M&M'S CASE

GROUP 1
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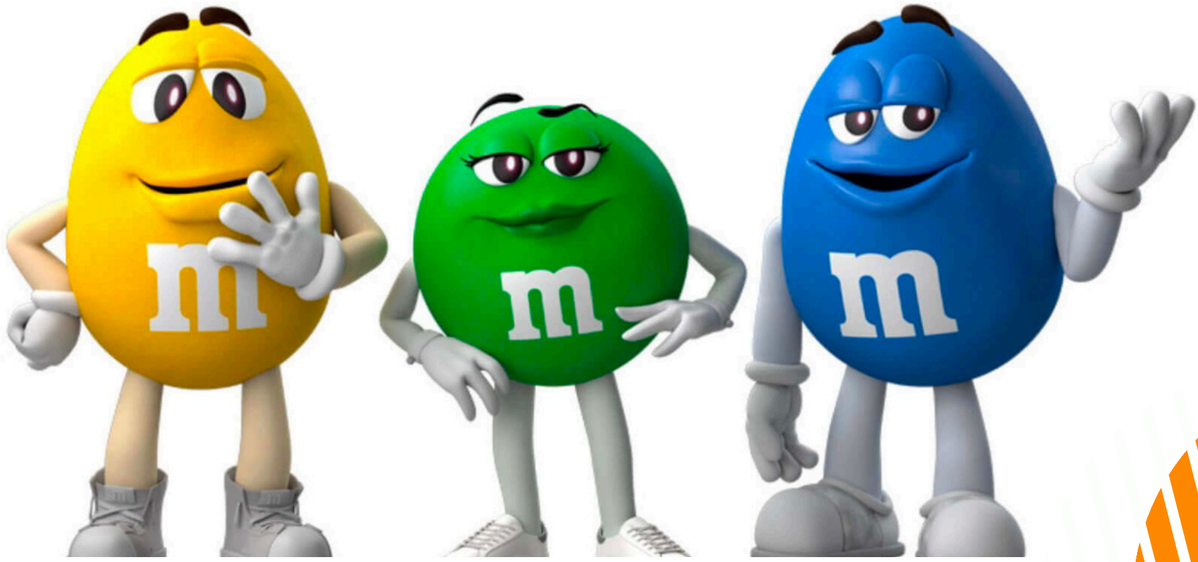


QUESTION:

Are M&Ms colours randomly distributed when they're packaged?

Null Hypothesis (H0):
The M&Ms colours are randomly distributed or equally proportioned*

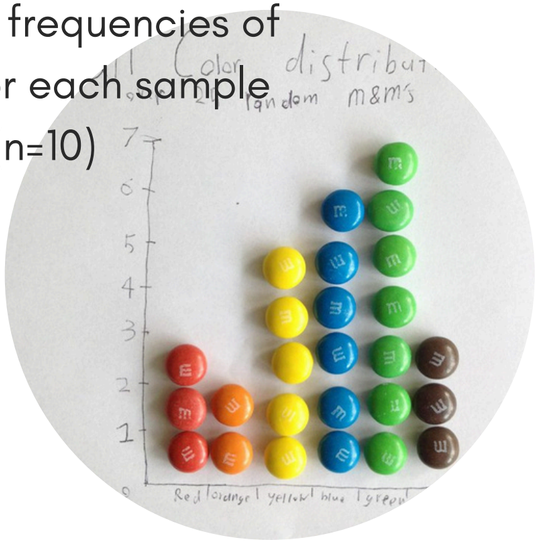
Alternative Hypothesis (H1): The M&Ms colors have a particular pattern of distribution

*If the M&M colour frequency per package is random, we are going to see that we are close to an equally proportioned distribution

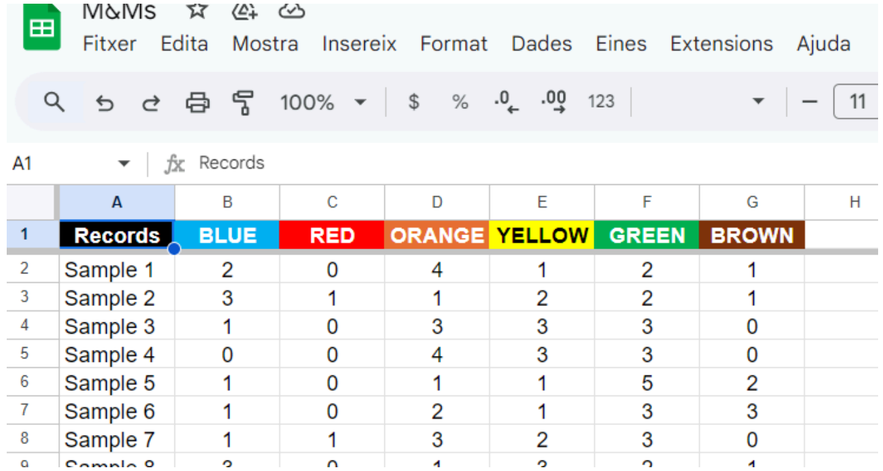
DATA COLLECTION PROCESS

Buy some packages in different stores for more independence

Count the frequencies of colours for each sample (n=10)



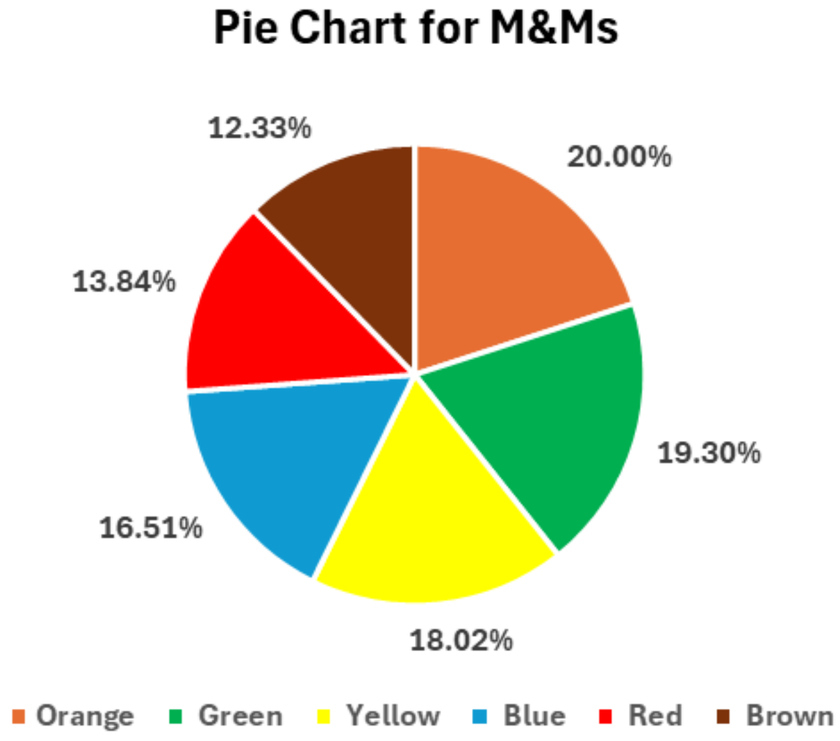
Record our data in google sheets and analyze

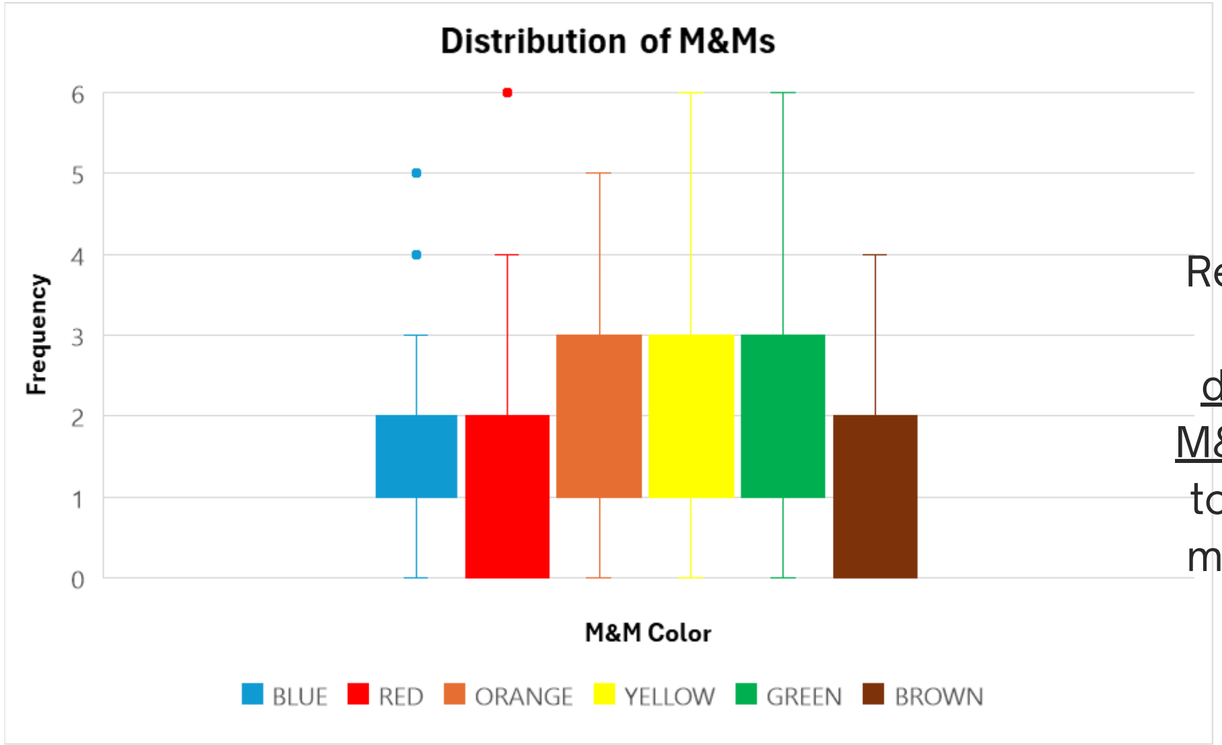


	A	B	C	D	E	F	G	H
1	Records	BLUE	RED	ORANGE	YELLOW	GREEN	BROWN	
2	Sample 1	2	0	4	1	2	1	
3	Sample 2	3	1	1	2	2	1	
4	Sample 3	1	0	3	3	3	0	
5	Sample 4	0	0	4	3	3	0	
6	Sample 5	1	0	1	1	5	2	
7	Sample 6	1	0	2	1	3	3	
8	Sample 7	1	1	3	2	3	0	

Taking samples of 10 M&Ms

DESCRIPTIVE STATISTICS





Representation of each distribution of M&Ms by colour to address any missing values, outliers, or errors.

M&M	Min	Max	Range	Mode	Median	Mean	Std Dev	1st Quartile	3rd Quartile
BLUE	0	5	0-5	1	1	1.6512	1.1888	1	2
RED	0	6	0-6	1	1	1.3837	1.3907	0	2
ORANGE	0	5	0-5	2	2	2.0000	1.2575	1	3
YELLOW	0	6	0-6	1	1	1.8023	1.3013	1	3
GREEN	0	6	0-6	1	2	1.9302	1.2921	1	3
BROWN	0	4	0-4	1	1	1.2326	0.9962	0	2

We can observe a higher frequency of orange and smaller frequency of brown M&Ms. We can also see wider distributions for yellow and green M&Ms frequency distributions and some minor outlier frequencies on blue and red M&Ms.

PROBABILITY

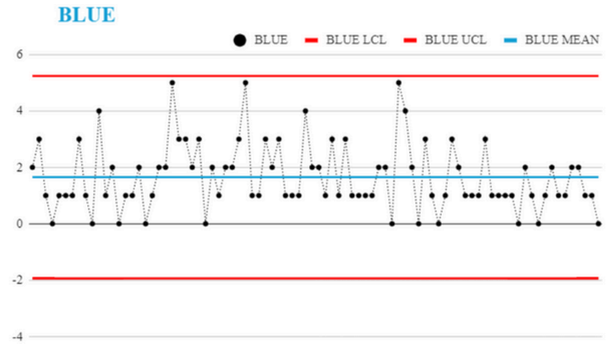
Based on our data, if we take a random M&M from our sample population, the probabilities of getting either one colour **OR** another is:

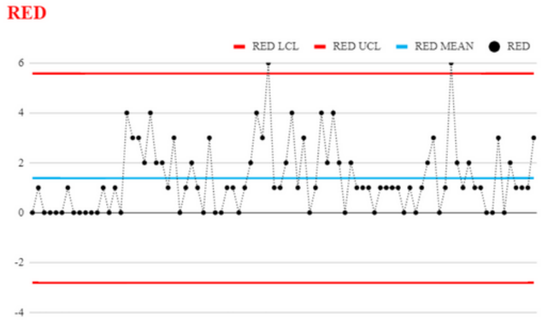
	BLUE	RED	ORANGE	YELLOW	GREEN	BROWN
BLUE	0.165	0.303	0.365	0.345	0.358	0.288
RED	0.303	0.138	0.338	0.319	0.331	0.262
ORANGE	0.365	0.338	0.200	0.380	0.393	0.323
YELLOW	0.345	0.319	0.380	0.180	0.373	0.303
GREEN	0.358	0.331	0.393	0.373	0.193	0.316
BROWN	0.288	0.262	0.323	0.303	0.316	0.123

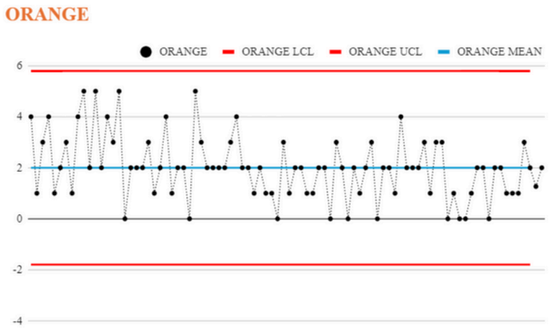
P(AUB)

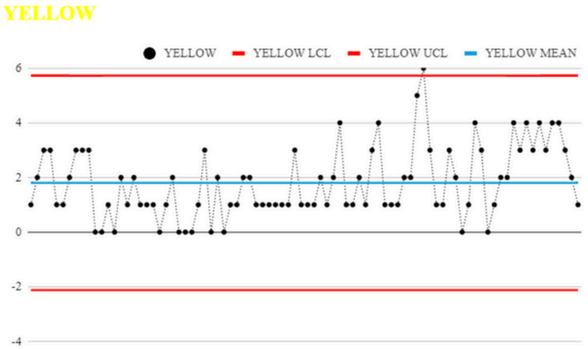
QUALITY CONTROL

To check that our data was collected in a consistent and accurate way, we performed a control chart for each colour batch frequency.







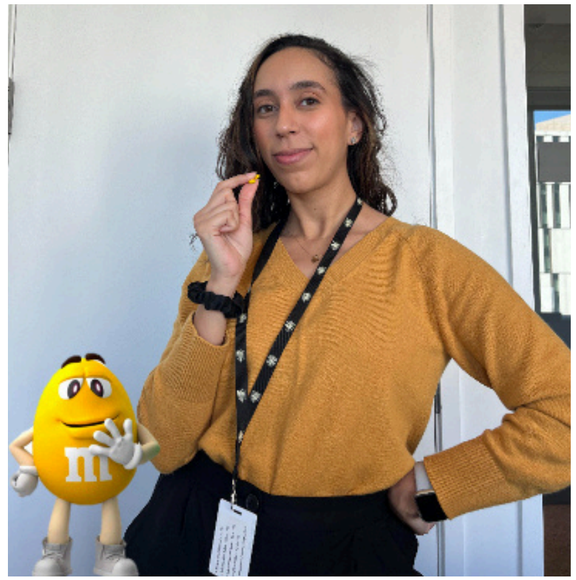


While some data points slightly exceeded the upper control limit, most measurements fell within the control limits. Thus, 10 M&Ms per batch were sufficient for our study. Nevertheless, increasing the sample size would improve accuracy.

CHI-SQUARED TEST

We used a chi-squared test to check our hypothesis by comparing the observed and expected frequencies of M&M colors.

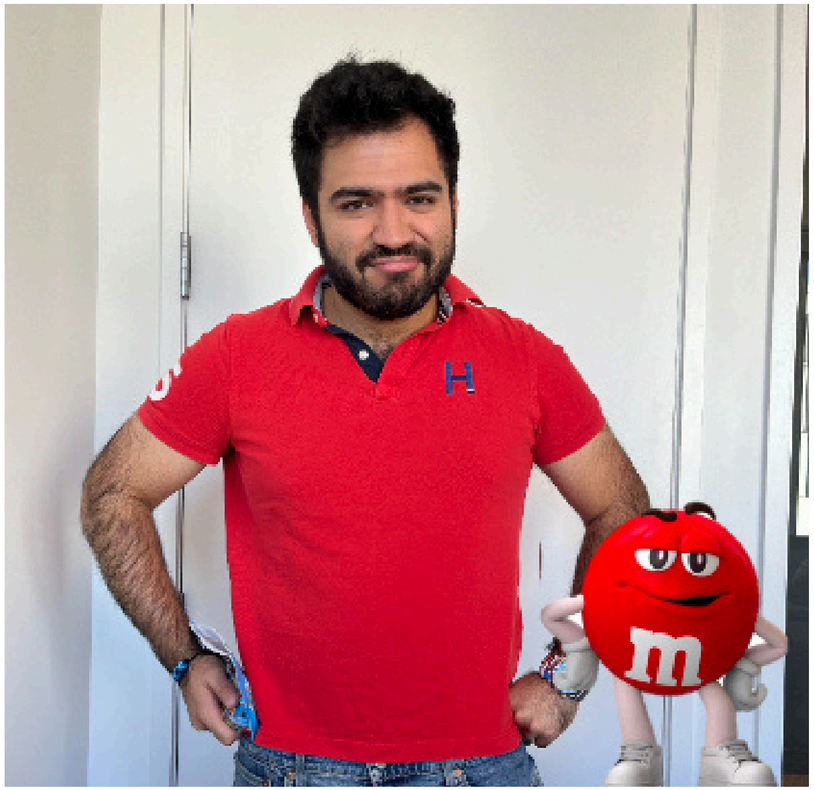
Color	Observed	Expected
Blue	142	143.33
Red	119	143.33
Orange	172	143.33
Yellow	155	143.33
Green	166	143.33
Brown	106	143.33



p-value: <0.001

Since the p-value is **smaller** than 0.05 (the significance level with 95% of confidence), we **REJECT** the Null Hypothesis. Thus, we can say that there is a particular pattern for the colour frequencies on M&M packages.

CONCLUSIONS



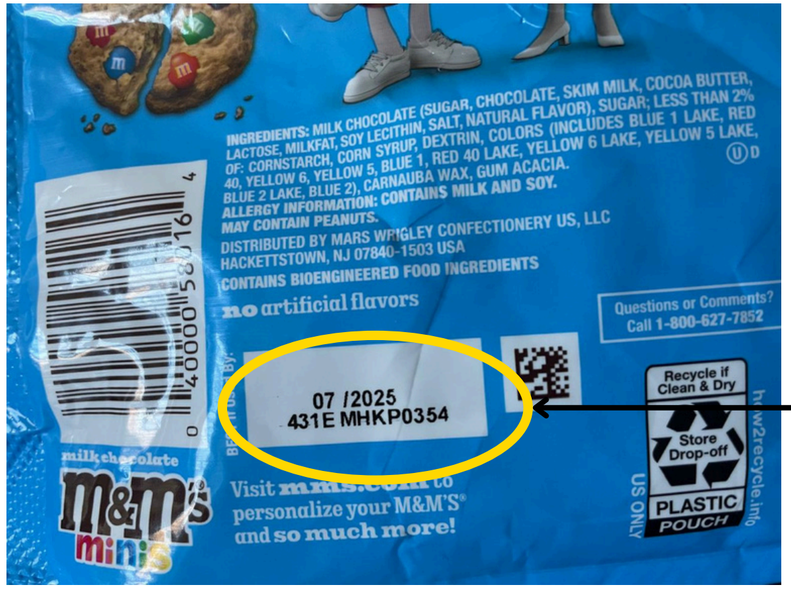
- Limitations may arise from the sampling method, including a small sample size and a limited range of stores, which could affect the findings.
- The chi-squared test results **rejected** the **null hypothesis**, suggesting that M&Ms are not equally distributed. Our descriptive analysis revealed a distinct **pattern**, particularly with the **orange and brown colours**.

POSSIBLE CAUSES:

- According to psychology, **orange** and red colors **stimulate appetite** and are commonly used as **marketing strategies** (Color Psychology, 2023). Moreover, **brown** does not highlight the **brand identity.**
- When comparing food dye prices, blue dyes tend to be the most expensive, followed by yellow, and red. Orange and Brown colouring result from a mix of various food dyes, hence it is more costly (Sensient Food Colors, n.d.).

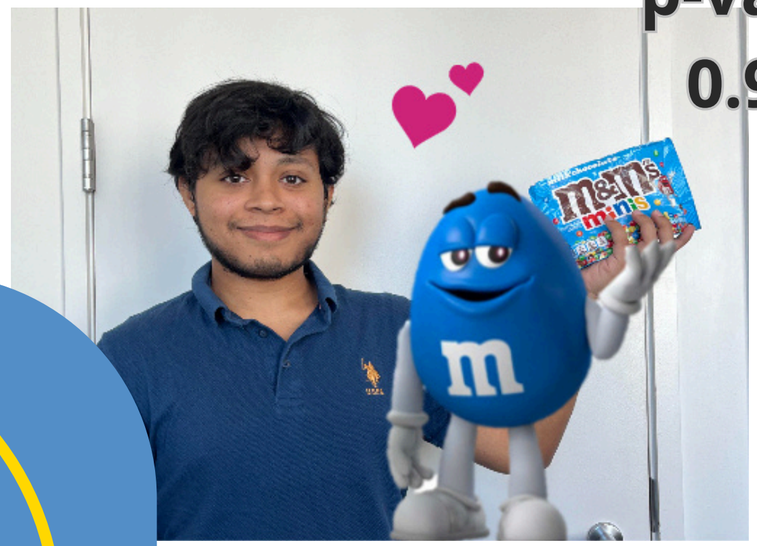
ENSURING OUR SAMPLE ACCURATELY REPRESENTS THE LARGER POPULATION

We found additional data showing that the New Jersey and Cleveland plants have established specific proportions. A subsequent Chi-Squared Test with H0 stating that they're distributed in the plant's proportion confirmed that our values align with these proportions (Wicklin, 2017).



HKP: code for the plant in Hackettstown, NJ

CLV: code for the plant in Cleveland.



p-value: 0.999

Color	Observed	Expected
Blue	16.51%	25.00%
Red	13.84%	12.50%
Orange	20.00%	25.00%
Yellow	18.02%	12.50%
Green	19.30%	12.50%
Brown	12.33%	12.50%

STRATEGIC DECISIONS

We know blue is the most expensive dye. Mars has a bigger proportion of blue coloured M&Ms in the plant of New Jersey. A possible **strategic decision** could be to swap their stablished 25% into red color, leaving blue in 12.5%. This might result in savings while stimulating appetite.

Patented in 1941 by Forrest E. Mars, Sr., M&Ms were a imitation of UK treat Smarties, which Mars may or may not have seen British volunteer soldiers eating during the Spanish Civil War. A hard sugar shell avoided chocolate from melting, that would help sales during summer. (next analysis seasonality?)

Data Google Sheets Link

REFERENCES:

Color Psychology. (2019, September 16). How color affects appetite in marketing. https://www.colorpsychology.org

Sensient Food Colors. (n.d.). Coloring foods and dyes in confectionery applications. Sensient Colors LLC. https://na.sensientfoodcolors.com

Wicklin, R. (2017, Febuary). The distribution of colors for plain M&M candies. SAS Blogs. https://blogs.sas.com/content/iml/2017/02/20/proportion-of-colors-mandms.html