# Effects of heat and ph on plant pigments biology essay

The aim of this laboratory exercise is to determine and consider the effect of heat and pH on plant pigment by using the examples of peas, cranberry juice and blackberry juice. Carotenoids, chlorophylls and flavonoids are the three major groups of plant pigment. The results of this laboratory was that the different colour and texture of peas were caused by different pH. In addition, the heat and pH will influence the structure of carotenoids, chlorophylls and flavonoids so that changes the colour of the plant. Anthocyanins are water soluble that easily lose in water.

## INTRODUCTION:

Plant pigments include a variety of different kinds of molecules that absorbs and reflects light. The various pigments contained in their tissues tell the colors differently because they have differing abilities to absorb and reflect various colors of light (Charley 1982). Most of the pigments occur in a specialised bodies lying in the protoplasm of the cell called plastids. Occasionally, the water soluble pigments are dissolved in the vacuoles however they are not generally dispersed throughout the cell. The main pigments of vegetables and fruits fall into two groups: water soluble and fat soluble (Srilakshmi 2003).

Plant pigment can be classified as carotenoids, chlorophylls, and flavonoids. Flavonoid pigments are water soluble and it can be divided in to anthocyanins and anthoxanthins (Brown 2008). Anthocyanins are highly water soluble pigment that range in colour from red to purple. The anthoxanthins are colourless, white or pale yellow. However, flavonoid pigments are sensitive to heat and readily to be lost in cooking water (Charley 1982). Carotenoids and chlorophylls are fat soluble which are found in plastids. Carotenoids are the colour groups of yellow, orange and red. Carotenoids are present as alpha-carotene, beta-carotene, gamma-carotene, xanthophylls and cryptoxanthin in plants (Hanson 1954). On the other hand, in green leaves they occur in chloroplasts. Chlorophylls are the green pigments of leaves that found in chloroplasts along with some carotenes and xanthophylls. In addition, it is critical for the light reactions of photosynthesis (Srilakshmi 2003).

The pigments of chlorophyll that are commonly include chlorophyll a and chlorophyll b. Chlorophyll a is dynamic blue green in colour and it is present in the florets of blue green broccoli. Chlorophyll b is dull yellow green colour and it is present in stalks. The different heat conditions caused the changes of the structure of chlorophyll which is connected with the loss of magnesium ion from the chlorophyll molecule and replaced by hydrogen therefore affects the colour of vegetables (Stathopoulos 2010).

The factors including changes in temperature and pH may influence the colour of anthocyanin in plant food during simmering (Brown 2008). Acid tap water amplifies the red colour of anthocyanins. Alkaline water changes the reddish-blue to blue and then to green. This phenomenon of colour is because the changes in structure of the same basic compound (Srilakshmi 2003).

Plant food have been recognised as a good source of carbohydrates and daily fibre. Plant food are also contain minerals and vitamins A, E, C, thiamin, vitamin B6, riboflavin, niacin and folate. Phytochemicals in fruits and vegetables, such as polyphenolics, carotenoids, and glucosinolates, may also have nutritional value (Jongen 2002). However, vegetables lose nutrients when they are cooked, mainly by solution to the cooking water (Charley 1982).

The objective of this experiment is to consider the effect of heat and pH on plant pigment by using the examples of peas, cranberry juice and blue berry juice.

## METHODS AND MATERIALS:

The methods and materials required to determine the effect of heat and pH on plant pigment were performed according to the laboratory manual. However, the blueberry juice was changed to blackberry juice. In addition, in the experiment of cranberry juice, group 2 did not collect the value of pH.

## RESULTS:

Table 1: The class pH result of each group about chlorophyll.

**Group 1**

**Group 2**

**Group 3**

**Group 4**

**Group 5**

**Group 6**

**Average**

**Sample**

**pH**

**pH**

**pH**

**pH**

**pH**

**pH**

**pH**

Peas + Distilled $H_2O$

6. 83

6. 02

6. 06

7. 2

6. 75

6. 96

6. 6

Peas + Vinegar + Distilled $H_2O$

2. 49

2. 72

2. 6

4. 8

3. 89

3. 77

3. 4

Peas + 1N NaOH + Distilled $H_2O$

12. 20

12. 88

12. 23

12. 2

12. 49

12. 78

12. 463

Peas + Vinegar + Cold Distilled H2O

2. 77

2. 97

2. 5

4. 04

3. 65

3. 68

3. 3

Peas + 1N NaOH + Cold Distilled H2O

12. 41

12. 78

12. 24

12. 02

12. 72

12. 58

12. 458

Canned Peas

5. 95

5. 37

5. 2

6. 15

5. 90

6. 17

5. 8

According to Table 1, the example of peas with NaOH and distilled water has the highest average pH that is 12. 463, followed by peas with NaOH and cold distilled water that is 12. 458, which are very close. The lowest pH is peas with vinegar and distilled water that is 3. 3.

Table 2: The class colour results of each group about chlorophyll.

**Group 1**

**Group 2**

**Group 3**

**Group 4**

**Group 5**

**Group 6**

**Sample**

**Colour**

**Colour**

**Colour**

**Colour**

**Colour**

**Colour**

Peas + Distilled $H_2O$

Bright green

Bright Green

Pea green

Green

Yellow green

Light green

2. Peas + Vinegar + Distilled H2O

Dull green

Light/Pale Green

Brown- green

Faint Green

Army green

Olive

3. Peas + 1N NaOH + Distilled H2O

Bright green

Green

Pea green

Green

Bright green

Bright green

4. Peas + Vinegar + Cold Distilled H2O

Very dull green

Pale Green/ Yellow

Brown green

Faint Green Yellow

More green than yellow

Green

5. Peas + 1N NaOH + Cold Distilled $H_2O$

Bright green

Bright Green

Pea green

Green

Green uniform

Green

6. Canned Peas

Brown

Pale Green

brown

Brown Yellow

Dark army green

Olive

Table 2 reflects that sample 1, 3 and 5 have similar colour range which is green, and sample 2, 4 and 6 have semblables colour which is brown. These results shows under the acid conditions, the range of peas' colour is from green to brown. On the other hand, the colour of peas will stay same under alkaline conditions.

Table 3: The class texture results of each group about chlorophyll.

**Group 1**

**Group 2**

**Group 3**

**Group 4**

**Group 5**

**Group 6**

**Sample**

**Texture**

**Texture**

**Texture**

**Texture**

**Texture**

**Texture**

Peas + Distilled H2O

Firm

Firm

Firm

Firm

Dry

hard

2. Peas + Vinegar + Distilled H2O

Moderately firm, dry, loss of shape

Slightly Firm

Firm

Firm

Very dry

Soft

3. Peas + 1N NaOH + Distilled H2O

Soft, mushy, sticky, loss of shape

Mushy

Mush

Mushy

Mushy

Very soft /mushy

4. Peas + Vinegar + Cold Distilled H2O

Very firm

Very Firm

Firm

Firm

Medium plump

Not so soft

5. Peas + 1N NaOH + Cold Distilled H2O

Very soft, mushy, loss of shape

Mushy

Mush

Mushy

Very plump

Hardest

6. Canned Peas

Very firm

Slightly Firm

Softish

Firm

Firm

Very soft

According to the result of Table 3, the texture of sample 3 and 5 are mush and soft, and others are firm. This result shows the alkaline caused the mush and soft texture of peas, and the acidity of the water will caused the higher firmness of peas.

Table 4: The class pH results of each group about anthocyanins.

**Group 1**

**Group 2**

**Group 3**

**Group 4**

**Group 5**

**Group 6**

**Average**

**Sample**

**pH**

**pH**

**pH**

**pH**

**pH**

**pH**

**pH**

Blackcurrant Fruit Drink + Distilled H2O

2. 79

3. 02

3. 06

3. 12

3. 45

3. 12

3. 1

Blackcurrant Fruit Drink + Distilled H2O (pH 5)

4. 93

5. 07

4. 85

4. 98

5. 09

4. 95

5

Blackcurrant Fruit Drink + Distilled H2O (pH7)

6. 69

7. 17

7. 1

7. 2

7. 11

6. 94

7. 0

Blackcurrant Fruit Drink + Distilled $H_2O$ (pH10)

9. 97

10. 02

10. 04

9. 95

10. 64

10. 0

10. 1

Table 5: the class colour result of blackberry juice.

**Group 1**

**Group 2**

**Group 3**

**Group 4**

**Group 5**

**Group 6**

**Sample**

**Colour**

**Colour**

**Colour**

**Colour**

**Colour**

**Colour**

Blackcurrant Fruit Drink + Distilled $H_2O$

Dark burgundy

Red

Red

Reddish

Red

Pink

Blackcurrant Fruit Drink + Distilled H2O (pH 5)

Orange/pink translucent

Pink/ Red

Grey pink

Pink

Pink

Light pink

Blackcurrant Fruit Drink + Distilled H2O (pH7)

Brown/orange translucent

Brown/ Green

Dull green

Brown greying

Light green olive

Pink with a hint of yellow

Blackcurrant Fruit Drink + Distilled H2O (pH10)

Dark black/green

Dark Green

Dull green

Yellow green

Dark green olive

Yellowish green colour

Table 6: The class pH results of each group about anthocyanins.

**Group 1**

**Group 2**

**Group 3**

**Group 4**

**Group 5**

**Group 6**

**Average**

**Sample**

**pH**

**pH**

**pH**

**pH**

**pH**

**pH**

**pH**

Cranberry + Distilled H2O

2. 72

2. 88

2. 92

3. 00

3. 00

2. 9

Cranberry + Distilled $H_2O$ (pH5)

4. 25

5. 5

4. 97

5. 02

5. 57

5. 1

Cranberry + Distilled $H_2O$ (pH7)

7. 3

7. 2

7. 03

7. 03

7. 82

7. 3

Cranberry + Distilled $H_2O$ (pH10)

10. 62

10. 1

9. 93

10. 05

10. 41

10. 2

Table 7: the class colour result of cranberry juice.

**Group 1**

**Group 2**

**Group 3**

**Group 4**

**Group 5**

**Group 6**

**Sample**

**Colour**

**Colour**

**Colour**

**Colour**

**Colour**

**Colour**

Cranberry + Distilled H2O

Light pink

Pale Pink

Pale pink

Faint Pink

Light pink

Pink

Cranberry + Distilled $H_2O$ (pH5)

Lighter pink

Slight Clear/ Ting of Pink

Clear with a pink tinge

Clear Pink

Lighter pink

Dark pink colour

Cranberry + Distilled $H_2O$ (pH7)

Light yellow

Yellow/ Olive Green

Yellow green

Faint yellow

Apple juice green

Brownish

Cranberry + Distilled $H_2O$ (pH10)

Yellow

Olive Green

Yellow green (slightly greener than 7 pH)

Green yellow

Apple juice green

Olive green

According to the Table 4 to 7, although the average number of the pH is close to the laboratory manual's data, the results of each group are slightly different. Because the anthocyanins is very sensitive to pH that even a small different in pH will cause the colour changed (see page 12 to 15).

## DISCUSSION:

The green colour becomes brighter when a green vegetable is first put to cook in boiling water. Greater translucency of plant tissue due to expulsion of intercellular air has been suggested as a possible cause (Charley 1982). As boiling continues, compartmentalization within the cell is disrupted. Constituents, there are organic acid, diffuse from the vacuoles throughout the cell and into the boiling water (Sterling 1944). As the acids contact the chlorophylls the latter are converted to their respective pheophytins. No longer masked by the intense green chlorophyll, the yellow and orange pigments present in green plant tissue now show along with green. This combination together with the pheophytins gives the vegetable a muddy olive green hue (Srilakshmi 2003). Green vegetables that are lower in acid retain a higher percentage of chlorophyll and of their green colour when they are cooked than do more acid vegetables. Vegetables like peas, beans, greens are sometimes canned. During canning chlorophyll gets converted to pheophytin due to high temperatures used. Sometimes to retain the colour and to neutralise the acid, alkali is added (Charley 1982).

Furthermore, the soda changed texture, any soda not required to neutralize the acid in the cooking water will react with the chlorophyll. The sodium salt of chlorophyll gives to cooked green vegetables an intense and artificial appearing greenness. Vegetables cooked with soda tend to have a mushy texture, due to breakdown of hemicelluloses in the cell walls (Charley 1982)..

Anthocyanins have a positive charge on the molecule, and it enables to absorb light and thus have colour. Anthocyanidins are anthocyanins without sugar in their structure . They are pelargonidin, cyaniding and delphindin (Brown 2008). As pH changes, the colour of anthocyanin also changes. In the acid conditions, the molecules have positive charge on the oxygen atom due to the acidity of the cell in which these compounds are formed. This common form at a pH of 3. 0 or less, maintains or shifts the hue towards red (Charley 1982). However, as the pH is increased toward a weak acid or even neutral solution, the oxonium (the positively charged oxygen form) is changed to the quinine form. The quinine form has a violet colour. In an alkaline medium still another change takes place as a salt of the violet compound, called a colour base. The alkaline salt of the colour base has a distinctly blue colour (Srilakshmi 2003).

# Figure 1: The structure of anthocyanin.

Red cabbage presents unusually wild swings in colour with a alter in pH, it is because of the presence of more than four hydroxyl groups on the anthocyanin molecule. To ensure that the pH is sufficiently acidic, red cabbage is frequently cooked with addition of some slices of a tart apple in order to avoid the development of a blue, highly unpalatable pigment colour (Srilakshmi 2003).

The pigment of bluish green shade was given by the addition of alkali . This shade is probably caused by the presence of anthoxanthins with anthocyanins. On the addition of alkali, the anthoxanthins turn yellow during the anthocyanins turn blue, and then the mixture of the two colours appear green. The addition of alkali alters the structure of anthocyanin molecule and produces a salt (Srilakshmi 2003).

# CONCLUSION:

In conclusion, the bright colors of vegetables contribute to the esthetic pleasure of eating. The three major groups of plant pigment are carotenoids, chlorophylls and flavonoids which are effect by the pH and heat. The colour alters differently under variable conditions. Therefore, we need to understand the changes that take place in the colour of vegetables and how to kept

the pigment of the plant.