Studying of Mechanical and Physical Properties of Polyester Composite Reinforced by Cows and Buffalo Horns

Ali O. Radam[1], Adil I. Khadim[2*], Zainab S. Abdul-Ridha[3]

Abstract

Cows And Buffalo Horns waste particulate have been used as non-chemical reinforcement particulate to improve several features of polyester polymer, the particles of the cow and buffalo horns waste particles were used in three particle size $15, 200, and\ 300\mu m$, at rates of 0, 2.4, and 6%, where the reinforcement process by the horns waste particles, where the hardness values have been increase from (60 to be 80), Young Modulus from 0.137 MPa to be 8.951 MPa, while the density values have been deceases from (3.78 to 2.08) g/cm^3 as a result of light weight of horn waste particles and the creation of voids and pores the reinforcing particles during the preparation process and the light weight (low density) of the reinforcement horn particles, in addition to that the thermal conductivity increases from (0.818 to be 1.489) W/m.°C.

Key Words: Cows and Buffalo Horns Particulate, Biocomposite, Mechanical Features.

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Introduction

Due to environmental interest and attention, several of the researchers have concentrated on the development of sustainable material in particular bio-composite materials (Babaremu *et al*, 2019). Bio-composites have, reinforcement phase from biological material (Abolaji *et al*, 2017). Mostly in Bio-composites, the reinforced fibers are typically plants fibers like flax, bamboo, hemp; animal fibers, and chicken feather (Nasir *et al*, 2019). In composites, the natural fiber as reinforcement is very useful for an environmental advantage solution and in addition to the low cost (Kttafah *et al*, 2019). In the last decade, the natural reinforcing of materials of polymeric composite has an increasing interest, together of the academic field and industries (Jassim, 2016). The interest of polymeric composite reinforcing by natural materials is increasing every day (Stalin *et al.*, 2015; Ezeh *et al.*, 2020). In the few last years and until now, natural materials possess to a greater extent used as alternative reinforcing material in polymeric composites, for the reason that of their inexpensive, lower density, innocuous of the environment, and high biodegradability (Mohammed *et al.*, 2016; Udoye *et al.*, 2019).

For a material to be considered a green material, the following requirements should be met: it should be biodegradable, it should be renewable, and it should be processable using an eco-friendly and energy-efficient method (Kttafah *et al.*, 2019; Ezeh *et al.*, 2020).

Yet one of the greatest challenges for material scientists is producing a commercially viable green material (Ezeh *et al.*, 2020).

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(Ambali *et al.,* 2019) investigate the effect of cow horn particles as reinforcement in an epoxy polymer, with reinforcement weight rates of (5, 10, 15, 20. 25, 30, 35, and 40) % at of (100 and 150) μm particle sizes. Where the composites specimens were prepared by hand lay-up method (Ambali *et al.*, 2019).

(Kumar *et al.,* 2014), studied the influence of a particle composite reinforcement using defatted horn fiber with polypropylene. Different features with reinforcing fibers rates (5, 10, 15, and 20) % have been tested (Kumar *et al.*, 2014).

(Ahmad, *et al.,* 2019) investigate the effect of snail shell particles as filler in an epoxy (LY556) as a matrix material for the project composite samples that are produced of polymer 90% with 10% of hardener, with other fillers material and horn particles (Ahmad *et al.*, 2019).

(Vishwanatha, *et al.,* 2020) studied the influence of the mechanical properties of composite materials by using the date palm, horn & glass fiber reinforced polymer, at different rates (0, 5, and 10%). The samples are prepared and tested under tensile and impact tests, they observed that, increasing the rates of date palm and horn fibers constituents decreases the tensile strength of the composite samples and increases the impact strength of composites samples. The horn and Horn Fiber/ Date Palm composites (Vishwanatha *et al.*, 2020).

(Laynde, *et al.,* 2019) studied the influence of two IP / HP and AP / HP biocomposites on the thickness swelling ratio, density, modulus of elasticity, tensile strength modulus, and internal cohesion of IP / HP and AP / HP, each sample was made from a horn-clad powder resin and reinforced respectively with Iroko and Ayous wood particles, ranging in size from 125 to 625 µm were characterized (Laynde *et al.*, 2019).

(Kttafah *et al.,* 2019) investigate the effect of waste particles of dates palm to on the mechanical properties of silicone rubber. The reinforcement particles were used in three sizes (75, 150, *and* 300) μm, with rates of (1, 3, and 5)%, the reinforcement particles improved the tensile strength, the hardness, furthermore the composite prepared samples show high resistance to water absorption (Kttafah *et al.*, 2019).

Sample Preparation

Production of the samples initially started with segmenting the cows and buffalo horns into small pieces, then these pieces have been washed with distilled water and ethyl alcohol to remove the dirt, the blood, and the suspended soil, after that dried (removing the moisture) at room temperature for 24 hours.

After that, each type of horns pieces has been milled alone using a mill for two hours to obtain the powders (particles). Then each type of powder has been sifted alone using an electric vibrator (shaker) and three sieves of 150, 200, *and* 300 μm, to obtain three particles sizes of powders.

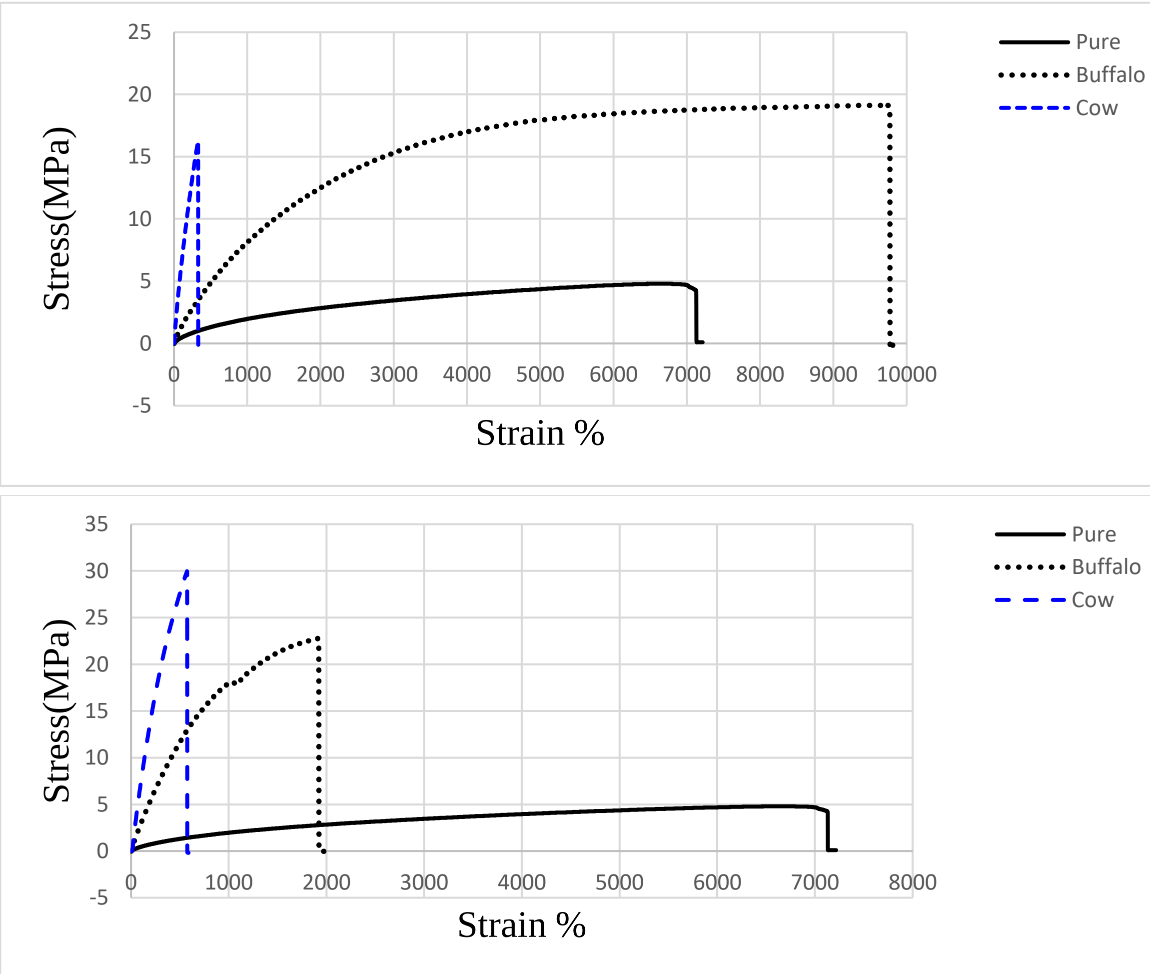
The production of the composite specimens include the addition of horn powder particles with respect to (0, 2, 4, and 6)%.

The molds (made of Teflon material), have been wash with distilled water and ethyl alcohol, drying in the oven at temperature 40°C for 2 hours, and to prevent the casts from sticking with the molds, therefore these molds lubricate in all casting stages. The properties of polymer matrix, Turkuaz (Turkey) TP 100 casting type polyester resins, non-accelerated, low reactive, low viscosity, orthophthalic, high filler capacity and low shrinkage, transparent and colorless. Scheme 1, shows, (a) cows and buffalo horns, (b) the powder of horns after milling and sieving depending on the particle size, (c) some of the Teflon molds that have been used in the preparation of the composite specimens.

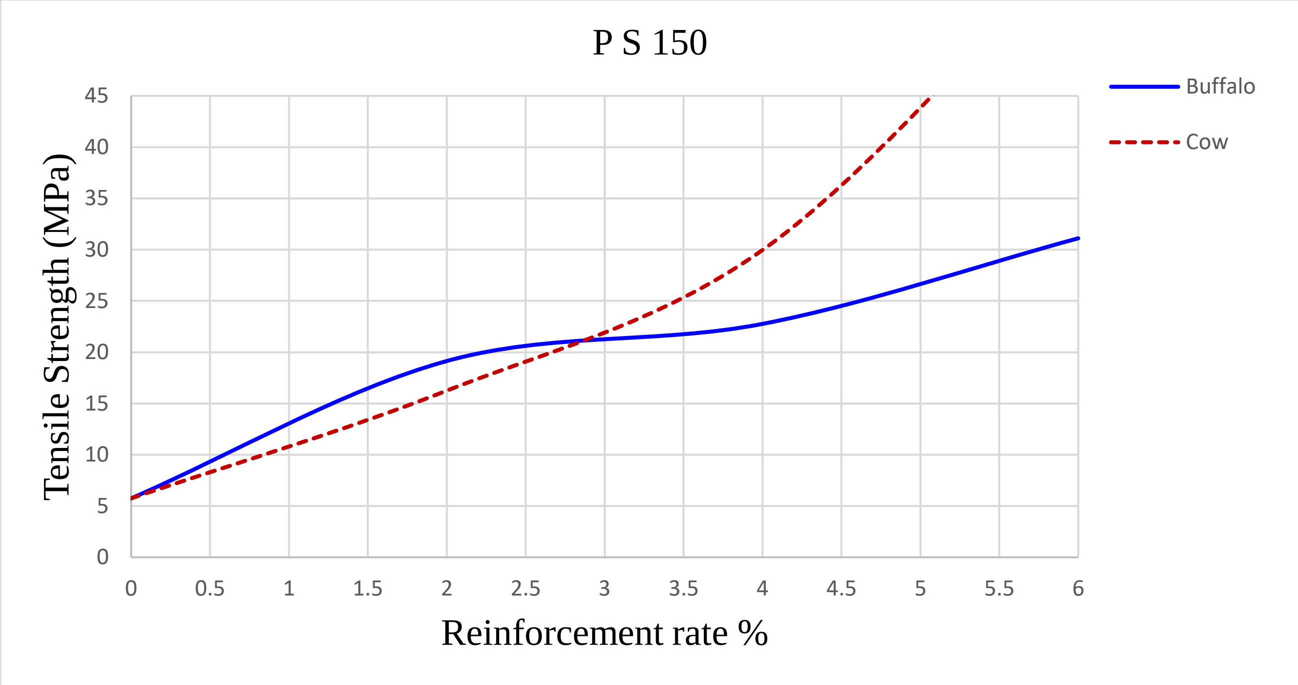
Scheme 1. a) Cows and buffalo horns, (b) the powder of horns (c) the Teflon molds

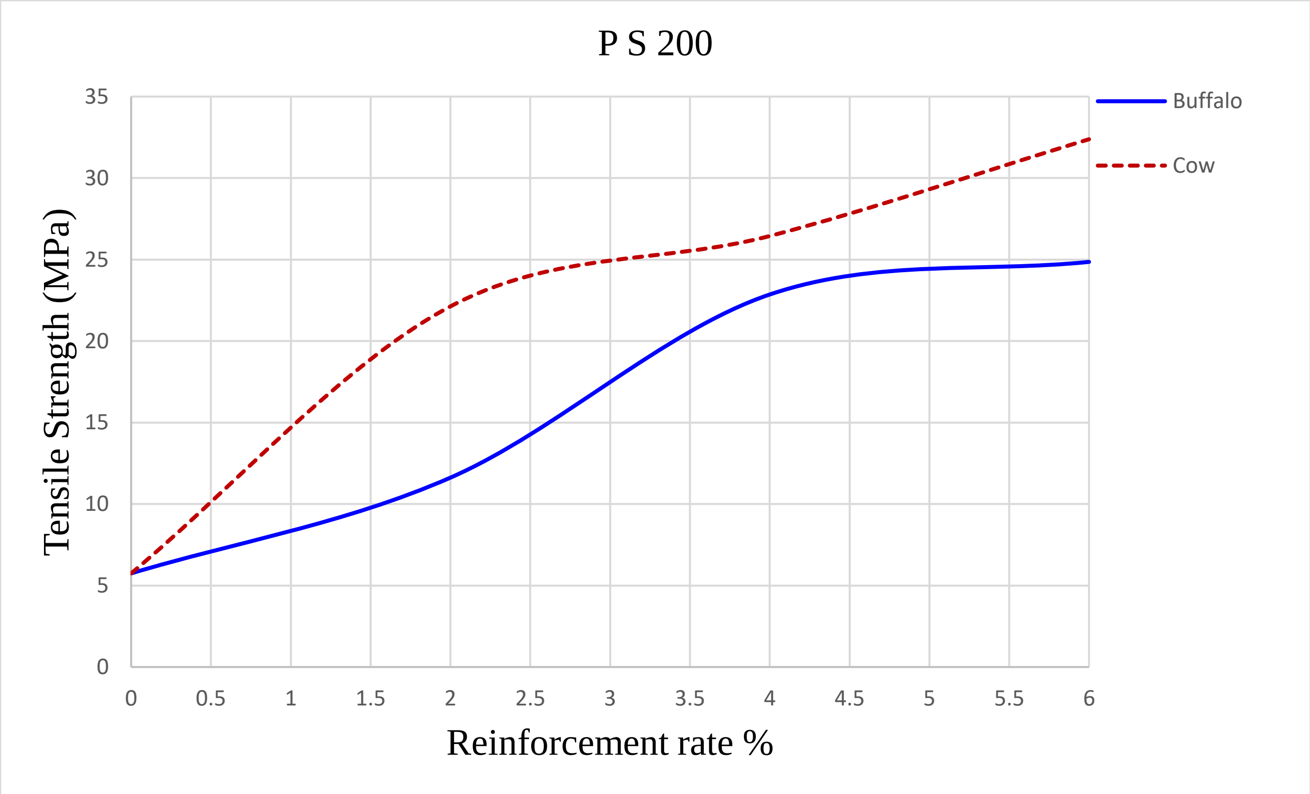
Result and Discussion

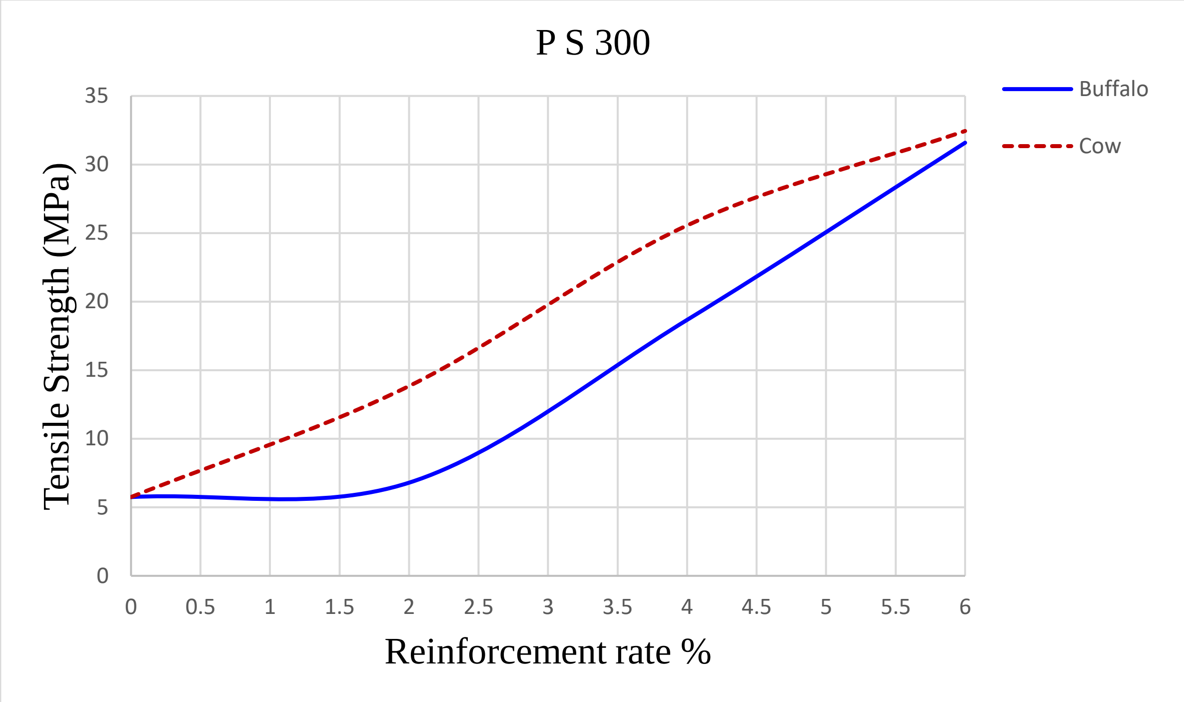
Scheme 1. Illustrates the behaviour of the stress – strain behavior of the prepared (pure and reinforced with Buffalo and Cow composites) samples of 150 μm at (2 and 4) % respectively.
Where it can be observed the obvious effect of reinforcement particles, rates, types on the stress-strain curve which includes elastic and plastic range, ultimate strength (tensile strength), and fracture points.
As the specimens have been prepared under similarly conditions, then, that means the Composition of a reinforcement material and the microstructure have a powerful effect on the features of the produced composite specimens.
We can notice that the tensile strength values have been increased by reinforcing the pure polymer specimens, and in the same time, we can notice that the tensile strength values have been increased by increasing the amounts (rates) of the reinforcement particles and that for the two types and all particle size (150, 200 and 300) μm. Where the maximum tensile strength value reached of the sample reinforced by cow horn particles (59.683MPa), at particle size 150 μm and reinforcement rate (6%), while the tensile strength value of the pure polymer sample (5.746 MPa), which means that the reinforcing process increases the tensile strength value by about (10.387 times). That means that these particles have connect the particles of the matrix (polyester) with each other strongly (support), sustained and withstand the external (load) force and that leads to strengthen and support the samples. and this behaviour applies on all samples. While the tensile strength decreased with increasing the particle size (for the same rate) of the reinforcement particles for all types rates, and this is due to the voids and vacancies or (pores) caused by the large reinforcement particles which displaced the polyester particles from each other and created large voids, which in turn weaken the samples, Scheme 2.



Scheme 2. Tensile - strain curves of the specimens at (2 and 4) %, rates at 150 μm

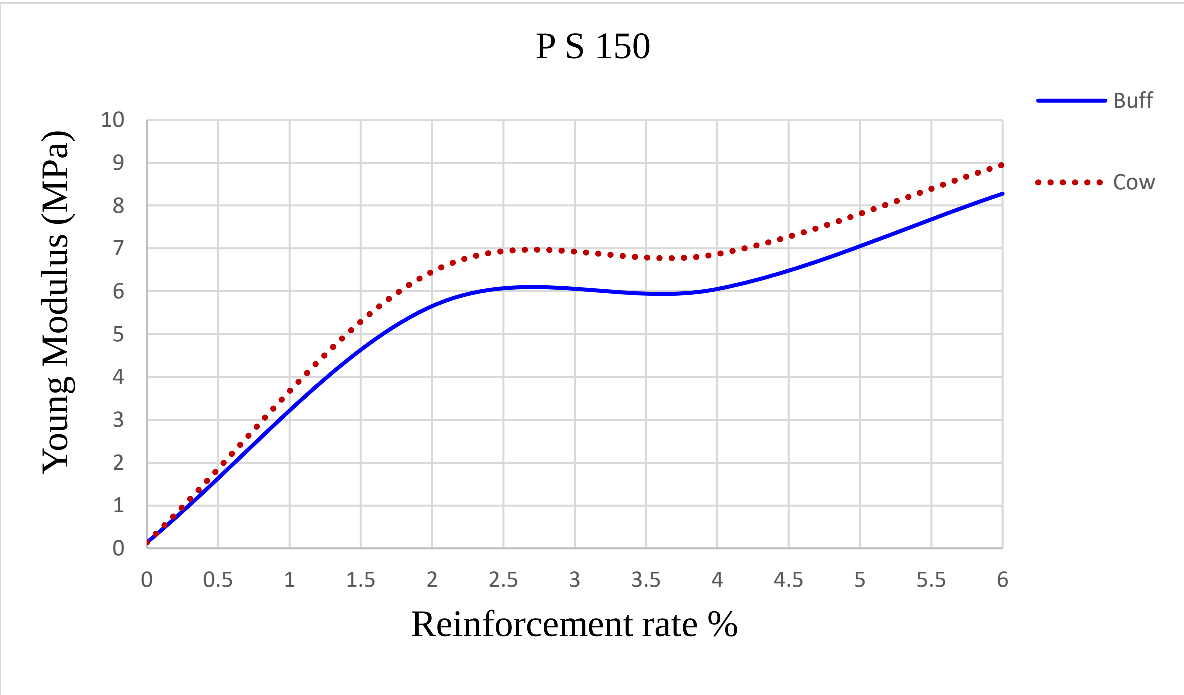

P S 150
Tensile Strength (MPa)
Reinforcement rate %
Buffalo
Cow
0
5
10
15
20
25
30
35
40
45
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6

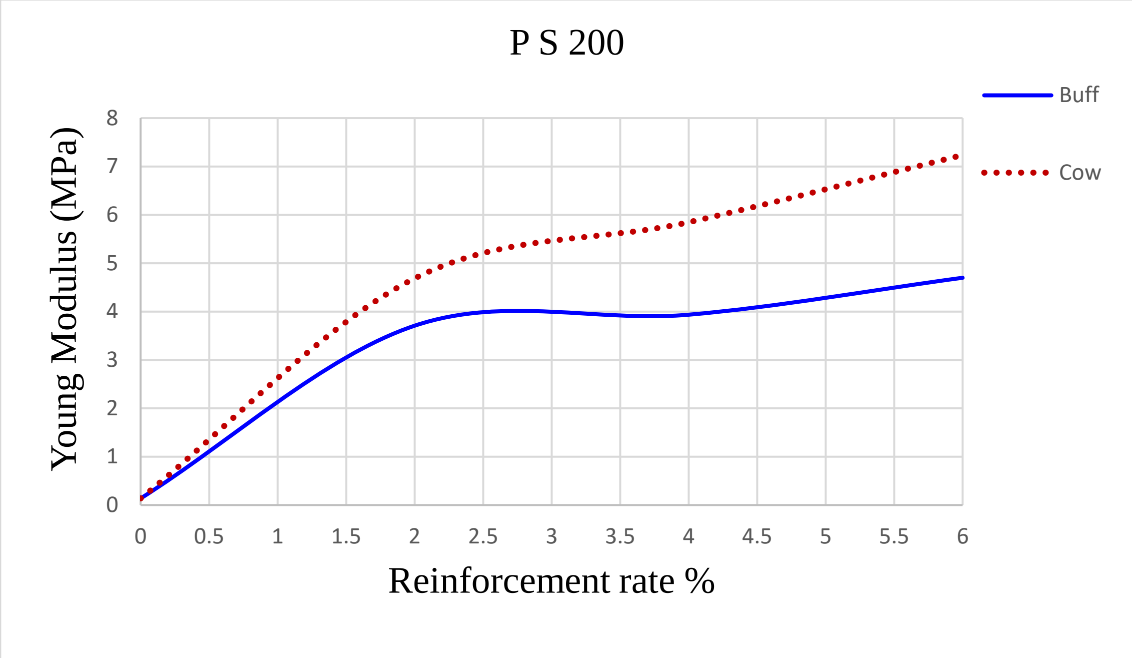

P S 200
Tensile Strength (MPa)
Reinforcement rate %
Buffalo
Cow
0
5
10
15
20
25
30
35
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6

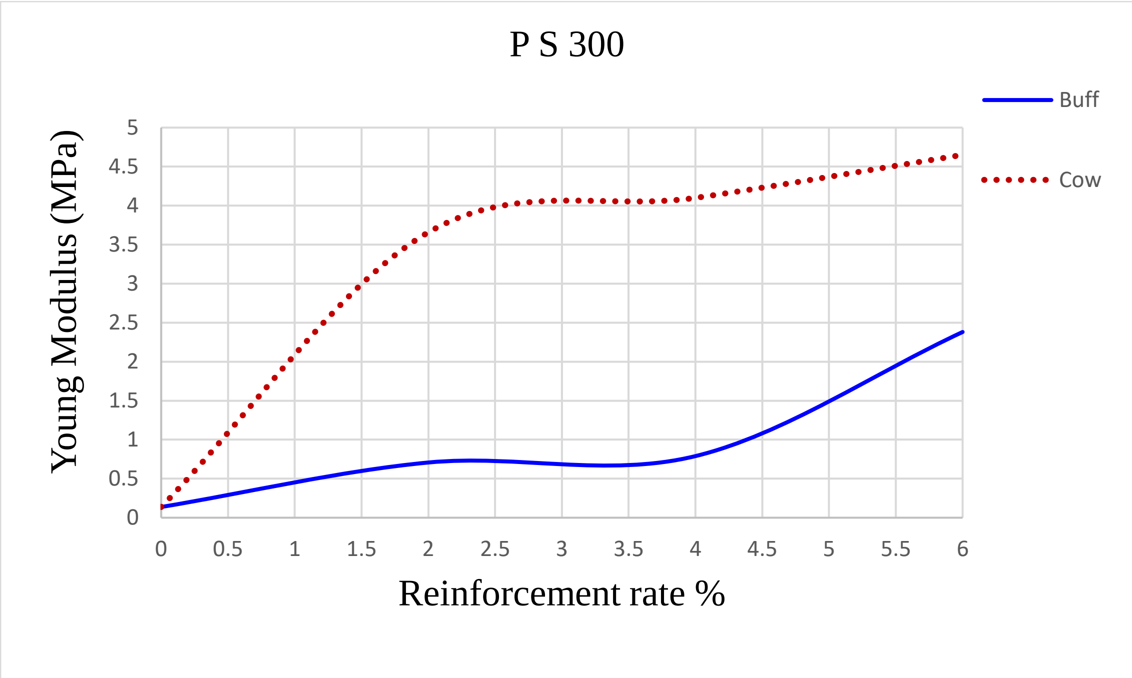


Scheme 3. The tensile strength of prepared specimens opposite the reinforcement rates

Young Modulus or (Elastic Modulus) results were obtained from the digital data of the tensile stress – strain test using the Excel program.
The reinforcing process increases Young Modulus values, where the best result obtained by reinforcing by Eucalyptus particles, and the maximum Young Modulus result obtained of the sample reinforced by Eucalyptus particles at particle size 150 μm and rate 6 %, which increases the Young Modulus from 0.137 MPa to be 8.951 MPa by (65 times). That means the reinforcing process increasing the sustain (support) of the sample to elastic deformation before fracturing, as shown in Scheme 4. 21



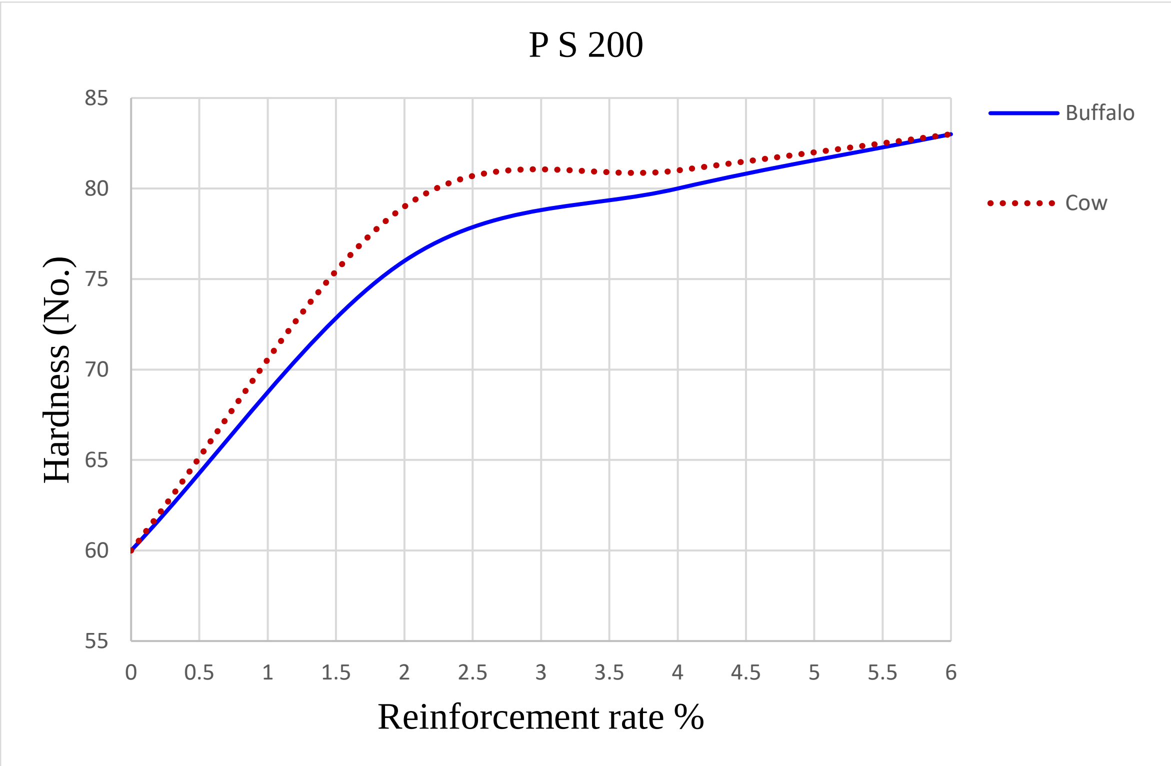


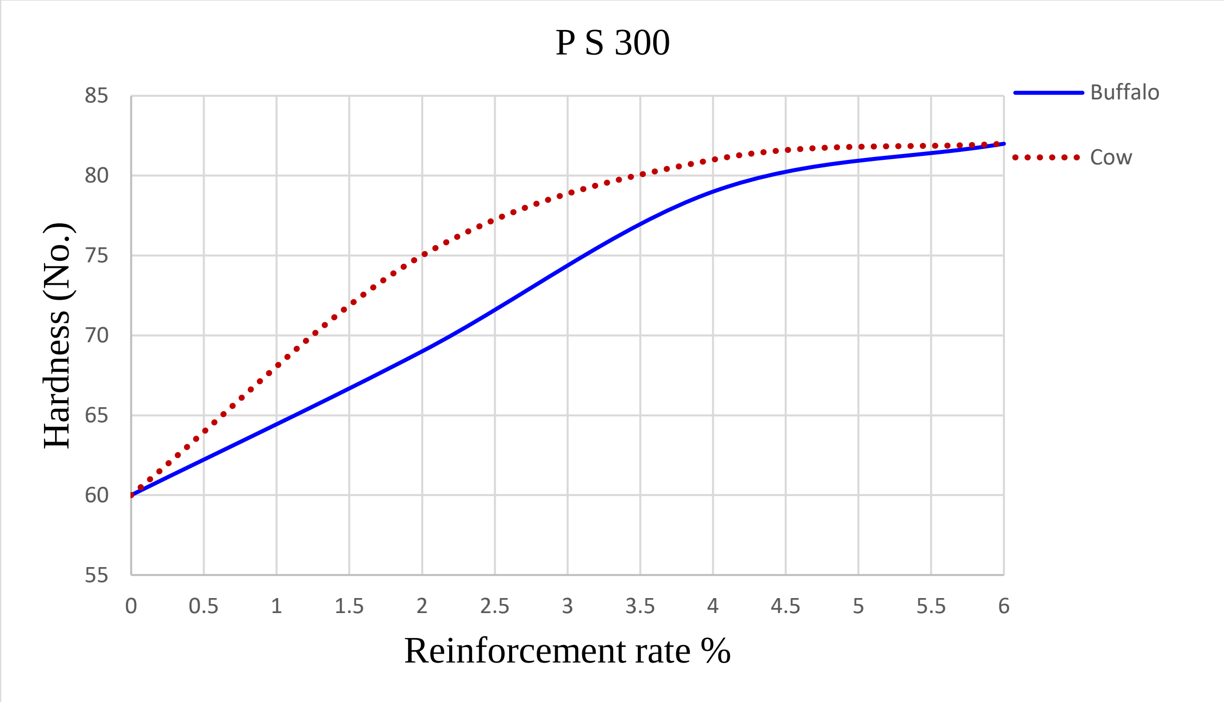


Scheme 4. Young Modulus of prepared specimens opposite the reinforcement rates

The effect of the reinforcement particles on the hardness values of the prepared samples can be noticed obviously, where the existence of reinforcement particles increased the connection between the polymer particles, which led to increased cohesion (resistance) of the sample structure to the external force; this applies to the two horn particles types, and all rates. The reinforcing of the polymer matrix with the waste horn particles increases the hardness value from (60 to 80) (where the maximum value obtained of the sample reinforced by cow horn particles at particle size 150 μm and rate 6%) by about (1.4 times). As explained in Scheme. 5.


P S 150
Hardness (No.)
90
85
80
75
70
65
60
55
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
Reinforcement rate %
Buffalo
Cow


P S 200
Hardness (No.)
85
80
75
70
65
60
55
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
Reinforcement rate %
Buffalo
Cow

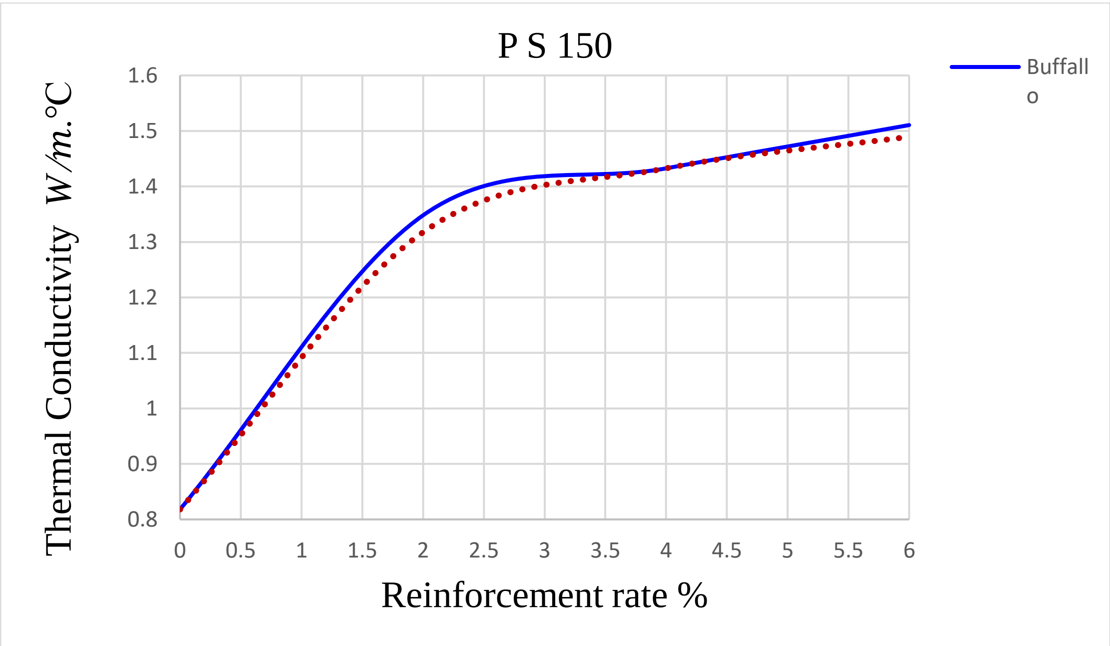


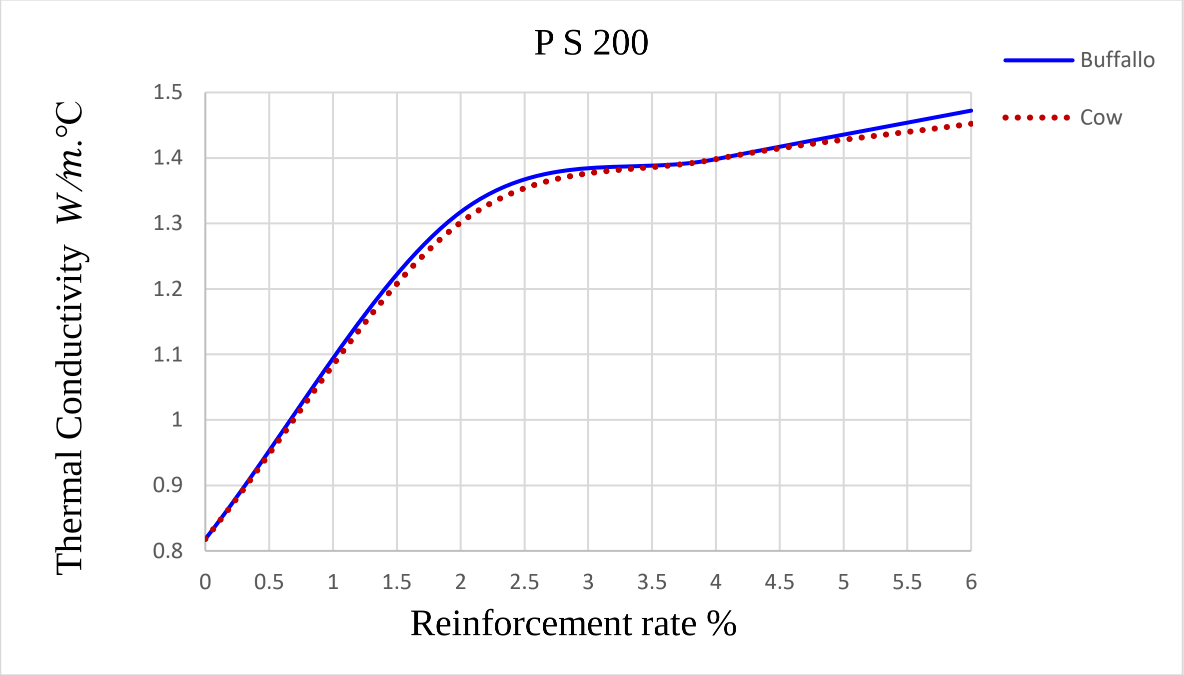
Scheme 5. The hardness of specimens opposite the reinforcement rates

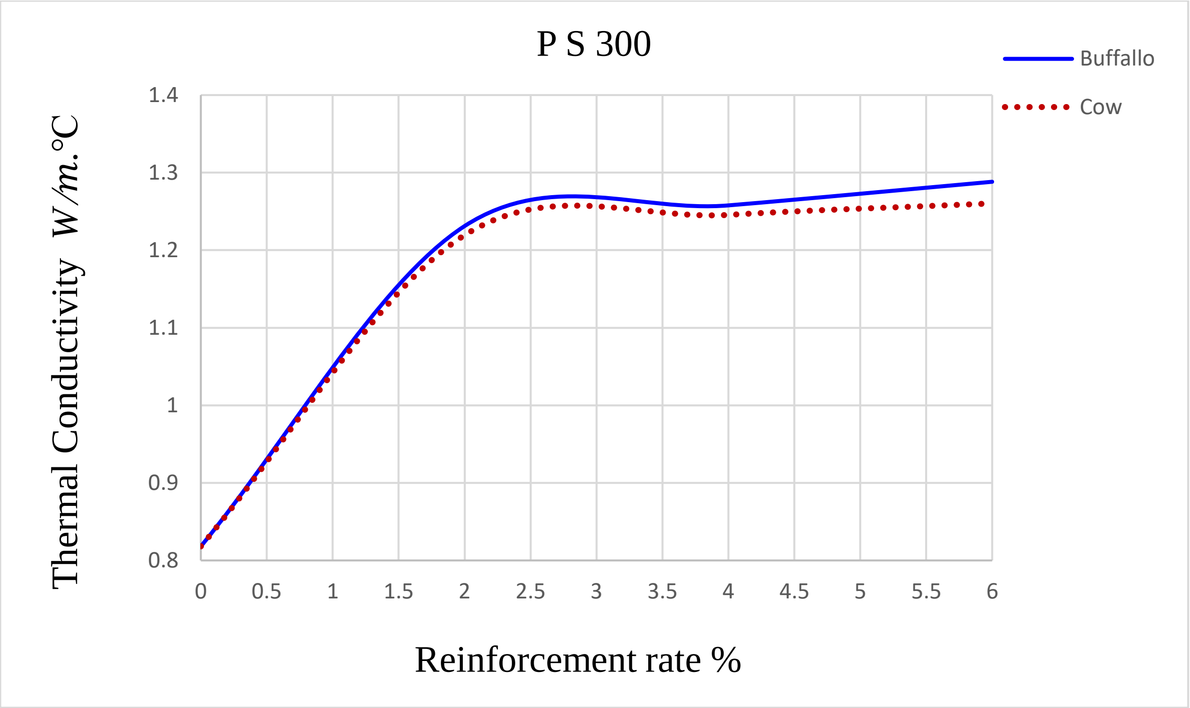
There are many factors that affect the thermal conductivity of the polyester composites samples, Such as the effect of different compositions of the horn wastes particles, the reinforcing rate, and the particle size.

The reinforcing process increases the thermal conductivity values, where the best result obtained of the composites samples reinforcing by Eucalyptus particles, and the maximum thermal conductivity result obtained of the sample reinforced by Buffalo Horns waste particles at particle size 150 μm and rate 6%, which increases the thermal conductivity from (0.818 to 1.51) $W/m.$°C by (1.82 times), and that due to the different elements in the horn particles increase the thermal conductivity of the composites samples in addition.

While the increasing of the particles size creates large voids and pores, and therefore these voids and pores decrease the thermal conductivity of the samples. As explained in Scheme. 6.

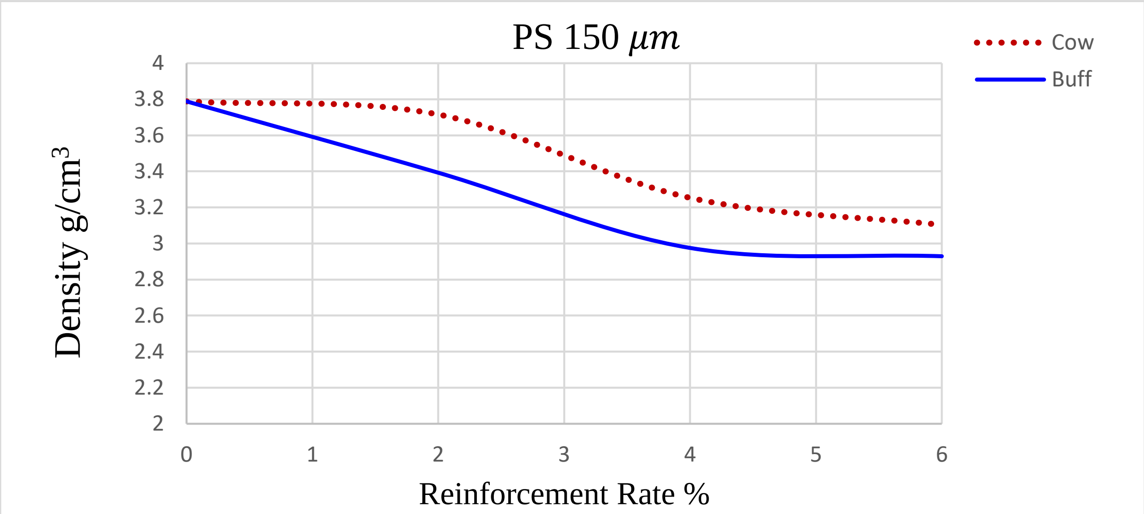


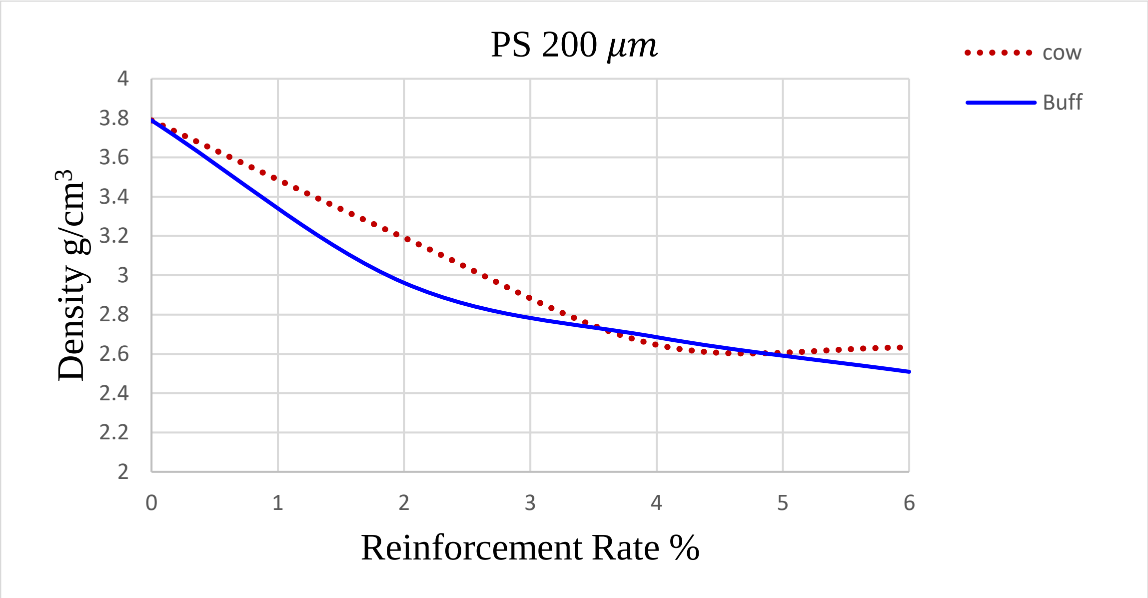


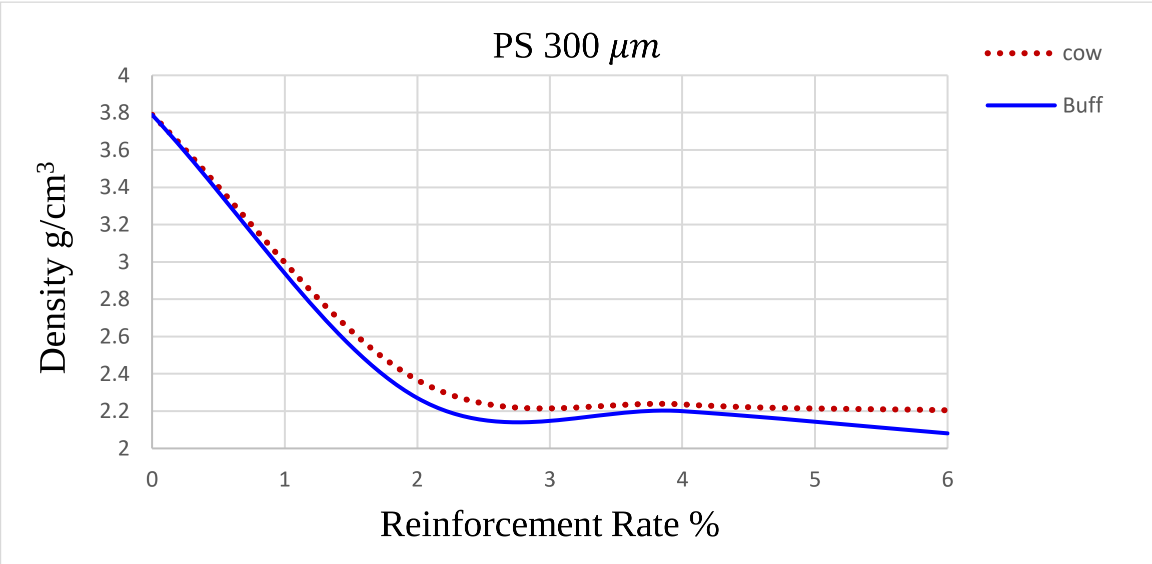


Scheme 6. The thermal Conductivity of the specimens opposite the reinforcement rates

As we can notice from Scheme. 6, that the reinforcement process by horns waste particles decreased the density values of the prepared composites samples, and that due to two reasons, the first is the voids and pores created by the reinforcing particles during the preparation process (which increases with increasing the particle size). In addition, the second reason is due to the lightweight (low density) of the reinforcement horn particles, where the density values of the particles are less than the density of the polyester. In addition, the density was reduced with increasing reinforcement rates for all particle sizes, where the density values (3.78 to be 2.08) g/cm^3, (where the minimum value obtained of the sample reinforced by cow horns waste particles at particle size 300 μm and rate 6%). As explained in Scheme. 7.







Scheme 7. The Density of the specimens opposite the reinforcement rates

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Conclusion

Using of Cows and Buffalo Horns waste particles as a reinforcement material for polymeric composites (polyester) has many benefits together. The first benefit is the improvement of the mechanical properties of the polymer composite by using the natural particles (Biocomposite) as a reinforcement particulate, the second is the reduction of environmental pollution by reduced of using chemical (materials) particles, and the third is reducing disease transmission resulting from these materials. Where the results of the Young modulus, hardness, thermal conductivity, and density tests of the samples reinforced by these particles evince the improvement of the mentioned properties of polymer composite, making it beneficial in practical applications.

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