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How Many Maxim Tomatoes Would Kirby Need to Consume to Fuel an Attack Against Bowser?

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Abstract
This paper describes and calculates both the forces of three types of attack (punching, kicking and headbutting) from Kirby directed onto Bowser, and the number of Maxim Tomatoes Kirby would need to consume to complete each of the attacks, within the Smash Bros title, *Super Smash Bros. Ultimate.* It is found that, at a pre-set damage of 300%, Bowser is launched at maximum recorded speeds of 2037 km hr^{-1}, 2093 km hr^{-1} and 1043 km hr^{-1} for punching, kicking and headbutting respectively. This then gave forces of 6.68×10^6 N, 6.86×10^6 N and 3.42×10^6 N for these attacks, and would require a respective Maxim Tomato count of 2050, 2169 and 537.

Introduction
Kirby is a small, pink, sphere-like character that is the main protagonist of the '*Kirby*' series owned by Nintendo. The series sees the character rescuing various lands against villainous rivals such as King Dedede and Meta Knight, whilst remaining iconic by being innocent and cheerful throughout [1]. In December 2018 *Super Smash Bros. Ultimate* was released for the Nintendo Switch, and features up to 74 playable characters from some of Nintendo's most famous franchises, including Kirby, as mentioned previously, and Bowser, the infamous antagonist from the Mario game series, being one of the heaviest characters available within the game [2].

It is possible to setup a 1 vs 1 match of Kirby vs Bowser within the game itself. However, one of Kirby's most notable abilities is the power to fully consume food, objects or enemies (and gain powers accordingly). With this, and the statistics presented at the end of each fight, it is possible to calculate how hard Kirby can punch, kick and headbutt, and which move is the most efficient with respect to conserving energy. It is also therefore possible to introduce the question of how many Maxim Tomatoes, a magical fruit that heals health when consumed from the Kirby series that appears as a collectable item within the Super Smash Bros. series, the character would need to consume to have enough energy to complete each attack [3]. *Note: Although similar discussions have been done elsewhere [4] the discussion in this work differs in its methods, calculations and context.*

Match setup
A custom ruleset was created on the game for the purpose of this paper and consisted of the following standard rules:

- Style: Stock (Lives)
- Stock: 10
- Time Limit: ∞
- CPU Lv.: 1
- Damage Handicap: On (300% on Bowser)

For each of the different attack types, Bowser was pre-set with a handicap to 300% (i.e. the maximum possible value) and was knocked-off the arena stage 10 times using the corresponding attack. With this, it was possible to record the maximum launch speed of Bowser for each of the corresponding attacks (table 1).

Force and Energy
Assuming Bowser's mass to be 1180 kg [5], it is then therefore possible to calculate an estimate of the force of the three different attacks by using the momentum principle:

$$\vec{F}_{net} = \frac{\Delta\vec{p}}{\Delta t}, \quad (1)$$

where $\vec{F}_{net}$ is the net force, $\Delta\vec{p}$ is the change in momentum (i.e. impulse) and Δt is the contact time of the attack [6].

Attack type	Button Combination	Launch Speed (km hr^{-1})	Launch Speed (ms^{-1})
Punch	A+A+A	2037	565.8
Kick	L-stick (Hold) + A	2093	581.4
Headbutt	L-stick (Dash) + A	1043	289.7

Table 1 – The maximum launch speeds of Bowser after being attacked by Kirby, in both the initially stated units of km hr^{-1} by the game itself and converted to ms^{-1}.

Assuming the force is acting in the same direction as the change in momentum, each attack begins from rest and the time of contact for each of the attacks is 0.1 s:

$$F = \frac{\Delta p}{\Delta t} = \frac{m\Delta v}{\Delta t}. \quad (2)$$

$$\therefore F_{punch} = \frac{1180 \times 565.8}{0.1} = 6.68 \times 10^6 N$$

$$\therefore F_{kick} = \frac{1180 \times 581.4}{0.1} = 6.86 \times 10^6 N$$

$$\therefore F_{headbutt} = \frac{1180 \times 289.7}{0.1} = 3.42 \times 10^6 N$$

It is found that Kirby can launch Bowser with a force of 6.68×10^6 N if punching, 6.86×10^6 N if kicking, and 3.42×10^6 N if headbutting. Putting this into context, a single punch such as the one measured in this paper is the equivalent of 742 American alligators bite force, 405 great white sharks bite force, or just under 4 times the thrust of the Space Shuttle Main Engine at lift-off [7, 8, 9]. On from this, it is also possible to simply calculate the kinetic energy of Bowser being launched in each of these manners by taking the standard equation for kinetic energy [9] and assuming the collision is perfectly elastic, and that 1 kcal is equivalent to 4184 J:

$$KE = \frac{1}{2}mv^2. \quad (3)$$

$$KE_{punch} = \frac{1}{2} \times 1180 \times 565.8 = 1.89 \times 10^8 J = 4.51 \times 10^4\ kcal$$

$$KE_{kick} = \frac{1}{2} \times 1180 \times 581.4 = 1.99 \times 10^8 J = 4.77 \times 10^4\ kcal$$

$$KE_{headbutt} = \frac{1}{2} \times 1180 \times 289.7 = 4.95 \times 10^7 J = 1.18 \times 10^4\ kcal$$

Maxim Tomatoes

It is assumed that all chemical energy stored within every consumed Maxim Tomato is transferred into kinetic energy in the form of each attack, and is subsequently transferred to Bowser, as this then allows the number required for each attack type to be determined. Assuming that each Maxim Tomato has a calorific value that of an average tomato (22 kcal) and that the calorific value of the tomato is not tied to the healing potential of the food [10]:

$$N_{punch} = \frac{4.51 \times 10^4}{22} = 2050\ Tomatoes$$

$$N_{kick} = \frac{4.77 \times 10^4}{22} = 2169\ Tomatoes$$

$$N_{headbutt} = \frac{1.18 \times 10^4}{22} = 537\ Tomatoes$$

It is found that for Kirby to fuel his attacks against Bowser in this manner, he would have to consume 2050 Tomatoes per punch, 2169 Tomatoes per kick and 537 Tomatoes per headbutt. Therefore, if Kirby attacks using a headbutt in this instance, he would save eating 1513 or 1632 Maxim Tomatoes in comparison to punching or kicking respectively. This is however assuming that Bowser is already on 300% damage taken, and this value would be different depending on the damage taken at the time of the point of contact of the attack, due to the character's launch speed being heavily reliant on the damage taken. At a value of 0%, the number of Maxim Tomatoes would be far smaller, as the launch speed would also be far smaller in magnitude.

Conclusion

In conclusion, for Kirby to punch, kick and headbutt Bowser in *Super Smash Bros. Ultimate* at a 300% damage taken state, he would have to consume the calorific equivalent of 2050, 2169 and 537 Maxim Tomatoes respectively. These types of attack would have the forces of magnitude 6.68×10^6 N, 6.86×10^6 N and 3.42×10^6 N respectively; therefore, it can also be concluded that Kirby's headbutt is his most energy efficient, whilst his kick is his most powerful.

References

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