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Determination of Sugar Content in *Lactuca sativa* L. Grown at Different Temperatures

Najia Shwerif [1*], Kirsten Brandt[2], Stephen Wilcockson[3]

[1*]Department of Plant Science, Gharian University, Libya.
[2]Human Nutrition Research Centre, School of Agriculture, Food & Rural Development Newcastle University, Newcastle Upon Tyne, NE1 7RU, UK.
[3]Nafferton Ecological Farming Group, Newcastle University, Nafferton Farm, Stocksfield, NE43 7XD, UK

Abstract— *Temperature has a large impact on the growth and development of plants. The temperature conditions that the plant is grown in may affect the content of phytochemicals, which in turn affects the quality of crops. This study investigates the effects of different growth temperature regimes on sugar content of two variety of lettuce grown in a controlled environment.*
The results showed that, highly significant effects of the temperature growth regimes on the lettuce varieties were observed. There were higher levels of sugar in plants grown at low temperature compared with high temperature.
Keywords*— *Abiotic stress, Leafy vegetables, Sugar content, Temperature.

I. INTRODUCTION

Temperature is an environmental factor with large effects on growth, development, yield and quality of food crops (Berry and Bjorkman, 1980; Kopsell, 2010). Global climate and temperature changes will affect vegetable productivity, nutritional value with consequences for diet and health. Lettuce is an important worldwide, dietary, leafy vegetable that is primarily cultivated and consumed as a fresh product or in salad mixes. It is an important source of phytonutrients, (Liu et al., 2007; Khoo et al., 2011; Cruz et al., 2012).

Sugars are organic compounds in plants resulting from photosynthesis, which play an important role in respiration by providing the energy. Sugars are condensed to store the energy in the form of starch, whilst the energy is transported in sucrose form and sugars play a role in cell wall structure, (Harborne, 1998). In addition to these functions, sugars perform a regulatory role in numerous mechanisms of plant growth and development (Rosa *et al.*, 2009). They aid control of plant metabolism and different stress responses during the whole growth stages from embryogenesis to senescence, involving a number of sugar signals that are generated depending on the surrounding environmental conditions, (Rolland *et al.*, 2006). The production and consumption of sugars are performed by plants, whereas the environmental abiotic stresses are one of the main factors that have an influence on soluble sugars due to their sensitivity. However, the soluble sugar levels increase in a plant with low temperature conditions (Rosa *et al.*, 2009). According to molecular size the sugars are divided into three groups: monosaccharaides such as glucose and fructose, oligosaccharide and polysaccharides (Harborne, 1998). The leafy vegetables including lettuce, fructose contributed the highest concentration (about 55 %) of total soluble sugars. In a lettuce plant sugar content changes during the late stages of growth and development as plants age and continues to increase. Furthermore, sugar levels increase from winter to summer when grown in greenhouses (Gent, 2012).

II. METHODS AND MATERIALS

2.1 Plant and growth condition

Different varieties of lettuce (Dixter and Exbury) were grown in growth chambers, at different day temperatures: 12, 17, 22, 27 and 32℃ with a 4℃ day/night temperature difference, an 11 hour photoperiod and with controlled light and water supply. The light was constant 150 µmol /m2/s. Each temperature treatment was applied at a separate time and the plants were harvested after having produced 10-12 leaves.

2.2 Sugar measurement

For sugars measurement of freeze dried lettuce samples, 1ml ultra –pure water was added to 100mg of samples, vortex mixed for a few minutes then the concentrated extracts were measured by hand with a refractometer (Bellingham and Stanley Eclipse refractometer, 0-30 BRIX⁰). According to (Gaweda, 2007), the concentration of sugars were proportionally distributed as glucose 2.9g , fructose 5.4g and sucrose 1.7g per 100ml. The standard curve provide the conversion of BRIXº unit to sugar gram per 100ml, therefore one BRIX corresponded to 1.1125g/100ml, Figure 1.

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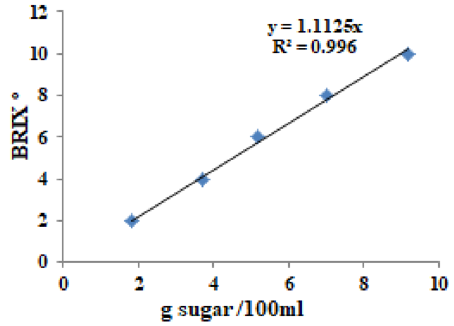

Fig. 1: Standard curves for the sugar determination of lettuce.

III. RESULTS

Temperature regimes had a highly significant effect on shoot sugar contents of both lettuce varieties. There highest content of sugar was at low temperature (12/8°C) and it decreased as temperature increased (Figure 2). Lettuce Dixter had higher sugar concentrations than Lettuce Exbury, but the interaction between the lettuce varieties and temperature was not significant. The non-sugar components of varied between the varieties and plant parts with a highly significant effect of temperature Figure 2.

IV. DISCUSSION

Accumulation of sugar in shoot of Lettuce was highest at a low temperature and decreases with increasing temperatures. According to (Pietrini *et al.*, 2002), at a low temperature the respiration rates slow down and there is less enzyme activity, which tends to reduce energy and leads to a high accumulation of sugar. By contrast, at a high temperature, increasing respiration (more energy requirement) leads to a decrease in the sugar content with a different response between the genotypes, as a result of the associated active nitrogen metabolism process that utilizes sugars, (Champigny, 1995). This offers an explanation for current results whereby, the mechanism of sugar production results in high levels in response to the effect of low temperatures, leading to the inhibition of nitrate accumulation associated with an increase in the rate of nitrogen metabolism. Similar observations were made in lettuce leaves by (Zhou *et al.*, 2013) with the same light intensity but a different light quality.

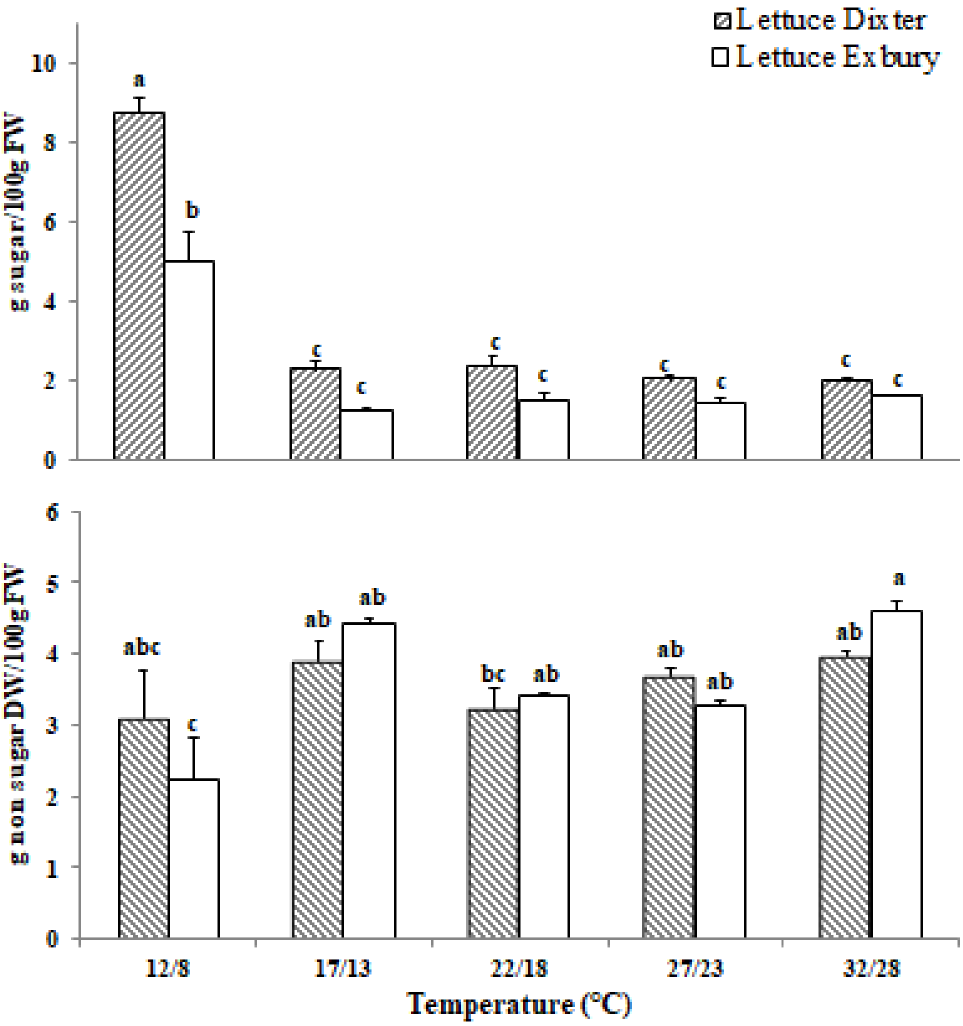

Fig. 2: Sugar and non-sugar content of Lettuce grown in different temperature.

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Additionally, the greater concentration of sugar is associated with slow growth and development of plants, due to the main effect of low temperatures on sugar accumulation. This contrasts with higher temperature regimes that lead to more rapid growth and less sugar. Therefore the physiological process (the photosynthesis and respiration alterations caused by temperature) is a possible reason, since dark respiration slows down and causes inhibition of carbohydrate consumption under low temperature conditions (Khayat *et al.*, 1988). Thus carbohydrate levels are influenced by the maturation extent of leaves and shoots (Jiao *et al.*, 1989) in rose plants. Although effects on sugar content were consistent in the recent study, this was not the case for the content of non-sugar materials (e.g. cellulose and protein) of lettuce plant.

V. CONCLUSION

Clearly growth temperature regimes have an effect on the physiological processes of plants and involve components, which either respond to or defend against extreme temperatures by means of large alterations in phytochemical compounds.

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