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Max Golf Balls: Biodegradable and Sustainable Golf Balls

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ABSTRACT

Golf is a game enjoyed and played around the world, at a detriment to the environment. The sport is typically associated with the destruction of habitats and increased usages of pesticides and herbicides. However, an often over looked consequence is the environmental damage of the estimated 300 million golf balls that are lost in the United States in a year. These lost golf balls never truly breakdown and leach heavy metals into the surrounding soil and water as they fall apart. Max Golf Balls are a green alternative, made of entirely biodegradable materials. Under proper composting conditions, the ball would break down in as quickly as two months. Their performance was tested and was found to be comparable to standard golf balls, so a consumer would not impact their game or enjoyment by switching to the environmentally-friendly golf balls.

Keywords: golf ball, biodegradable, composting, soy

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INTRODUCTION

Golf is a widely popular sport in first world countries and it has a huge economic impact on the international recreational sports industry. In the U.S. alone total golf equipment sales totaled to over 2 billion dollars in 2016 [1]. However, its negative environmental impacts have resulted in its popularity decreasing as consumers become increasingly environmentally friendly conscious. Pesticides and herbicides used in lawn maintenance and the destruction of natural habitats are two regularly listed environmental faux pas [2]. A less well known environmental impact however is the surprisingly large amount of golf balls that are shot into the surrounding green area and lost or forgotten. In the United States alone it is estimated that annually over 300 million balls are either lost or left behind [3]. Consider the fact that these balls can take anywhere from 100 to 100 years to decompose and this becomes a significant source of pollution [3]. Typical golf balls are made up of a polybutadiene rubber core and ionomers and/or polyurethane plastic outer shell [5]. Besides the fact that neither of these materials are biodegradable both are also produced from petroleum through processes that require large amounts of fossil fuels, water and harsh chemicals [4]. The obviously solution to this problem, make golf balls instead from a material that is biodegradable, for example, soy-based plastic.

Soy is one of the most commonly produced cereal grains in Canada. A record high of over 7.7 million tonnes was harvested in 2016 and this number is expected to increase [5]. Ongoing work ion innovative cultivation and harvesting practices have fuelled this continuous market growth and soy bean producers are continually seeking out new markets that can utilize soybeans in order to increase demand. Soy-derivatives are effective replacements for many petrochemical materials resulting in a more environmentally friendly product that is of equal quality and costs that same amount to manufacture [6]. Biodegradable soy plastics are currently widely used for food packaging products [7]. To a consumer they will look and act like a regular petroleum-based plastic but if exposed to prolonged high temperatures or humidity they will eventually biodegrade into non-harmful bio-products and carbon, oxygen and water which can enter back into the surrounding environment [7].

Additionally, the energy used to manufacture soy plastic is significantly less than petroleum-based products, and the process of cultivating soy when done sustainable will produce far less carbon emissions.

The following report outlines the design for a biodegradable soy plastic-based golf ball: the Max Golf Ball. Virtually indistinguishable from a regular golf ball, Max Golf Balls makes the decision to switch to the environmentally friendly option easy, without the player having to make any sacrifice in product quality or enjoyment of the game.

EXPERIMENTAL DESIGN

After preliminary research, two promising potential bioplastics were considered. These two included a polylactic acid (PLA)/soybean meal blend and a cornstarch soy plastic. Based on the properties and design of a standard golf ball, it was determined that a polylactic acid and soybean meal core could potentially be housed within a cornstarch soybean “plastic” coating.

After creating the soybean plastic, it was observed to have high elasticity and bounce comparable to that of a regular golf ball. The process was therefore altered so that the core of the golf ball would be the soybean plastic (emulating the rubber normally found in traditional golf balls) and the coating would be the PLA-soybean meal mixture to provide additional strength and durability. The production process was developed and is shown in Figure 1. The soybean meal-PLA process steps were adapted from [8] and the soybean plastic process steps were adapted from [9].

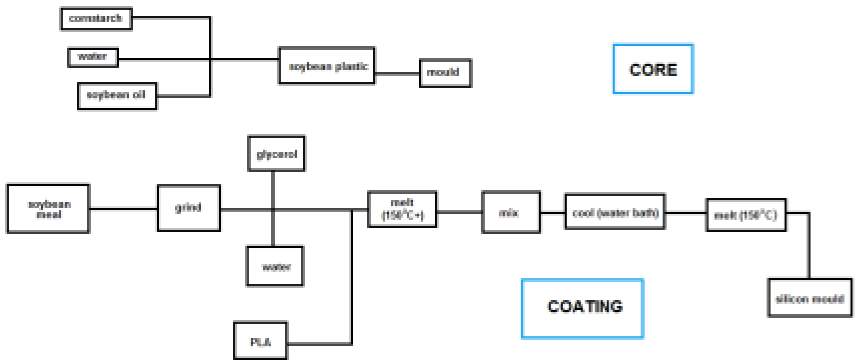

Figure 1: Initial process diagram for creating soybean-based golf balls, showing the planned steps to create the core and the coating

However, the coating process in Figure 1 proved to be unfeasible. The processed soybean meal and PLA did not melt and fuse together as expected. The next idea was to melt the PLA by itself and pouring it to coat the inside of the same silicon mold used to make the core; once it had hardened, the core could be made with its coating directly fused to it. Unfortunately, given the limited equipment this also proved to be unpractical because the PLA would harden immediately once it removed from its heat source, so it was not possible to pour it into the silicon mold. To address this, the next attempt was to keep the melted PLA in its pan over the heat source, drop a regular golf ball in the pan, quickly rotating it in order to coat it in the PLA, and then taking the PLA-coated golf ball out to harden; then, the coating would be sliced off and removed, to be used on the soybean core. This coating on the regular golf ball was too fragile for the extraction process, so the team had to think of a new solution again.

PLA fibres were purchased and used to 3D print the coating in two halves. This ensured a tough, durable, and even coat. The halves were then further hollowed out and the core ingredients were poured inside, thus making the core that was immediately coated. The two halves were then attached by soldering the edges and being clamped together. Several of these final prototypes were made to allow for several iterations of testing. The final average weight of the prototypes was 44.5 g, which is similar to the standard golf ball weight of 45.6 g and the floater golf ball weight of 39.6 g.

DATA ANALYSIS

Testing was done that would best reflect the golf ball properties that a consumer would be interested in. As such, the team decided to measure the distance the prototype ball could travel from an average-powered golf club swing and the subsequent amount of deviation the prototype demonstrates (i.e. how far does the ball roll in a straight line). The control was chosen to be a standard golf ball and a floater golf ball.

The force of the golf club swing had to be held constant between all experiments to ensure results were not biased or due to variability (Figure 2 shows a schematic of the experiment design that was used). This was possible by clamping the golf club such that the club was secure but still able to swing in one direction. Now, if the golf club is lifted at an angle, the resulting force of the swing as the club returns to its perpendicular position to the ground would be equal to gravitational force, calculable using

$$F_g = mg\cos(\theta) \qquad (1)$$

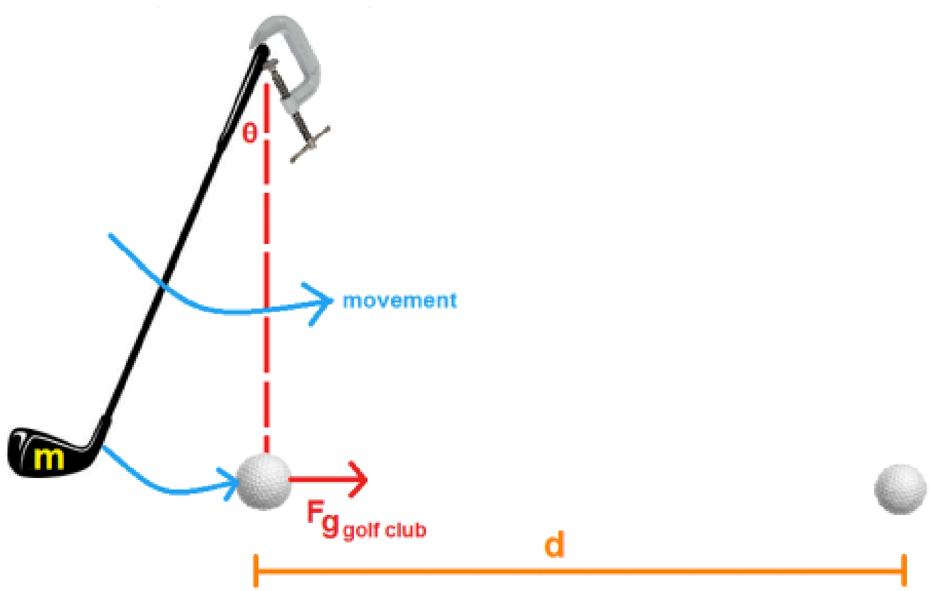

Figure 2: Schematic showing the experimental design used to determine how far the prototype and control golf balls traveled

Two planks of wood were set up parallel to each other to determine when the balls began to veer off the straight line. The results of this test are summarized in table 1. A one-way ANOVA test was used on the total distance and the straight distance values, and are shown in table 2 and 3.

One-way ANOVA can determine if differences between the results of the golf balls was statistically significant based on the p value. The results of the total distance were significant, which reflects that the prototype underperformed. The straight distance results, however, were determined to be statistically insignificant. This means that the prototype performance was comparable to the standard golf balls, which is the goal.

Table 1: Summary of results from the experiment between a standard, regular golf ball, floater golf ball, and the prototype golf ball.

trial #		total distance (cm)	straight distance (cm)		total distance (cm)	straight distance (cm)
1	real golf ball	58	50	floater golf ball	38	38
2		59	38		43	30
3		59	27		54	34
4		57	44		41	40
5		53	25		56	37
	average	57.2	36.8	average	46.4	35.8

trial #		total distance (cm)	straight distance (cm)
1	pla+coat and core	38	26
2		43	40
3		41	26
4		34	34
5		40	32
	average	39.2	31.6

Table 2: One way ANOVA on total distance values from Table 1.

Data Summary	Samples					
	1	2	3	4	5	Total
N	5	5	5			15
ΣX	286	196	232			714
Mean	57.2	39.2	46.4			47.6
ΣX^2	16384	7730	11026			35140
Variance	6.2	11.7	65.3			82.4
Std.Dev.	2.49	3.4205	8.0808			9.0774
Std.Err.	1.1136	1.5297	3.6139			2.3438

standard weighted-means analysis

ANOVA Summary 3

Source	SS	df	MS	F	P
Treatment [between groups]	820.8	2	410.4	14.8	0.000576
Error	332.8	12	27.7333		
Ss/Bl					Graph Maker
Total	1153.6	14			

Ss/Bl = Subjects or Blocks depending on the design.
Applicable only to correlated-samples ANOVA.

Table 3: One way ANOVA on straight distance values from Table 1.

Data Summary	Samples					
	1	2	3	4	5	Total
N	5	5	5			15
ΣX	184	158	179			521
Mean	36.8	31.6	35.8			34.7333
ΣX^2	7234	5132	6469			18835
Variance	115.7	34.8	15.2			52.781
Std.Dev.	10.7564	5.8992	3.8987			7.2651
Std.Err.	4.8104	2.6382	1.7436			1.8758

standard weighted-means analysis

ANOVA Summary 3

Source	SS	df	MS	F	P
Treatment [between groups]	76.1333	2	38.0667	0.69	0.520416
Error	662.8	12	55.2333		
Ss/Bl					Graph Maker
Total	738.9333	14			

Ss/Bl = Subjects or Blocks depending on the design.
Applicable only to correlated-samples ANOVA.

All three balls were qualitatively tested by several engineering students. They considered the performance between the golf balls compared but did note the prototype was heavier; although the weight was similar, the soybean plastic core makes the prototype seem heavier than the hollow standard golf balls. One student expressed their opinion that even if performance was slightly impacted, they would personally choose the biodegradable ball because of its minimal impact on the environment.

COMMERCIAL POTENTIAL

Recently, consumers have been growing increasingly concerned about the environmental impacts of the products they buy. The biodegradable pack

aging market is expected to increase around $6 billion from 2016 to 2021 [10]. This increase is primarily driven by the increasing concern for the environment and raised awareness surrounding waste management. Given that this product’s primary draw is its biodegradability, the increase in market share of similar products heralds a high potential for success of the product in commercial settings.

Beyond the regular consumer market, there is also a high potential for commercialization in the golf industry. As a popular golfing magazine reports, the Danish Golf Union has recently begun investigating the impact of lost or discarded golf balls. The magazine states that ’...during decomposition, the golf balls dissolved to release a high quantity of heavy metals. Dangerous levels of zinc were found in the synthetic rubber filling used in solid core golf balls. When submerged in water, the zinc attached itself to the ground sediment and poisoned the surrounding flora and fauna.” [11]. Given that around 300 million golf balls are lost per year, and that it can take upwards of a hundred years for golf balls to decompose, there is an immediate need for a biodegradable ball [11]. There is a market for individuals who enjoy the sport and are concerned about its effect on the environment.

While the performance of the ball is not directly equivalent to that of a standard golf ball in all measures, there is a niche market for individuals who may use this in a recreational setting. There are amateur golfers currently using floater balls to ensure ball retrieval in bodies of water. Floater balls do not replicate the exact performance of golf balls, but they are still used for specific applications. Golfers are willing to forgo certain elements of performance as a trade-off. Max Golf Balls can fit this niche by catering to golfers who don’t mind sacrificing a bit of performance for environmental sustainability.

It costs around $0.75 for one ball’s raw ingredients, which is comparable to the average price of $2 per regular golf ball. Even when accounting for manufacturing, the ball will have a similar cost to that of regular golf balls. Therefore, consumers will not have to consider potential cost differences between Max Golf Balls and regular golf balls.

CONCLUSION

In the future, the primary goal will be to reduce the cost of raw materials and manufacturing of the ball. This can give Max Golf Balls an edge over the competition by being cheaper and more environmentally friendly. The cost can be reduced through finding methods of mass production and looking into other production methods such as injection moulding. In addition, more testing could be performed on the ball to compare it to existing golf balls and in-field, on a golf course. Having additional testing data can provide consumers with data that they can use when making purchasing decisions. Market testing could also be completed to see the viability of this, given actual consumer opinions.

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