THE IMPACT OF YARNS PRODUCED BY DIFFERENT SPINNING PROCESSES ON ELONGATION PROPERTIES OF PLAIN DOUBLE KNIT JERSEY FABRICS

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Abstract

More and more yarns are being made in the world that will replace classic cotton yarns produced by the ring spinning system. Single cotton yarns with counts of 14, 16, 20 and 25 tex are often used for underwear production. For a number of reasons the increasing number of population does not cause a proportional increase in the production of cotton yarns. Therefore, yarns are manufactured that will replace or complement cotton yarns in different areas of application. For this study five 20 tex yarns were made which are used for manufacturing weft knitted fabrics from which various lightweight articles of clothing are made, generally with a fabric mass from 120 to 200 g/m^2. The yarns were made by the ring, rotor and aerodynamic spinning process of viscose, Tencel, modal and micromodal fibers. Using these yarns, one viscose Siro yarn and one cotton yarn, seven samples of plain double knit fabrics were knitted on a circular double bed knitting machine with a gauge of E17 and needle bed diameter of 8 inches (200 mm). The machine knitted with 8 knitting systems at a rotation speed of 60 rpm. The results of the study especially highlight significant differences in stretching properties of the finished and unfinished knitted fabrics caused by specific structures and properties of individual yarns.

Keywords: knitted fabric, weft-knitted, double knit, plain, structure parameters, yarn, 20 tex, manufacturing procedures

1. Introduction

With increasing number of the world population and standard of living, it is necessary to increase the production of textile fibers and their areas of application [1, 2]. In the world various institutions collect data on production and consumption of textile fibers. Based on the collected data, it is estimated that around 92 million tons of fibers were produced in 2013 or about 12 kg/capita [3,4]. From the total quantity of fibers about 35 % are natural or 32 million tons, and 65 % are man-made fibers or 60 million tons. Among the natural fibers, cotton is the most common with a share of around 27 % or around 24.8 million tons (Fig. 1). Wool fibers are represented by only 1.5 % or 1.4 mill. tons. Other natural fibers are present only in small amounts. From the total quantity of man-made fibers 60 % or 55 million tons are attributable to synthetic fibers, while only 5 % are attributable to man-made fibers from natural polymers.

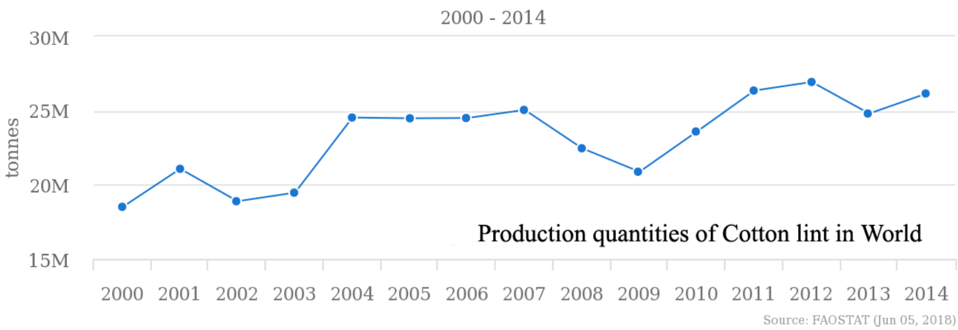


Figure 1. World production of cotton for the period from 2000 to 2014 [1]

World projections foresee an increase in fiber production and accordingly in fiber consumption that would result in the production of more than 140 million tons by 2025 with the two most common fibers being polyester and cotton [4,5]. In the last fifteen years the world largest manufacturer of cotton fibers is China, which together with India produces about 50 % of cotton fibers. China, India, America and Pakistan produce about 3/4 of the world volume of cotton fibers, and ten of the most significant cotton fiber manufacturers produce more than 90 % of the world cotton production. The estimated average cotton fiber price in 2013 amounted to US $ 1.76/kg [5]. In less developed countries the average price was far lower than the above mentioned, while in highly developed countries the average price was higher. In less developed countries the cultivation of cotton is related to the socio-economic conditions of living, and with the cultivation of cotton many families are provided for as well as regions. In highly developed countries, various auxiliary chemical agents such as pesticides, herbicides, fungicides, defoliants etc. are used in the cultivation and harvesting of cotton. They significantly contaminate the soil and remain in cotton fibers. It is estimated that in the world around 85 % of cotton is medium staple cotton and about 2 % extra-long staple cotton [3,6].

For several reasons, it is difficult to produce fibers that will replace cotton fibers. Man-made fibers that are intended to replace cotton fibers can be made in different lengths, or fibers are cut to a certain length. Depending on use and requirements, the yarn made of man-made fibers can have a different number of fibers and portions of fiber lengths in its structure, e.g., 70 % of the fiber portion is attributable to 34 mm long fibers, 20 % of the fiber portion is attributable to 30 mm long fibers and 10 % of the fiber portion is attributable to 25 mm long fibers. In this way, basic assumptions are made about the properties of the desired yarn. After selecting the fiber length portions, one of the spinning processes is selected, e.g. ring, rotor or aerodynamic spinning process. Each process yields a yarn of certain structural features, and hence stretching properties. The portion of individual fiber lengths and the spinning process are selected according to the desired yarn structure and the performance properties of yarn, i.e. according to its use. In this way, by using man-made fibers it is possible to obtain some yarn properties that are significantly different from cotton yarns, and the resulting fabric will also have different properties. By using new yarn structures, modern products have been developed, retaining existing areas of application and opening up novel ones [1,7].

2. Elongation properties of knit fabrics

The elongation of double knit jersey fabrics is considerably higher in course direction than in wale direction. Theoretical elongation at break in course direction amounts to around 400 % and in wale direction to 100 %, i.e. elongation at break in course direction is about 4 times higher than in wale direction, Fig. 2 [1,8].

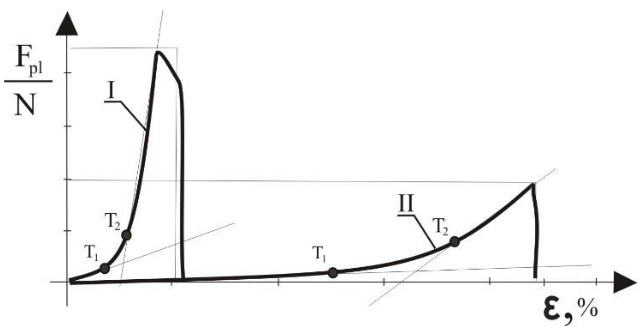


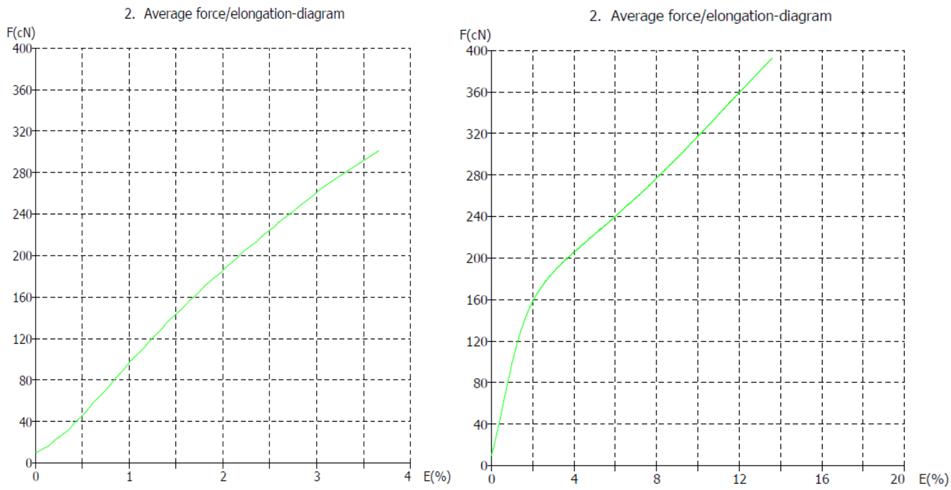
Figure 2. Force-elongation diagram of double knit jersey fabric; I) in wale direction and II) in course direction; T_1 – end of the elastic area, T_2 – point of inflection, beginning of the elastic area

In the force-elongation diagram three points or areas forming three points are often very significant. The first, linear part of the diagram up to point T_1 represents the elastic area (ε_e). In plain double knit jersey fabrics stretching in course direction this elastic area up to point T_1 occupies about 50 % of the total elongation of the knitted fabric. The second part of the diagram from point T_1 up to point T_2, or point of inflection, represents the border area or the part connecting the elastic area and the area of permanent deformation, and in such structures it occupies about 20 %. The third part of the diagram is from point T_2 up to the point of fabric breakage and represents permanent or plastic deformation (ε_p). In total elongation, this share is about 30 %. When stretching and at the moment of tearing the knit fabric the tensile strength tester registers the length of elongation at break (ε_t), and this data is often not disputable. However, it is not always easy and accurate to determine or evaluate the elasticity area, i.e. point T_1 and the inflection point or the beginning of permanent deformation, i.e. point T_2. In the case of knitted fabrics made of yarns of different raw materials, counts and structures, this area, i.e. the border area of elasticity and the area of permanent deformation has not been sufficiently investigated, and it is very important in the production of quality recreational clothing.

3. Experimental part

Using different raw materials and spinning processes, seven 20 tex yarns with different structures were made for the needs of this study. The differences are also observable in tensile properties, Fig. 3. Table 1 lists the basic parameters of tensile properties of yarns at $p = 0.05$. The lowest breaking force amounted to 267 cN and was recorded for the viscose yarn made by rotor spinning and the highest breaking force amounted to 532 cN and was recorded for the Tencel ring spun yarn. The ring spun cotton yarn had the lowest elongation at break of 3.7 %, while the highest elongation at break was recorded for the viscose ring yarn amounting to 13.8 %. On the basis of the breaking forces, the breaking strength of the yarns was calculated. Thus, the viscose rotor yarn had the lowest breaking strength, whereas it was twice as high in the Tencel ring spun yarn. A more detailed analysis of the recorded work of rupture revealed that there were essential differences among the individual yarns. Fig. 3a shows the force-elongation diagram of a 20 tex single cotton yarn. The breaking force was 302 cN and the elongation at break was 3.7 %. At a tensile force of 92 cN, yarn elongation of only 1 % was achieved, and at a force of 192 cN, or at about 64 % of breaking force, yarn elongation of 2 % was achieved. Yarn elongation of 3 % was achieved at a force of 266 cN or 88 % of breaking force.
The Siro yarn has a significantly different structure causing different tensile properties. The breaking force amounted to 393 cN, and the elongation at break was considerably higher than of the cotton yarn amounting to 13.6 %. At a tensile force of 92 cN the yarns were also elongated about 1 % and 2 % at a force of 160

cN. Already at an elongation of 4 % the yarn linearly assumed permanent deformation until breakage. The smallest work of rupture was recorded for the ring cotton yarn amounting to 301 cN·cm, and the greatest work of rupture for the viscose Siro yarn amounting to 1,700 cN·cm. Based on the above presented and other data, it is possible to conclude that the analysed yarns differ significantly in their tensile properties.



P-KK-BW; F_{pr} = 302 cN; ε = 3.7 %; R_{pr} = 301cN·cm; SIRO; F_{pr} = 393 cN; ε = 13,6 %; R_{pr} = 1700 cN·cm;

a) b)

Figure 3. Elongation properties of yarns: a) ring cotton yarns, b) viscose Siro yarns

Table 1: Tensile properties of 20 tex yarns made by different spinning processes

Yarn	Breaking force, *cN*	Elongation at break, *%*	Breaking strength, *cN/tex*	Work of rupture, *cN·cm*
P-KK	302 ± 5	3.7 ± 0.1	15.1 ± 0.3	301 ± 10
V-R	312 ± 5	13.8 ± 0.3	15.6 ± 0.5	1379 ± 49
V-OE	267 ± 9	10.5 ± 0.3	13.4 ± 0.4	919 ± 50
M-AJ	406 ± 10	9.0 ± 0.2	20.3 ± 0.5	1067 ± 42
MM-AJ	365 ± 11	8.2 ± 0.2	18.2 ± 0.5	886 ± 46
T-R	532 ± 13	9.6 ± 0.2	26.6 ± 0.7	1515 ± 68
SIRO	393 ± 7	13.6 ± 0.3	19.7 ± 0.4	1700 ± 59

Where: P-KK – ring cotton yarn, V-R – ring viscose yarn, V-OE – rotor viscose yarn, M-AJ – modal aerodynamic yarn, MM-AJ – micromodal aerodynamic yarn, T-R – Tencel ring spun yarn and SIRO – viscose Siro yarn

4. Knitting machine for making knitted fabric samples

A circular double bed knitting machine was used to make knitted fabric samples. It is generally used to knit plain double knit jersey fabrics intended to manufacture underwear, tab. 2. Its gauge is E17 and it is recommended to knit single cotton yarns from 12 to 36 tex or ply yarns from 10 tex x 2 to 17 tex x 2. The machine knits with 8 knitting systems. Thus, it is necessary to prepare 8 packages for each yarn group. *Coni* positive feeders regulating the tensile force of the yarn fed to the knitting system, which amounted to 3±1 cN were used to feed the yarn to the machine. The samples were made of 7 above mentioned yarns of different structures and tensile properties. 20 meters of each sample were made. The fabric take-down was performed by two pairs of rollers that are located 700 mm away from the knitting zone. The fabric was plaited down on the tray below the take down rollers, i.e. it was not wound onto a fabric roll.

Table 2: Construction features of the double bed circular knitting machine

Machine gauge, E	**Cylinder diameter, *e"* (*mm*)**	**Number of knitting systems, S**	**Number of needles, N_i**	**Cylinder working speed, *rpm***
17	8 (200)	8	432 x 2	60

5. Results of the parameters of the knitted fabric structure

A change in all parameters of knitted fabric structure was reflected through fabric mass, which ranged from 129 ± 3 to 180 ± 3 g/m^2, tab. 3. All the samples were made on one machine and under the same conditions, i.e. without machine operation control. From a theoretical point of view, these are very interesting data. All the yarns had the same fineness, i.e. 20 tex, and a great difference in fabric masses up to 40 % was obtained. If only this information is taken into account, it suggests that yarn structures are considerably different. The most lightweight unfinished fabric had a fabric mass of 129 ± 3 g/m^2 and was made by knitting the micromodal yarn, and the most heavyweight fabric had a fabric mass of 180 ± 3 g/m^2 and was made by knitting the viscose Siro yarn. By knitting the viscous rotor yarn, modal and micromodal aerodynamic yarn the knitted fabrics were made which had an approximately equal fabric mass of about 130 g/m^2. With the other three yarns fabric masses from 152 ± 3 g/m^2 to 165 ± 3 g/m^2 were obtained whereby with the Siro yarn a significantly higher fabric mass of 180 ± 3 g/m^2 was obtained. Mass per running meter of the knitted fabric is closely connected with fabric mass, being the highest for the knitted fabric made of the Siro yarn and was 66 ± 2 g/m, while the lowest was achieved by knitting the rotor Tencel yarn and was 61 ± 2 g/m^2. The volumetric mass of the manufactured knitted fabrics ranged from 0.212

to 0.262 g/cm³ representing a wide range for samples made of yarns of the same fineness.

Table 3: Basic structure parameters of the manufactured and analysed unfinished knitted fabrics

Samples	Knitted fabric mass, m, *g/m²*	Volumetric mass of the fabric, m_z, *g/cm³*	Loop density in wale direction, D_v, *oč./cm*	Coefficient of loop density of the fabric, C	Loop length ℓ, mm
P-KK	157 ± 3	0.246	11.4 ± 0.2	0.97	3.15 ± 0.01
V-R	165 ± 3	0.262	11.8 ± 0.2	0.92	3.12 ± 0.01
V-OE	131 ± 3	0.222	12.0 ± 0.2	0.72	3.10 ± 0.01
M-AJ	131 ± 3	0.218	11.6 ± 0.2	0.78	3.13 ± 0.01
MM-AJ	129 ± 3	0.212	12.2 ± 0.2	0.72	3.12 ± 0.01
T-R	152 ± 3	0.241	11.8 ± 0.2	0.92	3.13 ± 0.01
SIRO	180 ± 3	0.251	12.6 ± 0.2	0.89	3.13 ± 0.01

In plain double knit jersey fabrics made of cotton yarns with a count range from 17 to 25 tex it often occurs that the coefficient of loop density (C) amounts to about 0.75. In the produced samples this coefficient ranged from 0.72 to 0.97. In the case of viscose rotor and modal aerodynamic yarns the coefficient of loop density was lower than 0.8, while in the other yarns it was higher than 0.8. It is interesting to note that it was the highest in cotton knitted fabrics amounting to 0.97. Two rotor yarns, viscose and Tencel, also produced a high coefficient of loop density amounting to 0.92. The smallest loop length necessary to form a loop amounts to 3.10 ± 0.01 mm and was achieved by knitting the viscose rotor yarn. This yarn produced the widest knitted fabric whereby fabric contraction was the lowest after its removal from the machine and relaxation which amounted to 22 %. For practical use in making women's lingerie the fabric had the satisfactory coefficient of loop density of 0.72. The greatest loop length for forming a loop was measured in the cotton fabric amounting to 3.15 ± 0.01 mm, or about 1.6 % greater than the smallest loop length. More lightweight fabrics are suitable for making women’s lingerie and more heavyweight fabrics can be used to make men’s underwear or various lightweight women’s skirts or dresses and children’s clothing articles.

6. Results of elongation properties of knitted fabrics

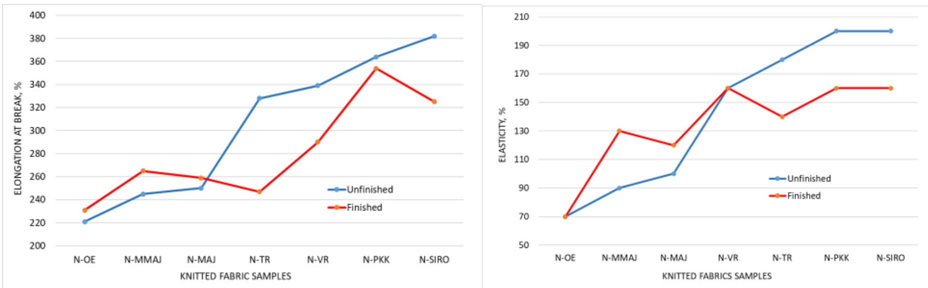
Elongation of knitted fabrics was measured in course and wale directions. For these measurements samples were 50 mm wide and 200 mm long. The distance between the grippers of the tensile strength tester was 100 mm. Table 4 and Fig. 4a show average values of the elongation of the unfinished and finished fabric up to breakage in course direction (ε_{tp}), and Fig. 4b shows the elongation of the knitted fabric (ε_{ep}). It is noticeable that the elongation at break of the knitted fabric (ε_{tp}) ranged from 221 to 382 %.

Table 4: Measurement results of fabric elongation in course direction – transverse

Sample	Knitted fabric	ε_{ep}, %	$\Delta\varepsilon_{ep}$, %	ε_{pp}, %	$\Delta\varepsilon_{pp}$, %	$\Delta\varepsilon_{pp}$ - $\Delta\varepsilon_{ep}$ %	ε_{tp}, %	$\Delta\varepsilon_{tp}$ - $\Delta\varepsilon_{pp}$ %
P-KK	N	200	55	280	77	22	364	23
	D	160	45	260	73	28	354	27
V-R	N	160	47	220	65	18	339	35
	D	160	55	210	72	17	290	28
V-OE	N	70	32	130	59	27	221	41
	D	70	30	140	61	30	231	39
M-AJ	N	100	40	160	64	24	250	36
	D	120	46	180	69	23	259	31
MM-AJ	N	90	37	150	61	24	245	39
	D	130	49	200	75	26	265	25
T-R	N	180	55	240	73	18	328	27
	D	140	57	180	73	16	247	27
SIRO	N	200	52	270	71	18	382	29
	D	160	49	220	68	18	325	32
			46±5		69±3	23±3		31±3

Where: N – unfinished fabric, D – finished fabric, ε_e – stretching or elongation of the fabric up to point T_1, elastic area, %; ε_p – stretching or elongation of the fabric up to point T_2, up to the beginning of the plastic area, %; ε_t – stretching or elongation of the fabric up to the moment of tearing, %, $\Delta\varepsilon_e$ – share of the elastic area in relation to the total elongation, %; $\Delta\varepsilon_p$ – share up to the beginning of the plastic area in relation to the total elongation, %; $\Delta\varepsilon_p$ – $\Delta\varepsilon_e$ – share between points T_1 and T_2, %; $\Delta\varepsilon_t$ - $\Delta\varepsilon_p$ – share between point of breakage and T_2, %; course direction marked with index *p* – transverse, and in Table 5 longitudinal direction is marked with index *u*.

The lowest elongation at break was recorded in the unfinished knitted fabrics made of OE yarns, and the highest one was also recorded in the unfinished knitted fabrics made of Siro yarns. It should be noted that the OE and AJ yarns produce the structure of the knitted fabric in which elongation at break is lower in unfinished than in finished knitted fabrics, whereas knitted fabrics made of Tencel rotor, viscose rotor, cotton and Siro yarns give up to 33 % lower stretching properties after the finishing process. The Siro yarn has a different construction; thus, elongation at break of the knitted fabric made of these yarns is about 15 % lower after finishing the fabric. Such great differences in stretching properties of the knitted fabrics made of yarns manufactured by different spinning processes suggest that special attention should be paid to the knitted fabric finishing process in relation to the yarn spinning process.



a) b)

Figure 4. Elongation properties of unfinished and finished knitted fabrics in course direction – transverse; a) up to breakage, b) elastic area

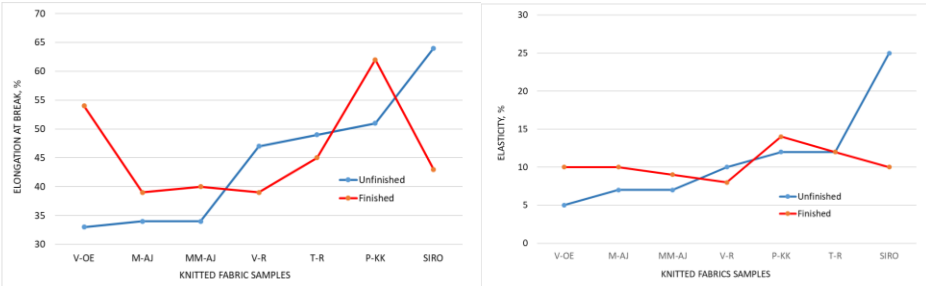
The point up to which the elasticity of a knitted fabric (ε_{ep}) reaches, i.e. point T_1 is estimated by reading the diagram. It was assumed that the fabric is elastic in the first linear area of the diagram. Thus, the knitted fabrics made of OE yarns had the lowest elasticity, accounting to 70 %. The knitted fabrics made of Siro yarns also had the highest elasticity, accounting to 200 %. The finished knitted fabric made of Siro yarns had 20 % lower elasticity than the unfinished fabrics. The finished fabrics made of Siro, cotton and Tencel rotor yarns had lower elasticity than the unfinished knitted fabrics.

When the share of elasticity of the knitted fabric ($\Delta\varepsilon_{ep}$) is analysed in elongation at break of the fabric (ε_{tp}), then it is observed that the average share of elasticity in all knitted fabrics amounted to 46 ± 5 %. It was the lowest in the finished fabrics made of OE yarns, amounting to 30 % and the highest in the finished fabrics made of Tencel rotor yarns, amounting to 57 %. The average share of fabric stretching up to the beginning of permanent deformation ($\Delta\varepsilon_{pp}$) amounted to 69 ± 3 %, and the share between the end of the elasticity area and the beginning of permanent fabric deformation was 23 ± 3 %. These shares are very important in making clothes, and in particular for recreational clothing. The average percentage of permanent deformation ($\Delta\varepsilon_{pp}$) in elongation at break of the fabric amounted to 31 ± 3 %, and it is often not significant in clothing manufacturing.

According to the above mentioned measurements and analyses it can be concluded that the average share of elasticity of the fabric elongated in course direction $\Delta\varepsilon_{ep}$ = 46 ± 5 %, the share between the elastic and plastic area, i.e. the share between points T_1 and T_2, $\Delta\varepsilon_{pp}$ - $\Delta\varepsilon_{ep}$ = 23 ± 3 %, or the share up to the beginning of plastic deformation $\Delta\varepsilon_{pp}$ = 69 ± 3 %, and plastic deformations $\Delta\varepsilon_{tp}$ - $\Delta\varepsilon_{pp}$ = 31 ± 3 %. The amounts are different for all structures of the unfinished and finished knitted fabrics and can simply be analysed or compared based on the provided results. According to the same principle, fabric elongation was dealt with in wale direction or along the fabric. The measurement results are given in Tab. 5 and Fig. 5. These data are important when determining the length of a garment, and especially for articles of clothing with pockets. Elongation at break in wale direction (ε_{tu}) was considerably lower than elongation at break in course direction (ε_{tp}). In this study the lowest elongation at break was in the unfinished fabric made of viscose OE yarns, amounting to about 33 %, and the highest one also in the unfinished fabric made of the Siro yarn, amounting to 64 %. In the case of rotor and Siro yarns the finishing process of the knitted fabric reduced its elongation at break. The biggest difference in the elongation at break of the unfinished and finished fabrics was observed in OE and Siro yarns. The knitted fabrics made of OE yarns had the longitudinal elongation at break of the fabric higher by 39 % than the unfinished fabrics, and the finished fabrics made of Siro yarns had 33 % lower longitudinal elongation at break. These differences are great enough to suggest a careful selection of products that will be manufactured from the above mentioned yarns.

Table 5: Measurement results of fabric elongation at break in wale direction – longitudinal

Sample	Knitted fabric	ε_{eu}, %	$\Delta\varepsilon_{eu}$, %	ε_{pu}, %	$\Delta\varepsilon_{pu}$, %	$\Delta\varepsilon_{pu}$ - $\Delta\varepsilon_{eu}$ %	ε_{tu}, %	$\Delta\varepsilon_{tu}$ - $\Delta\varepsilon_{pu}$
P-KK	N	12	24	28	55	31	51	45
	D	14	23	36	58	35	62	42
V-R	N	10	21	17	36	15	47	64
	D	8	21	18	46	26	39	54
V-OE	N	5	15	8	24	9	33	76
	D	10	19	20	37	19	54	63
M-AJ	N	7	21	13	38	18	34	62
	D	10	26	20	51	26	39	49
MM-AJ	N	7	21	13	38	18	34	62
	D	9	23	22	55	33	40	45
T-R	N	12	24	23	47	22	49	53
	D	12	27	25	56	29	45	44
SIRO	N	25	39	36	56	17	64	44
	D	10	23	20	47	23	43	53
			23±3		46±5	23±4		54±5



a) b)

Figure 5. Elongation at break of the finished and unfinished fabrics in wale direction – longitudinal; a) up to breakage, b) elastic area

The elasticity of the knitted fabric in wale direction (ε_{eu}), Fig. 5b, was considerably lower than the elasticity of the fabric in course direction (ε_{ep}), usually ranging between 5 and 15 %. It was considerably higher, amounting to 25 %. The average share of elasticity in the total elongation of the knitted fabric ($\Delta\varepsilon_{eu}$) amounted to 23 ± 3 % and it was considerably lower in course direction, amounting to 46 ± 5 %. The share of elasticity up to the inflection point or point T_2, i.e. up to the beginning of plastic deformation, was also considerably lower than in the transverse direction, amounting to 46 ± 5 % whereby the plastic deformation was 54 ± 5 %. Accordingly, the elasticity of the knitted fabric elongated in wale direction accounted for 23 ± 3 %, the plasticity of the fabric accounted for 54 ± 5 %, and the area between the elastic and plastic deformation accounted for 23 ± 3 %.

In this way, elongation properties of the knitted fabrics made of seven yarns of different raw material compositions and produced by different spinning processes were only superficially analysed. The mentioned knitted fabrics are used for making various underwear and summer lightweight articles of clothing. The research results indicate that the yarns made by different spinning processes produce essentially different structures of knitted fabrics, which also results in essentially different elongations at break of fabrics. Due to different raw material compositions and yarn structures it is desirable in commercial production to carefully select the knitting and finishing parameters of the knitted fabric to obtain the desired structures of knitted fabrics for the same products.

7. Conclusion

Seven different 20 tex yarns made by different spinning processes were used to knit plain double knit jersey fabrics for making underwear and lightweight articles of clothing. The knitted fabrics were made on a circular double bed knitting machine with a gauge E17 and had fabric mass from 129 ± 3 to 180 ± 3 g/m^2, coefficient of loop density from 0.72 to 0.97, loop length from 3.10 ± 0.01 to 3.15 ± 0.01 mm. Due to a different structure, and especially fabric mass, the knitted fabrics can be used for making men’s, women’s and children's underwear and various lightweight articles of clothing. Based on the conducted research the following conclusions can be drawn:

a) All fabric samples were made on one machine under the same knitting conditions. The samples were made of 20 tex yarns, and essentially different structures of fabrics were obtained, having fabric masses from 129 ± 3 to 180 ± 3 g/m^2.
b) The elongation at break of the knitted fabric in course direction or transverse elongation ranged from 221 to 382 %, and in wale or along the fabric was considerably lower, ranging from 33 to 64 %. All the differences were caused by the structure of the yarn and the knitted fabric as well as by the fabric finishing processes.
c) In the production of articles of clothing the elasticity of knitted fabrics plays an important role. It ranged from 70 to 200 % in course direction, and in wale direction it ranged from 5 to 25 %. The share of elasticity in the total fabric deformation was also due to the structure of the yarn and the knitted fabric as well as to the fabric finishing processes.

It is desirable in commercial production to carefully select the knitting and finishing parameters of the knitted fabric to obtain the desired structures of the knitted fabric. The research results indicate that it is very difficult to obtain the same structure of the knitted fabric that will be used in the manufacture of a product.

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