage (40%) a deficit of 123 kcal/cap/day may appear.

However, despite the potentially limited consumption of wheat flour and sugar, it is the reduction in the supply of selected animal products that may actually trigger changes in the structure of food consumption (Table 4). For example, in comparison to the base year, in the last change scenario (+/−75%) the proportion of milk in overall consumption structure falls by 15.44%, pig meat by 2.64%, chicken meat by 0.73%, beef by 0.46% (due to the generally low supply and consumption of beef in Poland), and flour by 10.48%. A decrease in the share of wheat flour in potential consumption structure causes the available amount of protein to drop by 9.39% (+/−75%). As for animal products, again the largest decrease in the structure of available protein concerns cow milk (by 7.2%), pig meat (5.54%) and chicken meat (3.72%).

4.2. Contribution to Further Research and Analysis

The above results indicate great possibilities of Polish agricultural production in terms of providing food for the country's population. Potential constraints on food wastage, coupled with a change in dietary habits, may open new possibilities, e.g., of increased production of ecological food, and therefore greater availability of products of highest nutritional quality. Currently, work is under way to strengthen the organic farming sector as one of the elements of the European Green Deal. The European Commission sets the goal of converting as much as 25% of agricultural land to organic farming by 2030 [42]. By striving to reduce food wastage, we therefore create potential opportunities for a wider development of organic farming, the efficiency of which—it should be noted—is often lower than that of the conventional system [43–46]. How far one can go in Poland to change conventional agricultural production to organic depends on many factors, including environmental awareness of consumers and producers, willingness to change the organization of production, a potential decrease in production efficiency and an increase in higher-quality food prices. Taking into account a very reasonable and sustainable approach to the consumption of food produced in Poland, the 25% transition to organic farming assumed by the European Commission may turn out to be the most realistic possible. These issues are addressed by Seufert et al. [43], Muller et al. [47], and Badgley et al. [48], indicating that organic farming is able to feed the world's population with a well-designed food system, including reducing food wastage and the consumption of animal products.

Another important issue to be analyzed is the potential change in Poles' consumption spending in the face of changes resulting from the proposed scenarios. More sustainable nutrition (domestic products, better-quality animal and plant products, local products or organic) may imply changes in the level of expenditure. Thus, in addition to the important issue discussed in this article (meeting human nutritional needs), equally important is the potential increase in consumption expenditure on food. However, various studies show that some conscious consumers are willing to incur higher costs for the purchase of sustainable products, e.g., domestic, health-friendly and environmentally friendly [49–53].

5. Conclusions

This article presents four change scenarios for consumption structure by analyzing changes in the supply of domestic food products. Changes in the proposed scenarios (gradually by 25%, 50% and 75%) towards a more sustainable supply allow an in-depth analysis of the extent to which human demands for kilocalories and protein are met.

It was demonstrated that even the greatest (+/−75%) change in food supply, allowing for a food wastage level of 40%, is capable of satisfying requirements arising from nutritional standards.

In the event of a reduction in the amount of selected animal and plant products, total available energy may equal 4141 kcal/cap/day, while keeping a balanced proportion of energy derived from protein (14.5%), balancing the proportion of animal protein (48%) and thus obtaining an increase in the share of energy derived from plant produce.

In addition, the present analyses prove that domestic production alone is capable of satisfying the demand defined in the norms.

Knowledge about the potential difference between the TFS (4141 kcal/cap/day) and TFD (2608 kcal/cap/day) in 2030 in the last scenario (+/−75%), can be used by decision-makers in terms of changes in Polish agricultural policy and shaping consumers' awareness about more sustainable food consumption.

Our findings will lay the groundwork for further research on changes in the consumption structure in Poland, resulting from the increase in the share of products from organic farming.

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