A Proposed Design for Women's Trousers made of Denim Fabrics Comfortable during Different Stages of Pregnancy

Marim A. A. Hussien

Lecture in Ready-Made Garments department, Faculty of Applied Arts, Damietta Univ.
Marim.aziem87@gmail.com

Hatem M. F. Idrees

Prof. of Production Management, Vice President of Graduate Studies. Damietta Univ.
hatidr@yahoo.com

Mostafa A. A. Badawy

Lecturer, Ready-Made Garments Technology Program, Faculty of Technology of Industry and Energy, Samannoud Technological Univ., mostafabadawy1990@gmail.com

Abstract:

During pregnancy, spanning nine months, significant changes occur in a woman's body measurements. however, the limited availability of maternity wear and lack of research in this area underscore the need for innovation and improvement in catering to the needs of Pregnant women. Pregnant women's clothes are functional clothes to meet their needs regarding functions (comfort, protection, safety, and attractiveness), and to enhance the personal appearance and body image, and hide the physical defects that resulted from the pregnancy period.

Denim stands as an iconic fabric in the fashion world, enjoying widespread acclaim across generations and social classes, so there's an imperative to elevate its comfort quotient.

In this paper 4 denim Fabrics ware produced with different Elastane ratio in warp and weft, produced to be used as trousers for pregnant women with comfort properties.

Various tests were performed on the 4 samples (Tensile strength, Elasticity, Tear strength, Stiffness, Fabric weight, Growth, Shrinkage, Fabric C pH). The final results show that sample No. (3) with ratios of (Cotton/Elastane 96/4 in the weft direction and Cotton 100% in the warp direction / Detex 117) is more suitable for pregnant women (trousers) because it is (easy stretch), as sample No. (3) was distinguished by (Growth, shrinkage, C pH, less stiffness and weight), which provides comfort properties and is suitable for functional performance for pregnant women's trousers. Sample fabric No. 3 was used to produce trouser suitable for the different woman's pregnancy stages to provide comfortable and functional properties for pregnant women.

Introduction:

The duration of nine months constitutes a relatively brief segment of one's life. However, for pregnant women, this period is incredibly intense and distinctive, leaving a lasting impression in their memories for many years. Nearly every woman wishes to undergo this transformative experience. The emergence of new challenges and responsibilities facilitates a process of personal transformation, preparing a woman for motherhood. The escalating mental, physical, and physiological discomforts become increasingly exhausting. Various thoughts and feelings continuously surface, contributing to a challenging mental state for the expectant woman.

Throughout the nine months of pregnancy, a woman faces numerous dilemmas and challenges. What might be considered normal, everyday issues can become problematic during this period. It is crucial to minimize stress during this particular time and ensure both physical and mental comfort. By prioritizing self-care, avoiding unnecessary worries, a woman positively impacts her own health as well as that of her baby (Abdukhashimovna 2022).

A defining characteristic of a pregnant woman is the transformation in her physique. The silhouette of expectant mothers undergoes significant changes. In addition to a steadily expanding belly, the waist diminishes, breasts enlarge, and hips broaden. There is a noticeable increase in body weight by several kilograms. While this transformation can pose challenges for women, it is increasingly accepted. Alterations in the figure contribution to physical symptoms, as the augmented body weight places strain on the joints and shift the center of gravity. This overloading of the body results in persistent discomfort (Cieśla, Frydrych et al. 2020).

The evolving dimensions of the figure during pregnancy necessitate a new wardrobe. Clothing for pregnant women should cater to the expectations of expectant mothers, providing both aesthetic and functional comfort. The limited number of manufacturers producing this type of clothing contributes to the relatively small variety available in the market. Additionally, there is a dearth of

research specifically addressing maternity wear. Undoubtedly, this aspect requires a fresh perspective and enhancement.

(Weigle and McAndrews 2022)

Research Problem:

The problem of this research can be represented by these questions:

1- The possibility of producing functional and economic clothes for pregnant women?
2- The possibility of producing a piece of clothing to be used throughout pregnancy?

Research Importance:

- Using stretchable denim fabrics containing Elastane to produce trousers for pregnant women to enhance wearing comfort, during the different stages of a woman's pregnancy

Research Aim:

- Determine the best elasticity ratio for jeans fabrics using elastane to provide comfortable and functional properties for pregnant women performance during the different stages of a woman's pregnancy

Methodology:

- Experimental analytical methodology

Limitations:

- Trouser for all pregnancy stages

Theoretical Framework:

1-1 Pregnancy-Related Changes:

Both medical literature and the field of apparel provide valuable insights into the body changes that occur during pregnancy. There are five primary changes during this period: alterations in body silhouette, size, posture, weight, and psychological state. In various studies, pregnancy is divided into trimesters:

- The first trimester spans from conception to the 12th week.
- The second trimester covers the 13th week to the 28th week.
- The third trimester extends from the 28th week until the birth of the baby.

External physical changes typically manifest around the fourth month, marking the onset of the second trimester. Addressing these physical changes requires special attention to comfort, fit, and size when designing maternity garments (Cieśla, Frydrych et al. 2020).

The initial trimester spans from the first week to the twelfth week. During this period, the embryo's outer layers develop, forming a placenta to deliver essential nutrients through the uterine wall or endometrium. The uterus undergoes changes as its muscular fibers thicken and lengthen, exerting pressure on the mother's bladder. Although changes in the belly may not be noticeable at this stage,

alterations in the upper part of the female body become more evident. With an increased cardio rhythm, the "galactophores canals" multiply, leading to a considerable increase in the size and weight of the breasts. Some women may be acutely aware of these changes, while the baby may not yet feel real, prompting women to focus more on themselves. A significant percentage of pregnant women experience no weight gain due to morning sickness during this trimester, which is also when most miscarriages tend to occur (FAUST 2013).

In the second trimester, spanning from week 13 to week 28, the fetus's development becomes more easily monitored. Weight gain typically starts during this period, especially in the case of a second pregnancy. The uterus expands to accommodate the growing fetus, leading to an enlargement of the belly. In the early stages of the second trimester, even if there is minimal visible evidence of pregnancy, it is not uncommon for an excited expectant mother to don maternity clothes as a form of "validation" of her pregnant state (FAUST 2013).

The third trimester begins around the 29th week, marking the stage of viability when the fetus becomes capable of survival outside the uterus, with or without medical assistance. During this period, the fetus becomes more active and stronger in its movements. However, discomfort may arise, including symptoms such as weakened bladder control and backaches. The woman begins to feel the fetus moving, potentially causing pain or discomfort around the ribs and spine. The third trimester is characterized by the most rapid growth of the fetus, gaining up to 28 grams per day. The expanding fetus exerts pressure on the digestive organs, compressing the stomach and bladder. This phase witnesses the final surge in weight gain, representing the most substantial increase throughout the pregnancy. The breasts become fuller and more sensitive. Additionally, the woman's belly may undergo a change in shape as it drops, a result of the fetus assuming a downward position in preparation for birth. It's also common for the woman's navel to become convex due to the expanding abdomen (Sohn 2009).

1-1-1 Changes in Body Silhouette:

Pregnancy brings about swift alterations in body size within a relatively brief timeframe, an experience common to all women. The most noticeable external physical transformations occur in the bust and abdomen, primarily during the last two trimesters of pregnancy. When examining clothing considerations, these final two trimesters assume particular significance, as women during

this period require attire that accommodates these changes (Cieśla, Frydrych et al. 2020).

1-1-2 Changes in Body Measurements:

Modifications in body measurements during pregnancy are evident in the circumferences. Typically, women notice an increase ranging from 20 to 26 centimeters around the waist. The extension of the abdomen varies due to the fetus's position, with some pregnant women carrying their babies low, while others carry them high. This can result in the abdomen appearing pushed forward or more concealed within their bodies (Sohn 2009).

Additionally, the breasts undergo size expansion, with an average increase of 5-8 cm in circumference measured from the bust point at the fullest part of the bust.

Studies reveal that among pregnant women, the most noteworthy changes occur in the waist, chest, hip, and high hip areas. The chest circumference measurement exhibits a maximum value of 125.23 cm and a minimum value of 86.90 cm. There is a range of differences of up to 38 cm, with the maximum value being 1.44 times that of the minimum. Regarding waist circumference, the maximum recorded value is 120.85 cm, and the minimum value is 83.82 cm, showcasing a maximum value that is 1.44 times that of the minimum. This emphasizes significant changes occurring in the waist during pregnancy.

High hip circumference, approximately 10 cm below the waist, indicates a maximum measurement value of 138.43 cm and a minimum value of 101.60 cm, resulting in a difference of up to 36 cm. Additionally, hip circumference measurement shows a maximum value of 134.62 cm and a minimum value of 97.79 cm, demonstrating a difference of 36 cm and a multiple of 1.38 times. These data underscore the substantial variation in these areas during pregnancy

(Cieśla, Frydrych et al. 2020).

1-1-3 Posture changes:

Alterations in posture are imperative to preserve body weight balance throughout pregnancy. Abdominal expansion disrupts this balance, prompting a temporary curvature of the spine to sustain equilibrium. This results in a backward tilt of the body posture, particularly evident in the second and third trimesters of pregnancy. Adjustments in posture, center of gravity, and gait contribute to discomfort, including lower back pain, pelvic girdle pain, fatigue, and a general sense of malaise (Rodriguez, Anisimova et al. 2017).

1-1-4 Weight changes:

During a 40-week of pregnancy, a woman gains about 13 kilograms

1-1-5 Psychological Changes:

Psychologically, pregnancy is characterized by a delicate balance between positive and negative emotions. Feelings can swiftly shift from joy and exhilaration to fear and loss. Maturation and adaptation processes occur simultaneously, leading women to react with uncontrollable laughter or tears during daily events. Emotional fluctuations are considered a normal response during pregnancy. It might appear that pregnant women harbor negative feelings about their bodies during pregnancy. However, research indicates that most of them have a specific attitude toward their body size. Surprisingly, the expanding girth doesn't bother women, with pregnancy being an exception to the rule. This positive outlook may be influenced by the community's favorable attitude on this issue today. Additionally, women who already have at least one child tend to feel more positive about their bodies than first-time mothers (Sohn 2009).

It's important to highlight that up to 80 percent of women experience discomfort with physiological changes. The intensity of these discomforts can vary, ranging from mild to severe. This may result in reduced functional mobility and challenging conditions during and after pregnancy [4]. In certain instances, people may stare at or try to avoid pregnant women, creating situations that make them feel uncomfortable and excluded from society (Sohn 2009).

The nine months of pregnancy prove to be a challenging period. Women encounter various discomforts as they prepare themselves for the role of motherhood. Despite the challenges, every mother acknowledges this time as unique, extraordinary, and wonderful.

1-2 Maternity Wear:

Similar to many specialized product categories, maternity wear has not been extensively explored in textile and apparel literature. Despite the rapid growth of new brands and quarterly sales in this category, only a few manuscripts have investigated maternity clothing from a consumer perspective since the beginning of the twenty-first century (Sohn and Bye 2015) (Ogle, Tyner et al. 2013). Changes in the cultural perception of pregnancy have generated a demand for maternity clothing that aligns with gender and class ideals. Only 50 years ago, pregnant women were restricted to wearing skirts and dresses to work due to the prohibition of trousers, and those who did so were frowned upon (Calvin 2015). Until the 1990s, maternity wear design predominantly featured loose-fitting tunics and dresses. In 1988, women were advised, "Low necklines may reveal fuller, softer breasts," yet styles continued to favor modesty. Two decades ago, there was a noticeable

shift in marketing efforts, transitioning from traditional depictions of maternity clothing as girlish and matronly to a focus on maintaining pre-pregnancy style through mainstream fashionable trends. Consequently, this places additional pressure on women to invest in new maternity garments that complement their rapidly changing bodies—a financial burden that many consumers try to avoid (Weigle and McAndrews 2022).

1-2-1 Key considerations for functional clothing for pregnant women:

Pregnant women's clothes are functional clothes to meet their needs regarding functions (comfort, protection, safety, and attractiveness), and to enhance the personal appearance and body image of the pregnant woman by being attractive, comfortable, loose, and fitted. The pregnant woman can use clothes to hide the physical defects that resulted from the pregnancy period. And highlighting areas of beauty, which pregnant women use to convey a message to others about the mental image that they want to appear to others (Esra 2013).

Comfort and its relationship to functional clothing for pregnant women:

As a result of the nature of the changes that occur during pregnancy, whether physical or psychological changes, comfort is the first requirement in pregnant women's clothing in particular. Comfort is divided into three types (sensory, thermal, psychological). To achieve comfort factors in pregnant women's clothing, care should be taken to choose a type of the appropriate clothing style is to use open collars and loose sleeves that can be controlled using cuffs or buttons, a scarf in the case of a long neck, and a shirt with open cuffs in the case of a short neck.

Also, choosing the appropriate type of material/ fabric from soft-textured fabrics, it is preferable not to use coarse or thick fabrics, while it is preferable to use fabrics made from natural fibers, followed by blended ones, and avoid using synthetic fibers. Choose clothes with good finishing for the joints, clothes that are draped around the thighs and do not result in ruffles, folds or wrinkles in that area, and clothing styles that facilitate the movement of the pregnant woman.

1- Protection and its relationship to functional clothing for pregnant women.

One of the basic requirements in functional clothing is protection. The weather factor is an important element that must be taken into consideration, as well as other risk factors such as the possibility of slipping or exposure to shocks, and health factors that affect the fetus itself. To achieve protection in functional clothing for pregnant women, fabrics with pores must be used to allow air permeability and moisture absorption, and dark colors should be chosen to absorb heat in the case of cold weather, and loose-fitting clothing in light colors in the case of hot weather.

2- Safety and its relationship to functional clothing for pregnant women.

Factors must be taken into account to ensure safety in clothing for pregnant women. The use of clothing made of tightly woven fabrics to prevent tearing, pregnancy supports under clothing to protect the pregnant woman from the risk of exposure to slipping or shocks, and the use of smart clothing equipped with electronic chips that monitor the pulse and pressure processes of both the fetus and the pregnant woman. Avoid highly flammable fabrics, wear clothes made of flame-resistant materials, use clothing styles with openings for ease of movement, and avoid wearing tight clothing that hinders the movement of the pregnant woman.

3-Attractiveness, elegance, and their relationship to functional clothing for pregnant women

The factor of attractiveness, elegance, and keeping up with fashion is a basic necessity for a pregnant woman, because of the physical and psychological changes that happen to her, which makes her look for clothing styles that have the factors of achieving attractiveness and elegance. As for the material or fabrics, it is preferable to have a soft texture to suggest thinness, and striped fabrics are not preferred. Occasional To hide body imperfections, shiny fabrics that reflect light and give the impression of spaciousness are not preferred (Rodriguez, Anisimova et al. 2017).

Elements of designing functional clothing for pregnant women.

The importance of design elements is becoming more and more important for women during pregnancy, as a pregnant woman can emphasize her areas of beauty, hide the effects of the physical changes that occur during pregnancy, and also use them to recreate the mental image she has of herself and her figure. The design elements are determined by four main elements:

1- Lines and their relationship to functional clothing for pregnant women:

Lines are used in clothing to enhance the personal appearance of a pregnant woman. Lines are used to draw attention to the areas of beauty in a pregnant woman, or to divert attention away from the physical defects resulting from the changes that accompany the pregnancy period. It is also used to suggest body in terms of appearing taller or thicker than it is. Vertical straight lines are used to reduce the size of the abdomen, give the illusion of its

length, and draw attention away from increasing its circumference. Horizontal lines are used to suggest an increase in the width of the body, and accordingly, they can be used to create a kind of harmony between areas of the body. Through them, it is possible to suggest an increase in the width of some areas of the body to appear in harmony with the areas in which the increase occurred as a result of pregnancy. As for the curved lines in the design of pregnant women's clothing, they are used to enhance elegance and attractiveness, as they give a feeling of softness, flow and grace. Care should also be taken to avoid using curved lines sometimes because they give a feeling of fullness, especially in areas that increase as a result of pregnancy (Engy 2018).

2- Shapes and their relationship to functional clothing for pregnant women

Shape is the first impression of a design, as shapes can give a woman a unique appearance. Shape is also one of the important elements in enabling women to keep up with fashion. Shapes can also be used in decoration.

The shape in clothing is determined by three factors that must be taken into consideration, which are the relationship between the lines of the internal parts and the external lines, the relationship between the main lines and the secondary lines, and the relationship of shadow and light in the high and flat areas of the design (Engy 2018).

3- Material and its relationship to functional clothes for pregnant women:

The texture of the fabric has a direct impact on the choice of functional clothing for pregnant women, as it suggests the nature of the personality. The permeability of the fabric and the tensile strength has a strong influence. To design suitable clothing for pregnant women that suggest shine and luxury, stretchy fabrics mixed with cotton are used; Draped fabrics are used for their ability to hide body defects.

1-3 Denim:

It's evident that fashion remains incomplete without denim. Throughout the history of textiles, no other fabric has gained as widespread acceptance as denim. It stands as a material for all generations, embraced by people of diverse classes and ages (Du, Zuo et al. 2019). Denim holds an undisputed position in the fashion industry, showcasing its ability to infuse creativity into fashion trends through unique and technologically advanced washing effects. Numerous scientific and technological advancements have been applied in the garment industry over the years, contributing to the durability and comfort of denim jeans, making them exceedingly popular (Asif and Hasan 2018). Technically, denim is a robust cotton fabric

traditionally woven with indigo-dyed warp and white fillings. While its manufacturing process adheres to classical principles established since its creation, technological advancements have transformed denim into a contemporary fashion material (Hosen, Asif et al. 2021).

Denim is a robust and sturdy cotton warp-faced textile material, where the weft thread passes under two or more warp threads. This twill weave structure gives rise to a distinctive diagonal pattern, setting it apart from cotton duck fabric. Denim holds the distinction of being one of the oldest fashion products globally (Elmogahzy 2020). Crafted from a 100% cotton twill weave structure, denim fabric is known for its comfort and pleasant feel (Hasan, Asif et al. 2021).

Customers' garment choices are primarily influenced by factors such as aesthetic appeal, fashion, comfort during wear, cost, and durability. Human skin stretches as the body moves, and clothing is expected to do the same based on the desired fit. Areas like the knees, elbows, and lower back are particularly prone to strain during body movement, making the stretching of clothing crucial for wear comfort (Shaw and Mukhopadhyay 2022). With the increasing demand for denim fabric, there is a need to enhance its comfort properties. Comfort properties are a vital consideration in the clothing industry, significantly dependent on fabric construction. Consequently, advanced fabric constructions have been developed to achieve improved comfort features (Akter, Repon et al. 2021).

1-3-1 Stretch-Denim Fabrics:

In recent years, to enhance wear comfort, denim fabrics containing elastane for casual wear have become a preferred choice. Stretch denim, commonly linked to a cotton-polyester blend that incorporates a small quantity of elastane, also known as spandex. Structurally, stretch denim is crafted with an indigo-dyed warp thread and a white weft thread, incorporating approximately 1% to 3% elastane. The weft threads of the denim fabric extend along the entire width of the fabric (Hasan, Asif et al. 2020).

The extension level in clothing during body movement generally varies from 20% to 45%. There are two categories of stretch-denim fabrics based on stretch levels: comfort stretch for fabrics with a stretch level below 30%, and power stretch for those above 30% (Choudhary and Bansal 2018). Various types of elastic yarns are used to impart stretch to denim fabric, typically with an elastane filament in the core and staple fiber as a sheath, covering materials like cotton, polyester, viscose, etc. Ring spinning, wrap spinning, intermingling, or

air covering are spinning technologies used to produce elastic yarns. While ring spinning is the traditional method, air covering is gaining popularity due to its lower production cost (Tian, Jiang et al. 2019). Elastic yarns are generally employed in the weft direction to provide horizontal stretch in stretch-denim garments. It's worth noting that bi-stretch denim is also produced to offer both horizontal and vertical stretch, providing a high level of skin fit. In bi-stretch fabrics, elastic yarns are used in both the warp and weft directions (Shaw and Mukhopadhyay 2022).

1-3-2 Elastane Fibers:

Elastane fibers have better mechanical and physical properties than rubber fibers, such as linear density, dyeing, and durability, as the durability of elastane ranges about (5:9.5 (cN/tex), while the durability of natural rubber is (2.2 cN/tex), and the moisture content of elastane ranges (1:13%). The cutting elongation of elastane fibers ranges between 450%-700% depending on the thickness and type of elastane fibers.

Stretchable denim fabrics are classified into two categories based on the level of stretch: power stretch and comfort stretch. Fabrics with a stretch level above 30% are termed power stretch, while those below 30% are categorized as comfort stretch. Power stretch is typically needed for sports activities, while comfort stretch is suitable for regular apparel (Shaw and Mukhopadhyay 2022).

Various denim fabrics are tailored to their specific end-uses, with factors like yarn count, fabric density, ends per inch (EPI), and picks per inch (PPI) influencing their weight. The weight of denim typically falls within the range of 5 to 15 oz/yd². Medium denim, ranging from 5 to 10 oz/yd², is well-suited for draping, softness, and versatility, making it ideal for dresses or tops. On the other hand, heavy denim, weighing 10–15 oz/yd², is suitable for crafting durable trousers and skirts, especially for classic blue jeans. Cotton is the primary material for denim fabric, often used in its pure form or blended with other fibers. While open-end yarns are commonly used in denim production, there is a notable shift towards incorporating ring-spun or compact yarns. Some denim fabrics even feature a hybridization of ring-spun and rotor-spun yarns (Akter, Repon et al. 2021).

Stretch is introduced in denim fabric by incorporating various types of elastane yarns in the weft. These yarns feature different elastane content levels and are paired with sheath fibers such as cotton, polyester, viscose, among others. Technologies like core-spun ring spinning, wrap spinning, intermingling, and air covering are employed to manufacture elastane yarns. In traditional stretch denim, core-spun elastane yarn, produced using a ring frame with an elastane filament at the core, is commonly used as the weft. However, a recent trend involves substituting conventional core-spun elastane yarn with more cost-effective alternatives like multifilament air-covered elastane yarn (Shaw and Mukhopadhyay 2022).

There are several methods for producing elastane threads, including (Uncvered elastic Yarns and Covered yarns) Covered yarns are divided into Core spun yarns, simple or cross covering, and stitch covering.

2- Experimental work

4 denim Fabrics ware produced with different Elastane ratio in warp and weft as shown in table (1). Fabric Weave twill 3/1 Z, warp Ne 8, and weft Ne12 was used. A Pıcanol 2011 Waving machine was used with denting 4.

The fabric was produced to be used as trousers for pregnant women with comfort properties.

Table (1) The Produced Fabric Specifications:

Sample No.	Warp	Weft	Elastan count (Detex)	Reed No
1	Cotton 100%	Cotton 100%	0	68
2	Cotton 100%	Cotton/ Elastane 98/2	44	56
3	Cotton 100%	Cotton/ Elastane 96/4	117	40
4	Cotton 100%	Cotton/ Elastane 92/8	310	32

Table (2) shows the Finishing of each sample to avoid over twist and slippage of stretch yarns during weaving

Table (2) The Produced Fabric Finish:

Finishing Chemical	Belsoft 300 25gm/lit, Adalin 20gm/lit, and Cottoclarin 2070 3gm/lit

Fabrics were experimentally tested in labs of National Research Center under slandered conditions as shown in Table (3).

Table (3) the experimental tests and their standards:

Experimental test	Standard
Warp and weft tensile strength (N)	ASTM D5035
Elasticity	ASTM D3107-80MODFY
Warp and weft tear strength (gm)	ASTM, D1424
Fabric Stiffness (Kg)	ASTM, D4032
Fabric weight (gm/ m2)	ASTM D3776
Growth	ASTM D3107
pH Index	EN ISO 3071
Shrinkage	3HL(3*60*60C)

3- Results and Discussions:

The results of experimental tests for the work samples are shown in Table (4).

Table (4) the results of experimental tests for work samples:

Sample No.	Tensile strength (N)		Elasticity(%)	Tear strength (gm)		Stiffness (Kg)	Fabric weight (gm/ m2)	Growth	Shrinkage (%)		Fabric C pH
	Warp	Weft		Warp	Weft				Warp	Weft	
1	93	51	5	6148	5059	1.3	385	3.0	-2.5	-3	5.7
2	92	44.6	30	6142	5264	1	410	4.5	-2	-15	5.8
3	90	36	90	6142	5755	1.1	453	6.0	-3	-22.5	5.2
4	90	33	100	6147	6251	1.6	488	4.0	-1	-14.3	5.2

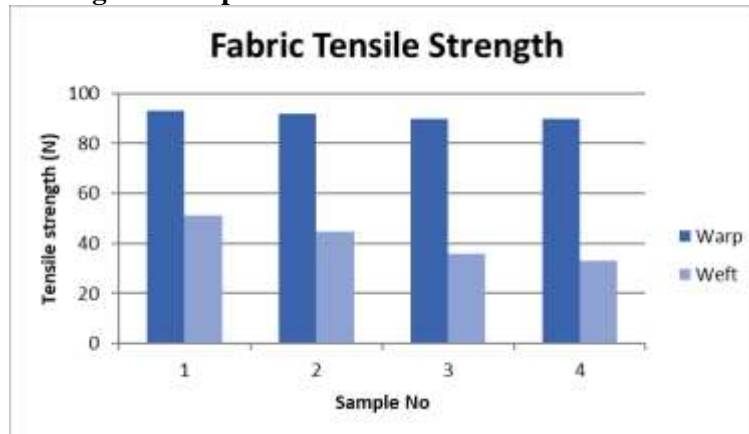**Tested samples tensile strength in warp and weft direction:**

Fig. (1) Tested samples tensile strength in warp and weft direction

- The results of the tested samples tensile strength in warp and weft direction showed that the highest value of the tensile strength in both the warp and weft directions was for sample (No. (1) (with 5% Elasticity)).
- This indicates an increase in the tensile strength of the cotton fibers, which in turn led to the strength of the threads, as by increasing the density of the thread, the threads gathered together in the tension area support the high load (tension), which led to an increase in the tensile strength.
- This means that with increasing thread density, the tensile strength of the fabric increases when using same construction and same yarn(NE).
- Sample No. (2) (Elastane 44 detex, 30% Elasticity) follows sample No. (1) in tensile strength.
- While the tensile strength was the lowest value in samples No. (3) (Elastane 117 detex, elastic percentage 90%) and sample No. (4) (Elastane 310 detex, 100% Elasticity)
- When the density of the cotton threads decreases (one of the properties of cotton fibers is high

tensile strength) and the percentage of elastane increases, the tensile strength of the fabric in the weft direction decreases, as the density of the cotton threads is lower in sample No. (4) than in the rest of the samples.

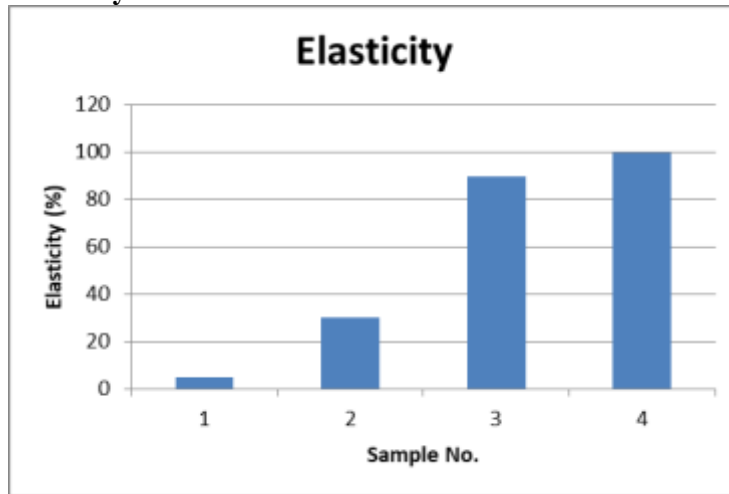**Tested samples tensile elasticity in weft direction:**

Fig. (2) Tested samples tensile elasticity in weft direction

- The results of tested samples tensile elasticity in weft direction showed that sample No. (4) with ratios of (Cotton/Elastane 92/8 in the weft direction and Cotton 100% in the warp direction / Detex 310) had the highest elasticity percentage of 100%,
- While sample No. (3) with ratios of (Cotton/Elastane 96/4 in the weft direction and Cotton 100% in the warp direction / Detex 117) is less elasticity than sample No. (4) as its elasticity percentage is 90%.
- Sample No. (2) with ratios of (Cotton/ Elastane 98/2 in the weft direction and Cotton 100% in the warp direction / Elastane Detex 44) is less elastic than sample No. (3) as its elasticity percentage is 30%.
- The lowest percentage of elasticity is sample No. (1) with percentages (Cotton 100% in the weft direction and Cotton 100% in the warp direction / detex 0), as its elasticity percentage is 5%.

Tested samples tear strength in warp and weft direction:

Fig. (3) Tested samples tear strength in warp and weft direction

- The results of the tested samples, By increasing the percentage of elastane in the direction of the weft, the tear strength increases
- Sample No. (4) (Elastane 310 detex, 100% Elasticity) achieved the highest tear strength. This is due to the use of Dtex 310, which has a higher diameter, Sample No. (3) (Elastane 117 Detex, 90% Elasticity) follows sample No. 4 in tear strength.
- It adds to their good properties and suitability for functional performance of denim clothing.
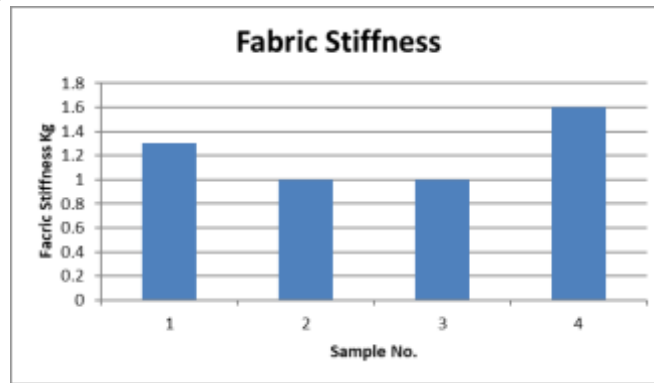
Tested samples stiffness:

Fig. (4) Tested samples stiffness

- The results of the tested samples stiffness showed that sample (4) achieved the highest percentage of stiffness for the fabric and this is due to the increase in (mechanical picks) in addition to (power stretch).
- Sample (1) follows sample (4) in the percentage of fabric hardness, which is a negative characteristic for denim clothing (jeans).

- Sample No. (2,3) also achieved lower hardness percentages than sample (1,4), which makes sample (2,3) better and more suitable for the functional purpose of maternity clothing such as trousers (Easy Stretch).
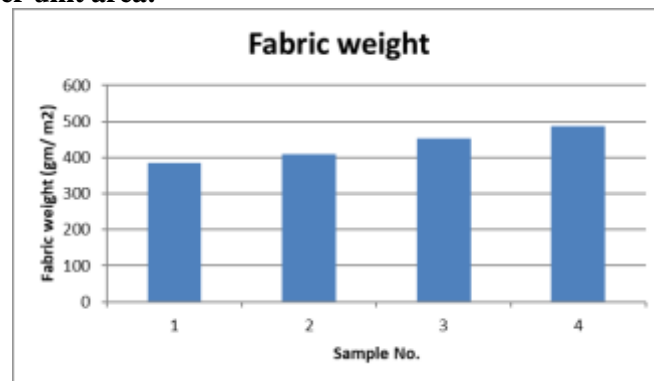
Tested samples weight per unit area:

Fig. (5) Tested samples weight per unit area

- The results of the tested samples weight per unit area showed that sample (1,2) has the lowest weight, which is a positive for the properties of denim clothing (jeans).
- The chart explains, by increasing the percentage of elasticity, the weight of the fabric increases, as sample No. (4) with ratios (Cotton/ Elastane 92/8 in the weft direction and Cotton 100% in the warp direction / Detex 310) achieved a higher weight.
- While sample No. (3) weighs less than sample No. (4), this is due to: The specific density of fiber is defined as the mass per unit volume and is expressed in grams per cubic centimeter. (g/cm3), so there is a direct relationship between the specific density of the material and the fabric weight.
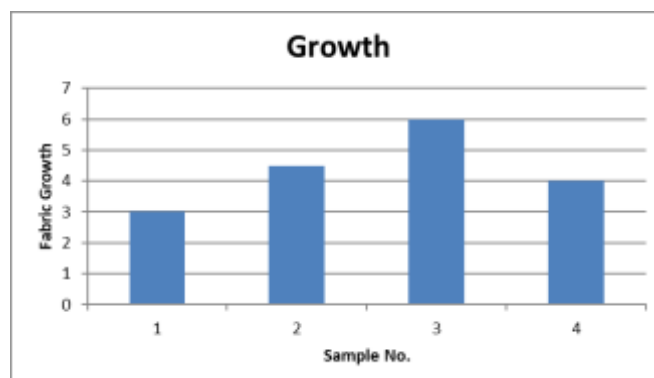
Tested samples Growth:

Fig. (6) Tested samples Growth

- The results of the tested samples growth showed that all samples were within the permissible limits, as the average acceptable percentages in the growth property of denim clothing (jeans) ranged between 3-6%.
- Sample (3) is higher in the percentage of growth, which is a negative characteristic in jeans clothes due to the fact that they are (easy stretch) and the strength of the return is weak,

- However, this feature is more suitable for the functional performance of pregnant women's clothing, especially trousers, as it gives more comfort and ease of growth.
- It takes the shape of the body easily and does not put pressure on the abdominal area. It is also easy to return to the original shape once the washing process occurs.

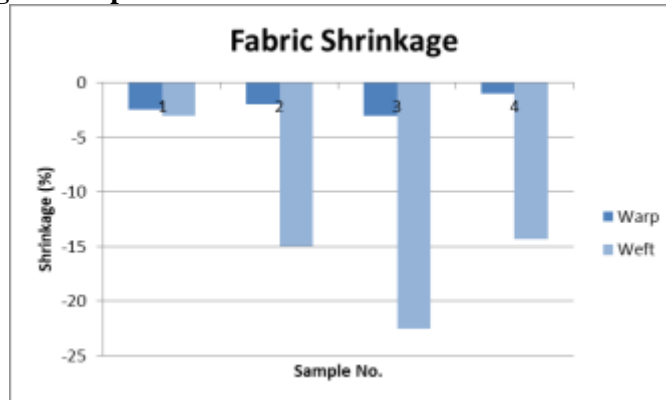**Tested samples shrinkage in warp and weft direction:**

Fig. (7) Tested samples shrinkage in warp and weft direction

Warp shrinkage:
- The results of the tested samples shrinkage in warp direction showed that all samples came within the permissible limits for jeans, as the average acceptable percentages in the shrinkage property of the warp ranged between (-1\-4%).

Weft Shrinkage:
- The results of the tested samples shrinkage in weft direction test showed that all samples were within the permissible limits for jeans.

- We also find that sample (3) has the highest shrinkage rate (-22.5) and this is due to it being (easy, high stretch), as well as a high percentage of (growth), which gives it comfort in the functional performance of the garment for pregnant women.
- It is easy to adapt the shrinkage property in sample No. (3) by increasing 3% in length and 22% in width when designing the pattern (in fabric).
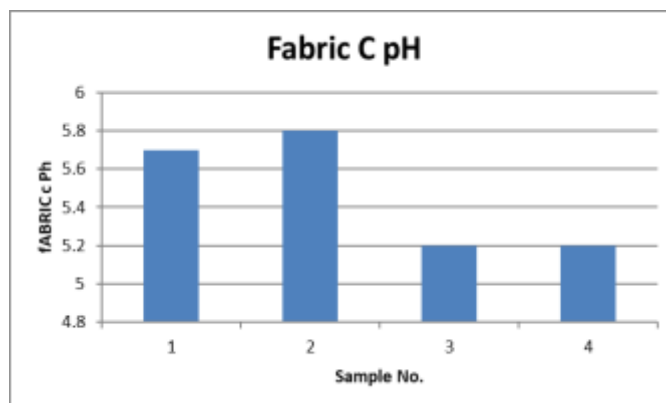
Tested samples C pH:

Fig. (8) Tested samples C pH

- The results of the tested samples C pH showed that all samples came within the permissible limits for jeans, which are less than 7.
- The best of them was sample No. (3, 4), which makes it less Irritation to the skin.

The Relative Values for Tested Samples
The relative values for tested samples are shown in Table (4), considering fabric weight, shrinkage, and C pH are –ve properties (the less values the better the property).

Table (4) The Relative Values for Tested Samples:

| Sample No.	Tensile strength (N)		Elasticity(%)	Tear strength (gm)		Stiffness (Kg)	Fabric weight (gm/ m2)	Growth	Shrinkage (%)		Fabric C pH	Average
	Warp	Weft		Warp	Weft				Warp	Weft		
	+ve	+ve	+ve	+ve	+ve	-ve	-ve	-ve	+ve	+ve	-ve	
1	100.0	100.0	5.0	97.8	80.9	81.3	100.0	44.1	83.3	13.3	91.4	75.7
2	98.9	87.5	30.0	97.7	84.2	100.0	94.9	66.2	66.7	66.7	89.7	73.9
3	96.8	70.6	90.0	97.7	92.1	100.0	86.1	88.2	100.0	100.0	100.0	86.0
4	96.8	64.7	100.0	97.8	100.0	62.5	78.9	58.8	33.3	63.6	100.0	77.3
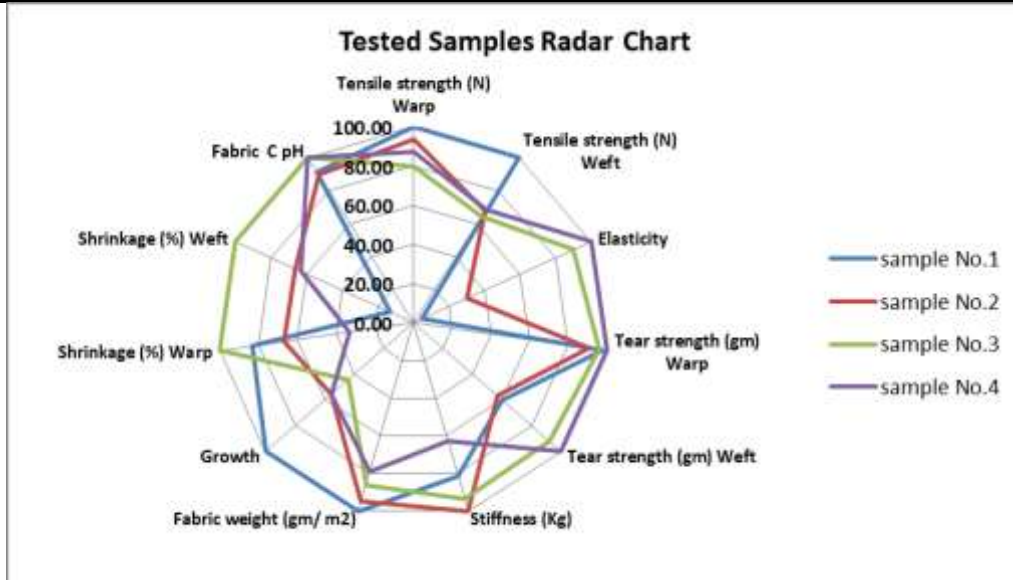
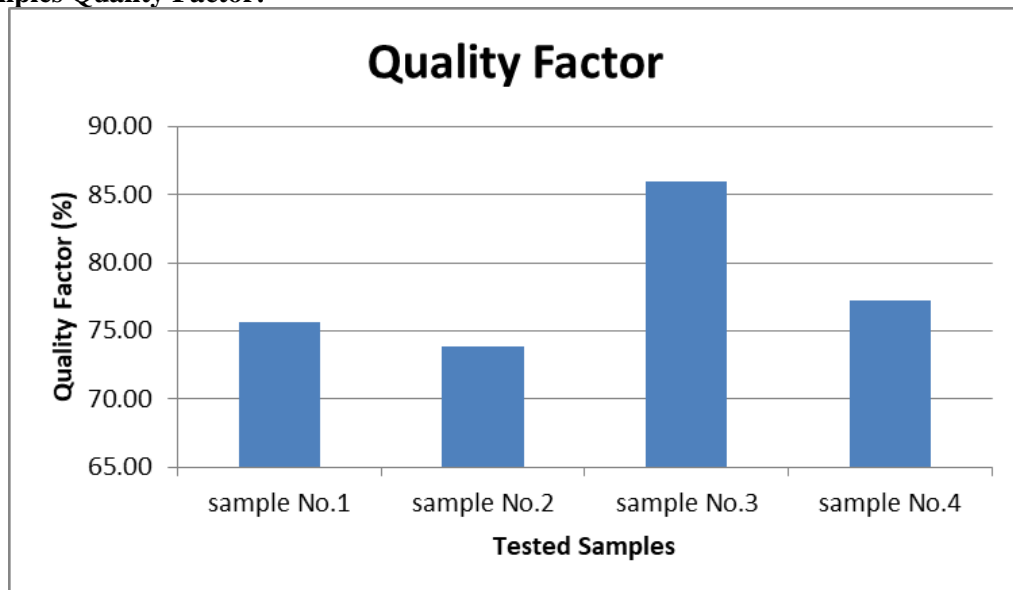Fig. (9) Tested samples Radar Chart

Tested samples Quality Factor:

Fig. (10) Tested samples Quality Factor

- The final results show that sample No. (3) is the best in terms of positive properties of denim clothing, was distinguished by (Growth, shrinkage, C pH, less stiffness and weight), which provides comfort properties and is suitable for functional performance for pregnant women's trousers.
- Then comes sample No. (4) with ratios of (Cotton/Elastane 92/8 in the weft direction and Cotton 100% in the warp direction / Detex 310) in terms of positive properties of denim clothing, but it is considered (hard stretch).

4- Design and produce Women's Trousers comfortable during different stages of pregnancy

According to the specifications and properties of the fabrics produced, sample No. (3) was chosen for its superiority over the rest of the samples under study in terms of properties (Tensile strength, Elasticity, Tear strength, Stiffness, Fabric weight, Growth, Shrinkage, Fabric C pH) which show the properties of the sample. It was used in a clothing product that suits its characteristics, suggested by the designer.

A piece of clothing (women's trousers) was designed and produced to suit different stages of pregnancy:

Design description:

The design is a women's trousers that takes the shape of the body and is characterized by a high waist consisting of two layers, in the shape of the letter (V), to cover the abdominal area and the back of the pregnant woman, with no sewing line in the abdominal area, which provides movement and sitting with comfort.

Fig. (11) Jean trouser produced from sample No. 3 fabric

By using jeans trouser for pregnant women, which were produced from fabric sample No. 3, it was found that it is suitable for different stages of pregnancy, as It is considered (easy to stretch), as was jeans trouser is distinguished by (Growth, shrinkage, C pH, less stiffness and weight).

Fig. (12) Jean trouser produced from sample No. 3 fabric during the different stages of a woman's pregnancy

Conclusion:

- 4 denim Fabrics ware produced with different Elastane ratio in warp and weft. Fabric Weave twill 3/1 Z, warp Ne 8, and weft Ne12 was used. A Pıcanol 2011 Waving machine was used with denting 4.
- The fabric was produced to be used as trousers for pregnant women with comfort properties.
- Various tests were performed on the 4 samples (Tensile strength (N), Elasticity, Tear strength (gm), Stiffness (Kg), Fabric weight (gm/ m2), Growth, Shrinkage (%), Fabric C pH).
- The final results show that sample No. (3) with ratios of (Cotton/Elastane 96/4 in the weft direction and Cotton 100% in the warp direction / Detex 117) is the best in terms of positive properties of denim clothing, more suitable for pregnant women (trousers) in terms of its properties as it is considered (easy stretch).
- sample No. (3) was distinguished by (Growth, shrinkage, C pH, less stiffness and weight), which provides comfort properties and is suitable for functional performance for pregnant women's trousers.
- Sample fabric No. 3 was used to produce jeans trouser, to provide comfortable and functional properties for pregnant women performance during the different stages of a woman's pregnancy.
- Then comes sample No. (4) with ratios of (Cotton/Elastane 92/8 in the weft direction and Cotton 100% in the warp direction / Detex 310) in terms of positive properties of denim clothing, but it is considered (hard stretch).
- According to the specifications and properties of the fabrics produced, sample No. (3) was chosen for its superiority over the rest of the samples under study in terms of properties (Tensile strength, Elasticity, Tear strength, Stiffness, Fabric weight, Growth, Shrinkage, Fabric C pH) which show the properties of the sample. It was used in a clothing product that suits its characteristics, suggested by the designer.
- A piece of clothing (women's trousers) was designed and produced to suit different stages of pregnancy
- By using jeans trouser for pregnant women, which were produced from fabric sample No. 3, it was found that it is suitable for different stages of pregnancy, as It is considered (easy to stretch), as was jeans trouser is distinguished by (Growth, shrinkage, C pH, less stiffness and weight).

Recommendations:

The study recommends using sample fabric No. (3) in the production of trousers for pregnant women, which provides comfort properties and is suitable for functional performance during the different stages of a woman's pregnancy.

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