
Supplementary Product Forms: Analysis of Polish Market Trends

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Abstract:

Purpose: The purpose of the paper is to present the results of research on the identification of supplementary product forms and analysis of the variability in all submissions of dietary supplements depending on the forms of supplementary products.

Methodology: Quantitative analyses of supplementary products submitted for registration in Poland at the State Sanitary Inspectorate (SSI) in 2007-2019*. Supplementary products subject to registration include, dietary supplements, fortified foods and special-purpose foods for infants, people requiring special medical care and food supplements for daily diet. In the studied period, the SSI received 86,849 submissions of products for registration that underwent statistical analysis, i.e., comparative analysis in groups, variability in the number of all submissions depending on the form in which the supplementary products were marketed.

Findings: The research allowed for the identification of the form in which supplementary products were principally marketed. Then, the products were divided into three main categories, solid (S), liquid (L) and semi-solid (SS). Research determined that 83.67% of all submissions include solid supplementary products.

Practical Implications: The conducted research can be useful to both decision-makers and to consumers. The study results specify the form in which supplementary products are most often marketed and can certify the consumers' acceptance of such a form or point to new trends.

Originality/value: The paper's original value is its scope and subject, especially the analysis of the supplementary products introduced into the Polish market depending on the product's form. New knowledge can determine innovative supplementary product production market development trends. It can especially determine new supplementary product form development trends and/or scope of in-depth research on new technologies, production processes, maintenance or safe disposal of supplementary products and the related wastes.

Keywords: Supplementary product, forms, solid (S), liquid (L), semi-solid (SS), Poland.

JEL classification: D49, I00.

Paper Type: Research paper.

1. Introduction

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The analysis of the supply of supplementary products in Poland demonstrated that the Polish supplementary products market basically covers three product categories, i.e., dietary supplements, fortified foods, and special-purpose foods (Hys and Koziarska, 2020). The global consumption of supplementary products, especially in terms of dietary supplements, is constantly increasing. It is possible to specify three consumption areas – high, medium, and low (Figure 1). The varied level of supplementary products' consumption results, among others, from the following factors, economic (e.g., income, poverty), demographic (e.g., population, population by age, family life cycle), sociological, behavioural, (e.g., purchase patterns), geographic (e.g., regional customs and traditions, natural environment features) (Hys, 2019).

Figure 1. Dietary supplements market: Market Size (%), Global (2020).



Source: Mordor Intelligence.

The *Grand View Research* report states that “The global dietary supplements market size was valued at USD 140.3 billion in 2020 and is expected to expand at a Compound Annual Growth Rate (CAGR) of 8.6% between 2021 and 2028” (Grand View Research, 2022). The *Fortune Business Insights* report reads that “The global dietary supplements market size is projected to reach, exhibiting a CAGR of 9.8% during the forecast period 2020-2027 (Fortune Business Insights, 2022). On the other hand, the Mordor Intelligence elaboration states that “The dietary supplements market is projected to register a CAGR (Compound Annual Growth Rate) of 6.91% during the forecast period 2021- 2026” (Mordor Intelligence, 2022). Even though there are various supplementary products market development rate scenarios around the world, it must be stated that the forecasts mentioned are optimistic (the forecast differences can derive from many factors, including the adopted study methodology, scope of research or the forecast period).

In view of the constantly growing supplementary products market around the world, scientific research concerning the multi-dimensional aspects of managing those products is highly recommended. In Poland, the supervision over the supplementary products' marketing is conducted by the State Sanitary Inspectorate (SSI). The studies conducted by the authors in Poland and covering the period between 2007 and 2019* confirmed that new dietary supplement submissions constituted 81.71%, special-

purpose foods 11.83% and fortified foods 6.20%. In the developed database, 0.25% were products not assigned to any of the aforementioned groups due to the inability to specify the correct identifiers in the database (Hys and Koziarska, 2020).

To continue the topic taken up in the research conducted in Poland (Hys, 2017; 2018; 2019; Hys and Koziarska, 2020), the authors of this publications focused on the issue of supplementary product form identification and the variety in dietary supplement submissions for marketing depending on their form. It is important to note that the study was conducted from the point of view of the entity that marketed the given supplementary product. The authors identified the scientific gap and conducted in-depth empirical research that correlates with the common phenomenon of supplementary product consumption but focused mainly on the supply perspective (Hys and Koziarska, 2020).

2. Literature Review

Subject literature lacks the classification on the unambiguous specification of supplementary product forms. It is possible to assume that the manufacturer's causal factor for choosing the form of supplementary products is the possessed technology, employee competencies and the consumers' purchase patterns (crnusa.org, 2020). It seems that such selection of supplementary product forms is insufficient. An analysis of 220 science publications on "supplementary products" (Web of Science, 04.01.2022) demonstrated that the authors mainly focus on notions regarding the following: Chemistry 29.545%, Food Science Technology 25.455%, Pharmacology Pharmacy 16.818%, Nutrition Dietetics 13.182%, Biochemistry Molecular Biology 11.364%, Toxicology 9.091%. Other research areas are also mentioned but their topic is highly scattered, and their importance is marginal.

Roseland *et al.* began the discussion on the reliability analysis of the vitamin and mineral content in dietary supplements (Roseland *et al.*, 2008). In their publication, Gabriels *et al.* raised the issue of legal regulations on supplementary product labels (Gabriels *et al.*, 2012). This issue was continued by Gabriels and Lambert who conducted a study on the label information and its impact on purchasing decisions (Gabriels and Lambert, 2013).

A study concerning the relevance of databases on the ingredients of supplementary products that are of crucial importance for consumer evaluation and planned consumption was conducted by Saldanha *et al.* (2012). On the other hand, Crawford *et al.* studied the issue of ingredients specified on the labels and compared them to their actual content in the product (Crawford *et al.*, 2020). Continuing this issue, Saldanha *et al.* conducted research on supplementary products in terms of quantity, forms and declarations on nutritional support and compared this information with the data specified on the label (Saldanha *et al.*, 2016; Saldanha, 2017). Furthermore, Saldanha *et al.* focused on the issue of dietary supplement label database modernisation (Saldanha *et al.*, 2021).

Researchers such as Sullivan and Sherma (2005) tackled the issue from a different perspective, i.e., they studied supplementary products in terms of the method and validation of selected supplementary product ingredients' designation. At the same time, other researchers conducted studies on the effects of dietary supplements' consumption (Eliason *et al.*, 2012; Haron *et al.*, 2022).

However, the aforementioned publications featured no papers on the general term or classification of supplementary product forms. This can raise a lot of controversy and can be abused in the market. Due to the above, the authors will conduct a study on the situation of supplementary products in Poland in terms of their form.

3. Research Methodology

Due to the subject literature review conducted in terms of the form of supplementary product introduced into the Polish market, the following research questions were formulated:

- What are the form categories for supplementary products?
- What are the structural similarity indices for the identified supplementary product form categories?

The scientific intentions announced in the title of this paper were accomplished by using qualitative and quantitative studies. To achieve their aim, the studies were conducted in two stages. The first stage featured a systematic review of the subject literature. The subject literature was generated mainly based on licensed international science databases, such as Web of Science. The analysis covered solely English papers published in the databases until 01.01.2021. A filtering criterion for the *supplement's products* phrase was applied. The next step featured a review, analysis, and verification of abstracts, thereby allowing for narrowing the publications' base to those with contents corresponding to the defined research aim. The topical literature analysis constituted the basis for the studies conducted in the next stage.

The second stage of the studies featured quantitative analyses of the range of supplementary products submitted for registration in Poland in the State Sanitary Inspectorate (GIS) in the period of 2007-2019* (*until day 02.12.2019). In the studied period, GIS received 86,849 submissions of products for registration. These data were used to create a database from which a full survey was conducted using the Statistica computer programme. According to the Polish law, enterprises that market supplementary products in the Republic of Poland for the first time are obliged to file a notification in the GIS (Polish Journal of Laws; Dz. U., 2006 no. 171 item 1225, ACT of 25 August 2006 on food and nutrition safety, Art. 29, 1). The supplementary products that are subject to registration include dietary supplements, fortified foods and special purpose foods for infants, babies, persons requiring special medical attention and foods supplementing the daily diet.

The following analyses were conducted as part of the study:

1. Preliminary analysis
 - preliminary quantitative analysis of all supplementary products specified in the database in 2007-2019* and introduced into the Polish market for the first time,
 - breakdown of supplementary products specified in the database according to the adopted categories, i.e., solid (S), liquid (L) and semi-solid (SS).
2. Comparative analysis in groups – analysis of supplementary product forms using structural similarity indices for categories, i.e., solid (S), liquid (L) and semi-solid (SS).
3. Analysis of the supply change dynamics - single-base and chain indices designated for all submissions and in the studied categories (S, L, SS).

The conducted studies allowed for the identification of the categories of forms of supplementary products introduced into the Polish market for the first time and conducting a structural similarity analysis. The conducted analyses allowed for the determination of the structure of forms of supplementary products in Poland in terms of the supply of these products in the market.

4. Research Results

Supplementary products introduced into the Polish market for the first time must be submitted to the Chief Sanitary Inspector. The submission requires the specification of the supplementary product's characteristics. One of the submission's elements is for the applicant to specify the supplementary product's form. According to the act, a supplementary product can be introduced into the market in various forms. One condition specified is the form that allows for the product's dosage. The act distinguishes capsules, tablettes, pills, powder bags, liquid ampules, dropper bottles and other forms of liquids and powders intended for product consumption in small, measured unit quantities (Article 3.1. point 3, 39) of the Act of 25 August 2006 on food and nutritional safety). Nevertheless, analysis of the data in the created database demonstrated that supplementary products are introduced into the market in forms that exceed the forms specified in the act many times over.

4.1 Foodstuff's Submission Dynamics – Preliminary Analysis

The preliminary analysis for supplementary products concerned 86,849 submissions into the SSI register of products introduced into the Polish market for the first time in 2007-2019*. The quantitative and percentage-based submissions are presented in Table 1. The data analysis demonstrated that the registration of new supplementary products in Poland was increasing in the studied period.

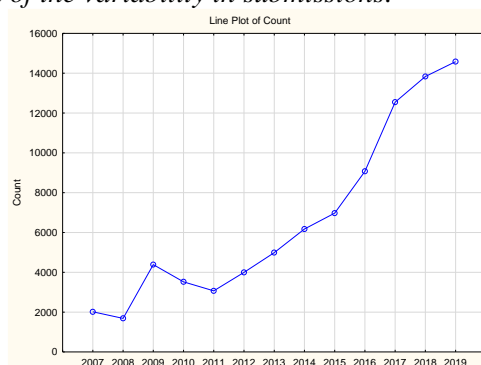
Table 1. Quantitative and percentage-based submissions.

Category	Frequency table: Rok zgłoszenia (dane korekta)			
	Count	Cumulative Count	Percent	Cumulative Percent
2007	2016	2016	2,32	2,32
2008	1687	3703	1,94	4,26
2009	4388	8091	5,05	9,32
2010	3521	11612	4,05	13,37
2011	3070	14682	3,53	16,91
2012	3996	18678	4,60	21,51
2013	4989	23667	5,74	27,25
2014	6174	29841	7,11	34,36
2015	6974	36815	8,03	42,39
2016	9072	45887	10,45	52,84
2017	12546	58433	14,45	67,28
2018	13834	72267	15,93	83,21
2019	14582	86849	16,79	100,00
Missing	0	86849	0,00	100,00

Source: Own study.

Figure 2 presents a graphical illustration of the variability in submissions in 2007-2019*. In 2007-2011, the upward trend was disrupted by submission drops, while from 2011, the number of submissions is rising constantly.

Figure 2. Illustration of the variability in submissions.



Source: Own study.

Due to the lack of regulations and reference classification of supplementary product forms, the authors adopted the classification of forms according to the physical and chemical properties intended for medicine to identify the supplementary product forms (Janiski *et al.*, 2008). The classification divides the forms into:

- solid (S), which include products such as, tablette, capsule, pill, lingualette, powder, granulate, suppository and soap,
- semi-solid (SS), which include, salve, cream, paste, gel,
- liquid (L), which include, solution, syrup, emulsion, suspension, liniment.

Due to the above, the database was studied in terms of the supplementary products' classification as one of the three defined forms. The quantitative and percentage-based breakdowns of the proposed forms are presented in Table 2. An analysis of the

obtained results allows for stating that:

- 0.83% of the submitted supplementary products was not classified in any group as the submitting entity did not specify the product's form (therefore, the database includes gaps),
- the dominant group among the submitted supplementary products are solid products which constitute 83.67% of all submissions,
- liquid supplementary products constitute 14.04%,
- semi-solid supplementary products constitute 1.47% of all submissions.

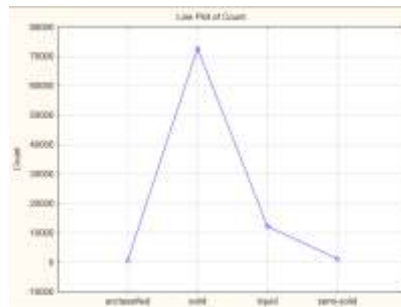
Table 2. The quantitative and percentage-based breakdowns.

Category	Frequency table			
	Count	Cumulative Count	Percent	Cumulative Percent
unclassified	718	718	0,83	0,83
solid	72666	73384	83,67	84,50
liquid	12191	85575	14,04	98,53
semi-solid	1274	86849	1,47	100,00
Missing	0	86849	0,00	100,00

Source: Own study.

The graphical illustration of the percentage breakdown of supplementary product forms is presented in Figure 3.

Figure 3. Graphical illustration of the percentage breakdown of supplementary product forms.



Source: Own study.

The chart demonstrates supplementary products organised in the adopted product form categories. Most supplementary products submitted for introduction into the Polish market for the first time are solid products – 72,666 submissions. The number of submitted liquid products amounts to 12,191 and of semi-solid products – only 1,274 submissions. In the case of 718 submissions, it was not possible to classify the products to any category due to the lack of adequate information in the submission.

4.2 Comparative Analysis of the Number of Submissions in the Studied Categories

Table 3 presents the detailed quantitative breakdowns for supplementary product forms submitted in 2007-2019*.

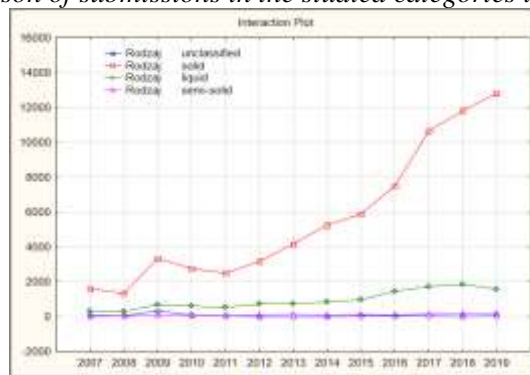
Table 3. *Quantitative breakdowns for particular supplementary product forms.*

Summary Frequency Table					
Marked cells have counts > 100					
(Marginal summaries are not marked)					
Year	unclassified	solid	liquid	semi-solid	Row Totals
2007	93	1595	308	20	2016
2008	49	1334	278	26	1687
2009	322	3309	681	76	4388
2010	62	2773	618	68	3521
2011	30	2474	518	48	3070
2012	9	3161	739	87	3996
2013	5	4154	714	116	4989
2014	12	5237	830	95	6174
2015	32	5874	946	122	6974
2016	38	7493	1448	93	9072
2017	23	10650	1720	153	12546
2018	17	11812	1836	169	13834
2019	26	12800	1555	201	14582
All Grps	718	72666	12191	1274	86849

Source: Own study.

In subsequent years, the number of solid supplementary product submissions was constantly increasing. The numbers of submissions of liquid and semi-solid (with a few exceptions) were also increasing. On the other hand, it is necessary to note the database’s irregularities concerning unclassified supplementary products which result from erroneous or missing correct entries in the database. The highest number of identified errors in the entries was recorded in 2009, while the lowest number of errors was recorded in 2013. In principle, this category should not be visible at all and the database entries should have been complemented. The graphical illustration of this breakdown is presented in Figure 4.

Figure 4. *Comparison of submissions in the studied categories in 2007-2019**



Source: Own study.

It can be seen that solid products constitute the overwhelming majority of all submitted supplementary products. 2017 was a pivotal year in which the dynamics of

the supplementary products submitted for introduction into the Polish market for the first time exceeded 10,000 submissions per annum. In subsequent years, this number was still increasing. The next stage's data analysis featured an analysis of the frequency of supplementary product form categories designated in relation to other categories. Table 4 presents the percentage-based frequency indices designated in relation to all submissions in the given category (Percent column), while Figure 4 – their graphical illustration.

Table 4. Percentage-based frequency indices – structural indices in the studied categories.

Frequency Table. Marked cells have counts > 100. (Marginal summaries are not marked)						
	Year	unclassified	solid	liquid	semi-solid	Row Totals
Count	2007	93	1595	308	20	2016
Column Percent		12.96%	2.19%	2.53%	1.57%	
Count	2008	45	1334	279	25	1683
Column Percent		6.82%	1.84%	2.28%	2.04%	
Count	2009	322	3309	681	76	4388
Column Percent		44.66%	4.56%	5.93%	5.97%	
Count	2010	62	2773	619	69	3523
Column Percent		8.54%	3.82%	5.07%	5.34%	
Count	2011	30	3474	618	43	3070
Column Percent		4.18%	3.40%	4.25%	3.77%	
Count	2012	9	3161	739	87	3996
Column Percent		1.25%	4.36%	6.06%	6.83%	
Count	2013	5	4154	714	116	4989
Column Percent		0.70%	5.72%	6.86%	9.11%	
Count	2014	12	5237	830	95	6174
Column Percent		1.67%	7.21%	8.81%	7.46%	
Count	2015	32	5874	946	123	6974
Column Percent		4.46%	8.09%	7.79%	9.60%	
Count	2016	38	7493	1443	93	9072
Column Percent		5.29%	10.31%	11.83%	7.30%	
Count	2017	23	19650	1720	153	12546
Column Percent		3.20%	14.56%	14.11%	12.01%	
Count	2018	17	11812	1836	169	13834
Column Percent		2.37%	15.26%	15.06%	13.27%	
Count	2019	26	12900	1555	201	14682
Column Percent		3.62%	17.61%	12.76%	15.73%	
Count	All Grps	718	72656	12191	1274	86849

Source: Own study.

The number of submissions of the studied solid, liquid, and semi-solid supplementary products was increasing in 2007-2019* and their variability structure was very similar (Figure 4). This is confirmed by the very high structural similarity indices which were calculated with the following formula:

$$\omega_p = \sum_{i=1}^k \min_i(\omega_{p_{1i}}, \omega_{p_{2i}}) \tag{1}$$

where:

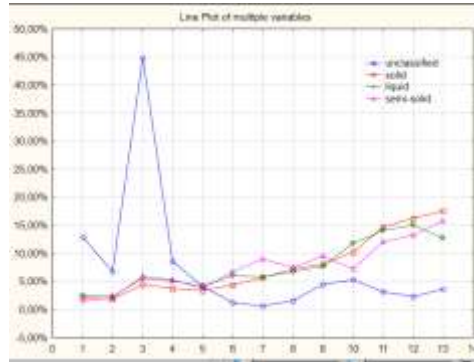
$\omega_{p_{1i}}$ is the proportion (structural index) in the i-th class for the 1st structure
 $\omega_{p_{2i}}$ is the proportion (structural index) in the i-th class for the 2nd structure

The following results were obtained for the studied variables:

- solid and liquid form – 92.7%,
- semi-solid and liquid form – 89.9%,
- semi-solid form and all submissions – 90.0%,
- solid and semi-solid form – 88.9%,
- solid form and all submissions – 98.5%,
- liquid form and all submissions – 94.2%.

The variability structure for the submissions of the studied solid, liquid, semi-solid and all foodstuffs is very similar. The structural similarity indices amount from 88.9% for the solid and semi-solid form to 98.5% for the solid form (the dominant form) and all submissions.

Figure 5. Comparison of the structural indices for the submissions in the studied categories in 2007-2019*.



Source: Own study.

The highest number of unclassified supplementary product submissions, i.e., 322 submissions, constituting approximately 45% of all unclassified submissions, but only 0.37% of all submissions, was recorded in 2009. After 2009, the share of unclassified products in all submissions was decreasing (Figure 5).

4.3 Evaluation of the Dynamics of Submissions in the Studied Categories

The last stage featured the use of single-base and chain indices to evaluate the dynamics of the supplementary products' supply changes (Table 5).

Table 5. Breakdown of individual indices for the submissions of all supplementary products in Poland.

Year	Number of submissions	Single-base indices	Chain indices
2007	2016	1,00	-
2008	1687	0,84	0,84
2009	4388	2,18	2,60
2010	3521	1,75	0,80
2011	3070	1,52	0,87
2012	3996	1,98	1,30
2013	4989	2,47	1,25
2014	6174	3,06	1,24
2015	6974	3,46	1,13
2016	9072	4,50	1,30
2017	12546	6,22	1,38
2018	13834	6,86	1,10
2019	14582	7,23	1,05

Source: Own study.

The single-base index is lower than 1 only in 2008, while the chain indices are lower than 1 in 2008, 2010 and 2011. The highest variability in the submissions can be observed in 2009, while the chain index of 2.6 means that a 160% increase was observed when compared to the year prior. In 2019*, when compared to 2007, the number of submissions increased by as much as 623%, which is indicated by the single-base index of 7.23. When analysing the submissions of solid supplementation products in 2007-2019, it can be noted that the number of submissions is increasing nearly constantly from 2007 onwards (Table 6).

Table 6. List of individual indices for the number of solid supplementary product submissions in Poland.

Year	Number of submissions	Single-base indices	Chain indices
2007	1594	1,00	-
2008	1334	0,84	0,84
2009	3305	2,07	2,48
2010	2772	1,74	0,84
2011	2474	1,55	0,89
2012	3161	1,98	1,28
2013	4154	2,61	1,31
2014	5228	3,28	1,26
2015	5874	3,69	1,12
2016	7487	4,70	1,27
2017	10648	6,68	1,42
2018	11810	7,41	1,11
2019	12793	8,03	1,08

Source: Own study.

The single-base index is lower than 1 only in 2008, while the chain indices are lower than 1 in 2008, 2010 and 2011. The highest variability in the submissions can be observed in 2009, while the chain index of 2.48 means that a 148% increase was observed when compared to the year prior. In 2019*, when compared to 2007, the number of submissions increased by as much as 703%, which is confirmed by the single-base index of 8.03.

When analysing the submissions of liquid supplementation products in 2007-2019, it can be noted that the number of submissions is increasing nearly constantly from 2007 onwards (Table 7).

Table 7. List of individual indices for the number of liquid supplementary product submissions in Poland

Year	Number of submissions	Single-base indices	Chain indices
2007	308	1,00	-
2008	278	0,90	0,90
2009	681	2,21	2,45
2010	617	2,00	0,91
2011	515	1,67	0,83

2012	739	2,40	1,43
2013	714	2,32	0,97
2014	830	2,69	1,16
2015	946	3,07	1,14
2016	1447	4,70	1,53
2017	1708	5,55	1,18
2018	1826	5,93	1,07
2019	1552	5,04	0,85

Source: Own study.

The single-base index is lower than 1 only in 2008, while the chain indices are lower than 1 in 2008, 2010, 2011, 2013 and 2019. The highest variability in the submissions can be observed in 2009, while the chain index of 2.45 means that a 145% increase was observed when compared to the year prior. In 2019*, when compared to 2007, the number of submissions increased by as much as 404%, which is indicated by the single-base index of 5.04.

When analysing the submissions of semi-solid supplementation products in 2007-2019*, it can be noted that the number of submissions is increasing nearly constantly from 2007 onwards (Table 8).

Table 8. List of individual indices for the number of semi-solid supplementary product submissions in Poland.

Year	Number of submissions	Single-base indices	Chain indices
2007	14	1,00	-
2008	26	1,86	1,86
2009	60	4,29	2,31
2010	48	3,43	0,80
2011	42	3,00	0,88
2012	62	4,43	1,48
2013	52	3,71	0,84
2014	72	5,14	1,38
2015	102	7,29	1,42
2016	77	5,50	0,75
2017	141	10,07	1,83
2018	155	11,07	1,10
2019	184	13,14	1,19

Source: Own study.

All single-base indices are not smaller than 1 which means that in 2008-2019, the number of submissions of semi-solid supplementary products was higher than in 2007. The chain indices are lower than 1 in 2010, 2011, 2013 and 2016. The highest variability in the submissions can be observed in 2009, while the chain index of 2.31 means that a 131% increase was observed when compared to the year prior. In 2019*, when compared to 2007, the number of submissions increased by as much as 1,214%, which is confirmed by the single-base index of 13.14.

5. Conclusion

When summarising the conducted studies, it can be stated that the division according to the physical and chemical properties applicable to medicine was used as the basis for classification in view of the lack of uniform classification of supplementary product forms. Due to the above, it was assumed that supplementary products submitted for introduction into the Polish market for the first time will be classified in one of three categories: solid (S), semi-solid (SS) oraz liquid (L).

The conducted analysis allowed for the formulation of the following conclusions:

- the dominant group among the submitted supplementary products are solid products which constitute 83.67% of all submissions,
- liquid supplementary products constitute 14.04%, while semi-solid products constitute only 1.47% of all submissions,
- due to the database's information gaps, 0.83% of the submitted supplementary products was not classified to any of the aforementioned categories,
- the number of submissions of solid, liquid and semi-solid supplementary products was increasing in 2007-2019* and their variability structure was very similar, which is confirmed by the very high structural similarity indices,
- the variability of all submissions was determined by the number of solid supplementary product submissions, wherein a reduction in the supply of liquid supplementary products in can be observed in 2016-2019*; semi-solid products were subject to the highest increase in submissions when compared to 2007 and to the liquid and solid products.

The obtained results can be useful to both decision-makers and to consumers. They can stimulate innovative directions for the development of the supplementary products' production technologies, create new supplementary product forms or ways of disposing of/recycling supplementary products and the related wastes.

From the customer's point of view, they can determine the directions of consumer need studies, generate awareness about the properties of particular excipients constituting the components of the given supplementary product form and their impact on every-day diet supplementation, demonstrating a nutritional or other physiological effect.

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