IJABS Volume 3. Special Issue (2024)
International Conference of Digital Business, Society & Economy (ICDBSE 2023)
ISSN: 2940-2735

International Journal of Advanced Business Studies
https://besra.net/index.php/ijabs/

Full length article

The Impact of Colour Vision Defect on Consumer's Fruits Selection Process while Purchasing from Retail Fruit Shops in Bangladesh

Dr. Morakinyo Dada[1], Mohammad Tawhid Reaz[2], James Jacob Ribero[3]

[1] PhD, School of Business, Asia Pacific University of Technology and Innovation, Kuala Lumpur, Malaysia.
Email: morakinyo@apu.edu.my Orcid: https://orcid.org/0000-0002-0358-5070

[2] MBA, School of Business, University of Liberal Arts Bangladesh, Dhaka, Bangladesh.
Email: tawhid.reaz@ulab.edu.bd Orcid: https://orcid.org/0009-0003-7193-384

[3] M.B.B.S, MBA, School of Business, University of Liberal Arts Bangladesh, Dhaka, Bangladesh.
Email: james.ribero@ulab.edu.bd

Article Info

Received: 23.01.2024
Accepted: 23.02.2024
Available online: 13.05.2024

DOI: https://doi.org/10.59857/IJABS.1648

ABSTRACT

Color Vision Defect affects about one in twelve males and two hundred women worldwide, according to research. CVD has a big impact in almost every marketing and branding circumstance, especially when product color is the key. This study began with a Red-Green CVD test of 522 Dhaka residents. Since few research have measured color blindness in Bangladesh, this study can be used as one of the Bangladesh color vision deficiency baseline results. The important factor of this study is whether this result is comparable to Bangladesh's earlier result and whether Bangladesh has a lower/higher CVD prevalence than other nations. The most common CVD is Red-Green Colour Vision Defect. Green fruits turn yellow and red when maturing and CVD patients have trouble distinguishing neighboring colours like Red, Green, Brown, etc. After examining baskets of green and ripe yellow, red, and partly reddish fruits, this study evaluated the findings. This study found out that people with color vision defects had trouble choosing fruits from baskets. Furthermore, the study tested hypotheses to determine severity of Red-Green CVD and found out it to be less than expected probably due to coping mechanism, experience etc. in Red-Green CVD subjects.

1. Introduction

The inability to distinguish between different colors under normal lighting conditions is known as colour vision deficiency (CVD) (Kundu & Chakma, 2020). According to earlier studies, approximately 8%–9% of men and 0.5% of women are reported to be colorblind (Fakorede et al., 2022).

Types of Colour Vision Defect or Colour Blindness:

Red-Green Color Blindness is the most common type of color blindness discovered worldwide (Color Blindness, National Eye Institute, 2023). There are millions of photo receptors present in the retina of human eye. Those millions of photo receptors can be divided into two types of receptors – Rods and Cones. Human eyes have more than 100 million rods. Rods are responsible for working at low light level. Humans can identify the darkness and brightness, and have night vision due to the active rods. There are around 6 million cones active in human retina. Cones are responsible for colour detection. Cones are further categorized into three types: Red, Green & Blue. As their name suggests, each are responsible for the visualization of each type of colours or colours of similar wavelengths (Monigatti, 2022; Types of Colour Blindness - Colour Blind Awareness, 2022; Woods, 2021).

People may suffer from several types of colour vision defects due to abnormal functioning of each cone type or complete inactivity or absence of a single cone type. Based on how many types of cones are damaged, inactive or partially active, CVD can be divided into the following types: Monochromacy, Dichromacy, Trichromacy and Tetrachromacy (Dada et. al. 2023; Monigatti, 2022; Woods, 2021).

Monochromacy is sometimes referred to as complete colour vision defect. It can be further categorized into two types: Rod Monochromacy (severe form of colour blindness) and Cone Monochromacy. As the name suggests, for cone monochromacy only one type of cones are active, the other two types are inactive. Complete colorblindness is also called Achromatopsia, where the affected people cannot see any colour, rather they can see different types of black and white shades (Dada et. Al. 2023; Monigatti, 2022; Woods, 2021).

Any two of the three types of cones are active in dichromacy patients, but the third type is completely inert. Dichromacy is the most common type of colour blindness. Dichromacy can be sub-divided into three colour blindness: Tritanopia (Blue-Blind) – part of Blue-Yellow colorblindness, Protanopia (Red-Blind) – part of Red-Green colorblindness & Deuteranopia (Green Blind) – part of Red-Green colorblindness (Dada et. Al. 2023; Monigatti, 2022; Woods, 2021).

In the case of Trichromacy, also known as trichromatic anomaly, all the cone types are available, but a single type is more anomalous or not working perfectly. Trichromacy can be sub divided into three colour blindness: Tritanomaly (Blue Weak) – partial Blue-Yellow colorblindness, Protanomaly (Red Weak) – Partial Red-Green colorblindness & Deuteranomaly (Green Weak) – Partial Red-Green colorblindness (Monigatti, 2022; Types of Colour Blindness - Colour Blind Awareness, 2022; Woods, 2021).

In the case of Tetrachromacy, there are four types of cones active. For humans this case is extremely rare or nonexistent, but this case is seen in animals and birds (Monigatti, 2022; Types of Colour Blindness - Colour Blind Awareness, 2022; Woods, 2021).

Colour Vision Defect Across the nations and in Bangladesh:

Based on geography and ethnicity, various groups may have a varying CVD prevalence percentage. As per irishtech.co and colourblindguide.com there are almost 300 million people around the world who are affected by colour vision deficiency. The prevalence of colour vision deficiency among the males can be varied by ethnicity (Caucasian: 5.6%, Asian: 3.1%, Hispanic 2.6%, Black 1.4%), (Kosari, 2022).

As no such authentic data of colour vision deficiency is available in Bangladesh, this study seeks to be a reference point for Bangladesh along with conducting a literature review of the previous studies on the colour vision deficiency in Bangladesh. A study on medical and dental students of Mymensingh Medical College (MMC), Bangladesh was conducted in 2013, where the prevalence of color blindness was found to be 3.35% (male - 8.04%, female - 0.66%) (Hossain et al., 2013). Another study conducted by Sir Salimullah Medical College among 500 Dhaka city school going students aged between 6-10 (Yasmin et al., 1970) showed that 5 out of 500 students found to be colour blind, and all the 5 students were males. As 290 male students and 210 female students were there in the study of Yasmin et. Al., (1970), it can conclude that 1.7% male and 0% female were found to be colour blind. From another study conducted in Dhaka University, CVD prevalence were found to be 6.95%, where 8.03% were male and 1.89% were female (Islam et al., 2016).

Impact of CVD on the daily life of the sufferers:

Those who suffer from CVD struggle to identify certain colors. They are at a clear disadvantage when completing specific visual tasks. Particularly, when a colored target is embedded into a variegated background of a different color, people with CVD have trouble telling the difference (Simunovic, 2009). CVD impairs the ability to recognize signal lights for example those with protanopia and protanomaly (Cole, 2002). Report shows that doctors with CVD misdiagnose or miss important clinical signs (for example rashes, jaundice, confusing blood and pigment on ophthalmoscopic examination, misinterpreting histopathological stains etc.) (Spalding et al., 2010). According to a study by Steward and Cole, people with CVD experience difficulties with a variety of daily tasks, including: detecting the colors of commonplace items like clothes, accessories, and furniture; engaging in hobbies such as arts and crafts; determining the freshness of food; participating in sports; and recognizing skin rashes (Steward and Cole, 1989).

Study suggests that near about 70% CVD affected person faces problems with dress sense and decor (Spalding, 1999). In addition, they have issues with the colour of the other things including birds, fruits, literature, maps, artistic abilities and interests, food and drink, and medical treatment. Tagarelli et al. (2004) shows how CVD affected people significantly finds it difficult in choosing clothing and outfits. They also find difficulties in distinguishing natural colours at work.

All the three studies of Steward and Cole (1989), Spalding (1991), and Tagarelli et al. (2004) individually suggest that people with CVD face difficulties seeing traffic signals. They also face challenges in identifying signals and indicators inside the car, such as braking & heat indicators.

About the Study

This study has been conducted on 522 people of Dhaka city with different age groups. The original goal of this research is to identify colorblind persons because there is no such authentic and recommended database or study on colorblind people of Bangladesh. On the second part of this study, test has been conducted to detect the effects of CVD on colorful fruits. Fruits in Bangladesh are mainly of three colours: Green, Yellow and Red/Reddish. People with Red-Green CVD frequently mix up Red-Green colors with colors that are in the same wavelength range. Therefore, it is not rare for Red-Green CVD afflicted people to have trouble identifying the right fruit types – whether they are ripe or green – when buying from retail stores.

Objectives of this study

1. To determine the prevalence of Red-Green Color Vision Defect in Dhaka city of Bangladesh.
2. To examine how CVD affects consumers' decisions while choosing fruits from Bangladeshi retail fruit shops.

2. Literature Review

According to earlier research, 8% of men and approximately 0.5% of women are unable to determine the precise color of any object (Dada et al., 2023; Jha et al., 2018; Kundu & Chakma, 2020). People who are colorblind encounter several difficulties performing daily chores (Male et al., 2022). According to the types of defects and the cones that are affected, colour vision problems can be roughly categorized into three groups: red-green CVD, blue-yellow CVD, and complete CVD (Birch, 2012). The most prevalent CVD in the world is Red-Green CVD, which affects 4-5% of men and 0.5% women worldwide (Color Blindness Prevalence, 2023).

There have been few studies that systematically record the daily struggles that people with CVD face on a personal level (Steward and Cole, 1989). Children with CVD are picky eaters because they see some foods, such vegetables, in unappealing colors (Sullivan, 2011). In a stage where a child's growth depends on proper nutrition, the impact on food preference shouldn't be disregarded (Chan et al., 2014). In several courses where color is employed as a teaching technique, such as mathematics, science, geography, reading, sport, and food technology, Sullivan (2011) observed that children with CVD tend to lag behind. Research suggests that, normal color vision is required for some occupations in the air force, navy, and infantry where CVD affected person may find it difficult to do their tasks (Poole, 2002). Several studies suggest that CVD affected person finds it difficult when studying maps, especially the boundary lines and other indicators that they find difficult to distinguish (Kuyk et al., 1986). Nearly 90% of dichromats and approximately two-thirds of trichromats reported difficulties with everyday tasks that involve colour (Steward and Cole, 1989).

Table 1 – Difficulties in everyday life reported by 151 CVD subjects and 302 Normal Colour Vision subjects [Conducted By Tagarelli et al. (2004) (Statistical significance of differences were calculated using the chi-square test or Fisher exact test, two-tailed significance level 0.05)].

Difficulties associated with	% of CVD observers	% of NCV observers	Significance (p value)
Clothing colours	23.8	1	<0.0001
Workplace/hobbies colours eg. pie charts	13.2	1	<0.0001
Natural colours	40.4	1	<0.0001
Colours relating to cooking s eg. Identification of cooked versus raw meat	31.7	8.6	<0.0001
Sports colours eg. shirts of players	21.2	1.3	<0.0001
Skin colours	3.3	1.7	0.0007
Television colours setting	6	0.7	0.0002

Source: Tagarelli et al. (2004)

Aforementioned table indicates (research done by Tagarelli et. Al, (2004)) how CVD affected people faces difficulties in daily life activities way more than Normal Colour Vision (NCV) peoples. This research did some interesting tests such as colour identification of cooked vs raw meat, and the findings suggest that 31.7% CVD affected finds it difficult to distinguish raw vs cooked meat.

Similar types of research works were done by Steward and Cole on their research conducted in 1989. This research has one aspect which is very important for our research. Along with other aspect of life, this research suggests that 41% and 33% protans find it difficult to identify the proper ripeness of food and vegetables. This research also suggests that, almost all the CVD affected people faces difficulties differentiating certain colours of clothing and goods from others. They face the difficulties in almost all the conditions, such as at home or while purchasing from retail or e-commerce shops.

Table 2 – Difficulties in everyday life

Difficulties associated with	**Dichromats (%) (n = 37)**	**Anomalous trichromats (%) (n = 65)**	**Protans (%) (n = 36)**	**Deutans (%) (n = 66)**	**NCV (%) (n = 102)**
Clothing/goods colours	86	66	78	71	0
Workplace/hobbies colours	68	23	50	33	0
Plant/flower identification	57	18	44	26	0
Ripeness of fruits and vegetables	41	22	31	27	0
Cooked versus raw meat	35	17	33	20	0
Sports colours	32	18	19	23	0
Adjust television colour settings	27	18	28	18	2
Skin colours eg. sunburn, rashes	27	11	17	17	0
Previously taken wrong medication due to colour difficulties	0	3	3	1	0

Source: Steward and Cole (1989)

According to a study by Poole (2002), occupations where CVD is a disadvantage are art teaching, bacteriology, botany, chemistry, interior design, histopathology, horticulture, geology, diamond grading, metallurgy etc.

Since colour vision defect restricts the affected people from distinguishing certain colours, activities like product purchase decision also gets negatively impacted. One of the simplest marketing strategies is color, which has a direct impact on how people behave when making purchases (Martinez et al., 2021). For young individuals, especially females, color is the most crucial deciding factor when making purchases (Dalgin & Sraiheen, 2018). One of the most crucial visual aspects of a product system that can instantly elicit the emotional needs of the user or consumer is color (Zhang et al., 2020). According to study, persons with CVD miss out on brand elements like logos and products like posters, since the colors used in product design are not obvious to them (Mohammed & Mohammed, 2016). Red and green being used together in a product design is a frequent issue. Red and green would both appear brown to people with severe CVD (Shaffer, 2016). Millions of people may not be able to use a product because of something as simple as color choices (Holmes, 2018).

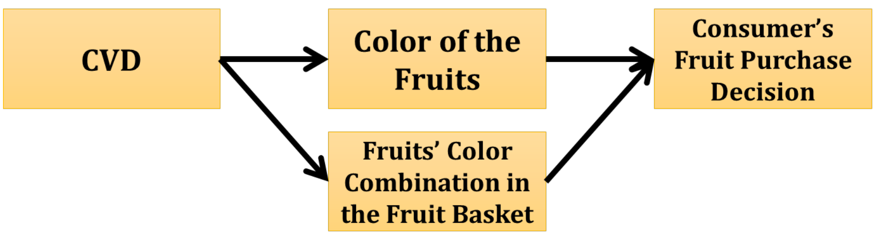
An interesting research done on monkeys fruit selection behaviour by Amanda D Melin et. al. (2019) suggests monkeys with red-green colour blindness sniffed fruits more frequently indicating that increased dependence on olfaction is a behavioral response that offsets lower ability to detect red-green color contrast. Although people who are color blind do learn coping mechanisms, buying fruits and vegetables can be a significant challenge. People who are color blind frequently have to learn that mature apples are frequently darker than unripe apples, that ripe fruit generally feels softer than unripe fruit, and that ripe food generally smells different (Types of Colour Blindness - Colour Blind Awareness, 2022). Protans and deutans reported in significant proportions having trouble judging the maturity of fruits and vegetables based just on appearance. The most difficult fruits and vegetables to determine when they are ripe were reported to be bananas, apples and tomatoes (Steward & Cole, 1989).

In his study, Carol Kaufman-Scarborough suggested that it is likely that color-blind consumers are unable to process some or all aspects of visual color information, potentially increasing their vulnerability in the marketplace. The most persistent set of issues seem to be with reds and greens, and poor lighting exacerbates them. Due to the fact that color-blind people interpret color information differently than color-sighted people, color distortions might impair their capacity to make product decisions, notice information in advertisements and on packaging, and function efficiently in retail environments (Kaufman-Scarborough, 2000).

Hence from the literature review, it is certain that fruit purchase decision are negatively impacted for colour vision defects due to colour of the fruits, and also due to confusion of the placement of the fruits with other fruits that can increase confusion for the CVD affected people.

Accordingly, in this study CVD affected consumers fruit purchase decision has been studied with two factors: color of the fruits and fruits' colour combination in the fruit basket.

Research Framework:



3. Data and Methodology

Detection:

First part of our study was to detect the colour blindness in the study population. For that, 522 person have been examined, mostly the students of University of Liberal Arts Bangladesh, students of Bangladesh University of Textile and 50 random corporate personnel of Dhaka city. The entire detection process taken place between September 2022 to April 2023.

Colour Blindness Test:

For this Colour Vision detection process, Ishihara 38 Plates Edition has been used. Participants were taken into a normally lit room, and 3 seconds per plate was given to each person for identifying the numbers. All other rules and test environment of Ishihara Test had been followed.

Research suggests that, Red-Green CVD covers more than 90% cases of colour vision defects. In this study Ishihara test was used which is the most common tool for Red-Green CVD Detection. Ishihara test is not a recommended tool for the detection of Blue-Yellow CVD. The Farnsworth D-15 test could have been used for identifying Blue-Yellow Colour vision defect but due to lack of tool availability and test facility, Farnsworth D-15 test were not used in this study. Hence all the outcomes will indicate only Red-Green CVD. Though many of this test participants made mistakes in one or two plates from the 38 Plate test but for the identification of perfect Red-Green Colour Blindness, the error rate has been used as suggested by Ishihara testing process. Protan and deuteron detection processes were also conducted as per the method described in Ishihara manual.

The participants also underwent tests using the Colour Blind Test Android App Version (By King Brain Inc.) for further cross-checking and confirmation.

Sampling:

This study applied convenient nonprobability sampling for selecting 522 samples.

Further testing:

CVD affected people were further tested in the following categories:

- Fruit Selection (Ripe or Unripe/Green Fruit Identification) from online pictures.
- Fruit Selection (Ripe or Unripe/Green Fruit Identification) from E-Commerce sites.
- Fruit Selection (Ripe or Unripe/Green Fruit Identification) from retail stores or fruit shops.

4. Results and Discussion

Demographics and age distribution profiles of the study population are shown in Table 3 and Table 4 below.

Table 3 – Demographics of study sample (n = 522)

		Percentage
Male	333	63.8%
Female	189	36.2%
People with CVD (Red-Green)	13	2.49%
Male with CVD	13	3.90%
Female with CVD	0	0.00%
Protan	1	0.002%
Deuteran	12	2.30%

Source: Prepared by the authors (2023)

In this study, among 522 respondents, 63.8% are male where 36.2% are female. After rigorous Ishihara (38 plate edition) CVD testing, 13 respondents were found as Red Green Colour Blind, and all of them are male. Even though many of the respondents (including females) in this study missed or incorrectly identified one or more of the 38 plates, this study only evaluated those respondents who had CVD as specified by the Ishihara handbook.

Among total sample, 2.49% (3.9% male and 0% female) are Red-Green colour blind. As previous study by Hossain et al. (2013) suggested 3.35% are colour blind (male - 8.04%, female - 0.66%) these two results are similar. However, in this research no female was found to be affected by Red-Green CVD.

Table 04 – Age distribution

	Population			RG CVD			CVD %		
Age	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
<10	0	0	0	0	0	0	-	-	-
10-15	2	0	2	0	0	0	0.0%	-	0.00%
15-20	5	3	8	0	0	0	0.0%	0.0%	0.00%
20-25	167	105	272	6	0	6	3.6%	0.0%	2.21%
25-30	67	35	102	3	0	3	4.5%	0.0%	2.94%
30-35	35	22	57	4	0	4	11.4%	0.0%	7.02%
35-40	33	11	44	0	0	0	0.0%	0.0%	0.00%
40-45	13	7	20	0	0	0	0.0%	0.0%	0.00%
45-50	7	3	10	0	0	0	0.0%	0.0%	0.00%
50+	4	3	7	0	0	0	0.0%	0.0%	0.00%
Total	333	189	522	13	0	13	3.9%	0.0%	2.49%

Source: Prepared by the authors (2023)

Age distribution of the study population surprisingly showed that 4 (11.4%) males to be CVD affected in 30-35 years of age group. These four people are all corporate employee i.e. working in multinationals or local companies of Bangladesh.

Hypothesis Assumptions:

From worldwide survey, it is known that 8% male and 0.5% female are colour blind. Combining this ratio with the sample ratio (63.8% male and 36.2% female) of this study, CVD affected mean comes as 5.3%. Hence to find out that the result of this study is more significant than actual population mean, null hypothesis has been assumed as:

Null Hypotheses H_0: $\mathbf{P \leq 0.053}$

Similarly, Alternative Hypothesis H_A: $\mathbf{P > 0.053}$

Table 5 – Hypothesis testing parameters

	Male	**Female**	**Total**	
General Case Worldwide	8%	0.50%		
Our Sample	333	189	522	
Sample %	63.8%	36.2%		
Population Mean	5.1%	0.2%	**5.3%**	0.053
Standard Deviation (Assumption)			5%	0.05
Confidence Level (Alpha)				95%
Null Hypothesis	$\mathbf{H_0}$	$\mathbf{P \leq 0.053}$		
Alternative Hypothesis	$\mathbf{H_A}$	$\mathbf{P > 0.053}$		

Source: Prepared by the authors (2023)

Table 6 – Hypothesis Testing for (For 13 CVD Affected Sample)

Case	Error	Sample	Data X	Mean M	STD	Sqrt n	Z-Score	Hypot-hesis
Online Pic-tures	13	522	0.02	0.053	0.05	22.85	-12.8	Cannot Reject H0

Source: Prepared by the authors (2023)

For this research paper, total 522 people have been tested for CVD. Among them 333 were male and 189 were female. In this test 13 persons as colour blind were found. All of them were male. As the Ishihara test has been used, only red-green CVD affected people are detected in this research.

While comparing with the world data, Z-test was done (Table 4) and found a low score, indicating that null hypotheses cannot be rejected. It means, the prevalence of Red-Green colour vision defect among Dhaka city dwellers is not significant in comparison to world data available.

In the second and most important part of this study, further testing with 13 CVD affected people were done to find out the difficulties CVD affected people have choosing fruits when they buy them from grocery stores, retail stores, and online shops.

As described in previous section, 13 CVD affected people were tested in categories:

- Fruit Selection (Ripe or Unripe/Green Fruit Identification) from online pictures.
- Fruit Selection (Ripe or Unripe/Green Fruit Identification) from E-Commerce sites.
- Fruit Selection (Ripe or Unripe/Green Fruit Identification) from retail stores or fruit shops.

Initially 20 types of fruits have been shown with 10 different combinations to the 13 CVD affected people.

They have made few mistakes. Similarly the experiment was done for E-Commerce sites. The CVD affected people went to retail shops and super shops for fruit detection. The outcomes from the testings are shown in Table 7.

Table 7 – Fruit Selection (Ripe or Unripe/Green Fruit Identification) from online pictures. (For 13 CVD Affected Sample)

Marketplace	Object Shown/Places Visited (A)	Fruit Combi-nation (B)	Total no. of Combination =(A*B*13)	Mistakes Made	Error %
Online Pictu-res	20	10	2,600	157	6.04%
E-Commerce Sites	3	20	780	17	2.18%
Retail Shops	8	10	1,040	66	6.35%
Super Shops	3	10	390	7	1.79%

Source: Prepared by the authors (2023)

The similar result simulated with all the 522 samples (considering the people with normal vision can easily distinguish ripe and green fruits) the Table 8 data has been prepared.

Table 8 – Fruit Selection (Ripe or Unripe/Green Fruit Identification) from online pictures. (For 522 People)

Marketplace	Object Shown/Places Visited (A)	Fruit Combination (B)	Total no. of Combination =(AXBX522)	Mistakes Made	Error %
Online Pictures	20	10	104,400	157	0.15%
E-Commerce Sites	3	20	31,320	17	0.05%
Retail Shops	8	10	41,760	66	0.16%
Super Shops	3	10	15,660	7	0.04%

Source: Prepared by the authors (2023)

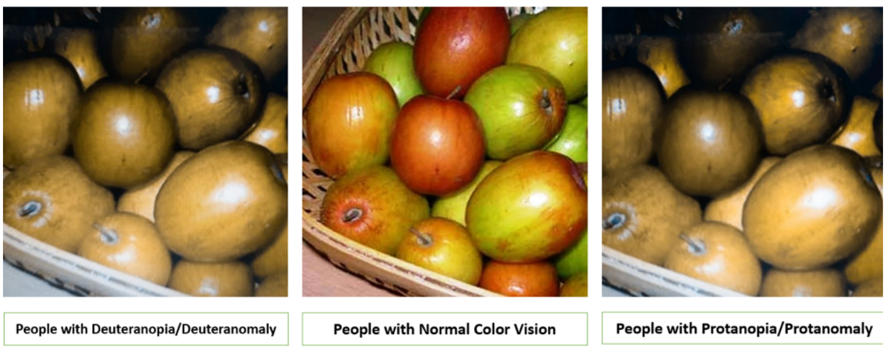
Online fruit pictures with mix basket of ripe and green Jujube fruits have been shown to the CVD affected respondents.

Picture 1: Green Jujube fruit selection

Source: J. (2018)

To understand how CVD affected people actually see the fruit basket full of ripe and green fruits, Picture 1 has been transformed through android CVD simulation app. Picture 2 shows how it becomes really difficult for the people having protanopia and deuteranopia to distinguish red/green/yellowish/reddish jujube fruits from the fruit basket. Almost all the fruits look brownish as shown in the picture. However, becuse of coping mechanism and lifelong experience, the rate of errors was not as large as previously thought.

Picture 2 – How Red-Green CVD affected people see the fruits



Source: Simulated with Chromatic Vision Simulator App: Version 2.2 by the authors (2023)

In Table 09 and Table 10, hypotheses testing was conducted to find out whether the mistakes rate is significant or not, and found that for online picture and retail shop fruit selection cases mistakes were high and mistake rate were significant among the CVD affected people. However, if the same test were conducted considering all the 522 samples, the error rate is nominal, hence no inference can be drawn.

Table 9 – Fruit selection (Ripe or Unripe/Green Fruit Identification) from online pictures (For 13 CVD Affected Sample)

Case	Error	Sample	Data X	Mean M	STD	Sqrt n	Z-Score	Hypothesis
Online Pictures	157	2600	0.060384615	0.053	0.05	50.9902	7.5	Reject H0
E-Commerce Sites	17	780	0.021794872	0.053	0.05	27.92848	-17.4	Cannot Reject H0
Retail Shops	66	1040	0.063461538	0.053	0.05	32.24903	6.7	Reject H0
Super Shops	7	390	0.017948718	0.053	0.05	19.74842	-13.8	Cannot Reject H0

Source: Prepared by the authors (2023)

Table 10 – Fruit selection (Ripe or Unripe/Green Fruit Identification) from online pictures (For study population, n = 522)

Case	Error	Sample	Data X	Mean M	STD	Sqrt n	Z-Score	Hypothesis
Online Pictures	157	104,400	0.001503831	0.053	0.05	323.11	-332.8	Cannot Reject H0
E-Commerce Sites	17	31,320	0.000542784	0.053	0.05	176.97	-185.7	Cannot Reject H0
Retail Shops	66	41,760	0.00158046	0.053	0.05	204.35	-210.2	Cannot Reject H0
Super Shops	7	15,660	0.000446999	0.053	0.05	125.14	-131.5	Cannot Reject H0

Source: Prepared by the authors (2023)

5. Conclusion

This research study finds that, Red-Green CVD affected people's rate in Dhaka city is nearly 2.49% (3.9% male and 0% female), where 2.3% are Deuteran (Green Type) and almost 0.002% are Protan(Red type) of CVD. These findings are quite similar to the previous Bangladeshi study of Hossain M.I, et. Al. (2013) which suggests 3.35% are colour blind (male - 8.04%, female - 0.66%). But this result is lower than result of the study conducted by a group of Dhaka University students where they found a total of 21 non-consanguineous colour blind individuals (out of 302, 6.95%). A total of 20 males (deuteran: 19, protan: 01) were found as colorblind out of 249, whereas only 1 female (deuteran) was found of the total 53 female samples. This corresponds to the frequency of 8.03% for male (deuteran: 7.63%, protan: 0.4%) and 1.89% for female (Islam et al., 2016).

For the fruit selection case, simulation shows colour of reddish (ripe) fruits and greenish (non ripe) fruits can be seen as almost of the same colour. Hence there can be 100% chance to make error while selecting ripe and green from the fruit basket. But in reality, the percentage error was not too high possibly due to coping mechanisms and lifelong experience. Nevertheless, Red-Green CVD affected consumers find it difficult to select their desired fruits from the baskets considering the time they have taken to choose the perfect fruit.

Recommendation:

To lessen the difficulty of CVD affected persons in differentiating between reddish and green colors, it is advised that shops, if they have the option, keep ripe and green fruits separated. A similar type of experiment can be done for products other than fruits. Further study using a larger sample size can be undertaken to find out the percentage of error rate among CVD affected persons and the coping mechanisms used by them in reducing their error rate in chosing similar colored shopping items.

References

Birch, J. (2012, February 16). Worldwide prevalence of red-green color deficiency. *Journal of the Optical Society of America A*, *29*(3), 313. https://doi.org/10.1364/josaa.29.000313

Chan, X. B. V., Goh, S. M. S., & Tan, N. C. (2014, October 9). Subjects with colour vision deficiency in the community: what do primary care physicians need to know? *Asia Pacific Family Medicine*, *13*(1). https://doi.org/10.1186/s12930-014-0010-3

Cole, B. L., & Lian, K. (2006, May 1). Search for coloured objects in natural surroundings by people with abnormal colour vision. *Clinical and Experimental Optometry*, *89*(3), 144–149. https://doi.org/10.1111/j.1444-0938.2006.00031.x

Cole, B. L. (2002, July 1). Protan colour vision deficiency and road accidents. *Clinical and Experimental Optometry*, *85*(4), 246–253. https://doi.org/10.1111/j.1444-0938.2002.tb03045.x

Color Blindness Prevalence. (2023, July 6). News-Medical.net. https://www.news-medical.net/health/Color-Blindness-Prevalence.aspx

Color Blindness | National Eye Institute. (2023, August 11). Retrieved October 3, 2023, from https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/color-blindness

Dada, M., Reaz, M. T., & Ribero, J. J. (2023). Displaying Colorful Products in Physical Stores and E-Commerce Sites Without Impacting Color Blind People. *Contributions to Management Science*, 635–647. https://doi.org/10.1007/978-3-031-27296-7_58

Dalgin M. H. & Sraiheen A. W., (2018), Product Color Importance, Color Choice and Meaning of Color among Canadian Consumers, Journal of Business, Economics & Technology.

Drew, J., & Meyer, S. A. (2008, January 1). *Color Management for Logos*. Rotovision.

Fakorede, S. T., Akpan, L. G., Adekoya, K. O., & Oboh, B. (2022, March 31). Prevalence and population genetic data of colour vision deficiency among students from selected tertiary institutions in Lagos State, Nigeria. *Egyptian Journal of Medical Human Genetics*, *23*(1). https://doi.org/10.1186/s43042-022-00287-9

Holmes, K. (2018, January 1). Mismatch. The MIT Press eBooks. https://doi.org/10.7551/mitpress/11647.001.0001

Hossain M. I., Nahar L., Dad M. S., Islam F. S., Uddin M. M., (2013), Prevalence of colour blindness among the first year medical & dental students of Mymensingh Medical College, Bangladesh, Mymensingh Med. Journal, 2013 Oct;22(4):661-4.

Islam, M. S., Roy, P., & Shehreen, S. (2016, July 20). Prevalence of colour blindness in young Bangladeshis. Dhaka University Journal of Biological Sciences, 25(2), 201–205. https://doi.org/10.3329/dujbs.v25i2.46342

J. (2018, April 7). Ber Fruit Cultivation Information Guide | Agri Farming. Agri Farming. https://www.agrifarming.in/ber-fruit-cultivation

Jha, R. K., Khadaka, S., Gautam, Y., Bade, M., Jha, M. K., & Nepal, O. (2018, December 31). Prevalence of Color Blindness in Undergraduates of Kathmandu University. *Journal of Nepal Medical Association*, *56*(214), 900–903. https://doi.org/10.31729/jnma.3913

Kaufman-Scarborough, C. (2000, December). Seeing Through the Eyes of the Color-Deficient Shopper: Consumer Issues for Public Policy. *Journal of Consumer Policy*, *23*(4), 461–492. https://doi.org/10.1023/a:1007253306383

Kosari, A. (2022, November 12). Colorblind People Population! Statistics. COLORBLIND GUIDE. https://www.colorblindguide.com/post/colorblind-people-population-live-counter

Kundu B. K., & Chakma B. (2020), Prevalence of Colour Vision Defect in the Indian Population - Results from a Pre-Employment Screening Centre of a Tertiary Care Hospital International Journal of Contemporary Medical Research, DOI: 10.21276/ijcmr.2020.7.9.47

Kuyk, T. K., veres, J. G., lahey, M. A., & clark, D. J. (1986, July). The Ability of Protan Color Defectives to Perform Color-Dependent Air Traffic Control Tasks. *Optometry and Vision Science*, *63*(7), 582. https://doi.org/10.1097/00006324-198607000-00015

Poole, C. J. M. (2002, March 1). Diagnosis of Defective Colour Vision, 2nd edn. By Jennifer Birch. Published by Butterworth Heinemann, Oxford, 2001. ISBN: 0-7506-4174-6. Price: pound30.00. *Occupational Medicine*, *52*(2), 109–109. https://doi.org/10.1093/occmed/52.2.109

Male, S. R., Shamanna, B. R., Bhardwaj, R., Bhagvati, C., & Theagarayan, B. (2022, September). Color vision devices for color vision deficiency patients: A systematic review and meta-analysis. *Health Science Reports*, *5*(5). https://doi.org/10.1002/hsr2.842

Martinez, L. M., Rando, B., Agante, L., & Abreu, A. M. (2021, March). True colors: Consumers' packaging choices depend on the color of retail environment. *Journal of Retailing and Consumer Services*, *59*, 102372. https://doi.org/10.1016/j.jretconser.2020.102372

Melin, A. D., Nevo, O., Shirasu, M., Williamson, R. E., Garrett, E. C., Endo, M., Sakurai, K., Matsushita, Y., Touhara, K., & Kawamura, S. (2019, June 3). Fruit scent and observer colour vision shape food-selection strategies in wild capuchin monkeys. *Nature Communications*, *10*(1). https://doi.org/10.1038/s41467-019-10250-9

Monigatti, L. (2022, July 28). Why Your Data Visualizations Should Be Colorblind-Friendly. Medium. https://towardsdatascience.com/is-your-color-palette-stopping-you-from-reaching-your-goals-bf3b32d2ac49

Mohammed, M., & Mohammed, K. (2016, January 31). The Problem of see the Colors in the Graphic Design to Color Blindness Patients. *Journal of Advance Research in Pharmacy & Biological Science (ISSN: 2208-2360)*, *2*(1), 01–11. https://doi.org/10.53555/nnpbs.v2i1.718

Shaffer. (2016). 5 Tips on Designing Colorblind-Friendly Visualizations. Tableau. Retrieved October 3, 2023, from https://www.tableau.com/blog/examining-data-viz-rules-dont-use-red-green-together

Simunovic, M. P. (2009, November 20). Colour vision deficiency. *Eye*, *24*(5), 747–755. https://doi.org/10.1038/eye.2009.251

Spalding, J. A. B., Cole, B. L., & Mir, F. A. (2010, January 1). Advice for medical students and practitioners with colour vision deficiency: a website resource. *Clinical and Experimental Optometry*, *93*(1), 39–41. https://doi.org/10.1111/j.1444-0938.2009.00434.x

Spalding, J. A. B. (1999). Medical students and congenital colour vision deficiency: Unnoticed problems and the case for screening. *Occupational Medicine*, *49*(4), 247–252. https://doi.org/10.1093/occmed/49.4.247

Sullivan, K. (2011, March). Colour-blind children. *Early Years Educator*, *12*(11), 21–23. https://doi.org/10.12968/eyed.2011.12.11.21

Steward, J. M., & cole, B. L. (1989, May). What Do Color Vision Defectives Say About Everyday Tasks? *Optometry and Vision Science*, *66*(5), 288–295. https://doi.org/10.1097/00006324-198905000-00006

Tagarelli, A., Piro, A., Tagarelli, G., Lantieri, P. B., Risso, D., & Olivieri, R. L. (2004, August). Colour blindness in everyday life and car driving. *Acta Ophthalmologica Scandinavica*, *82*(4), 436–442. https://doi.org/10.1111/j.1395-3907.2004.00283.x

Types of Colour Blindness - Colour Blind Awareness. (2022, April 1). Colour Blind Awareness. https://www.colourblindawareness.org/colour-blindness/types-of-colour-blindness/

Woods, R. (2021, February 24). What are the different types of color blindness? All About Vision. https://www.allaboutvision.com/conditions/color-blindness/types-of-color-blindness/

Yasmin, A., Janan, N., & Akhter, R. (1970, January 1). Assessment of Colour Blindness and Erythrocyte G6PD Enzyme Status among the School Children of Dhaka City. Journal of Bangladesh Society of Physiologist; Bangladesh Society of Physiologist (BSP). https://doi.org/10.3329/jbsp.v4i2.4175

Zhang, X., Yang, M., Su, J., Yang, W., & Qiu, K. (2020, July 20). Research on product color design decision driven by brand image. *Color Research & Application*, *45*(6), 1202–1216. https://doi.org/10.1002/col.22540