IMPACT OF ENVIRONMENT FACTORS ON MODIFICATION OF MASS LOSSES IN FRUITS AND VEGETABLES DURING STORAGE

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INTRODUCTION

Mass losses in vegetal objects during the post-harvest period are a material expression of their energy potential decrease. They are the result of product's energy exchange with the external environment, they are in direct correlation with the emitted warmth and are an evidence of metabolism processes uninterruptability [1-4].

Apart from known endogenic factors (concentration of energetically valuable elements, evaporation ability, ripeness degree, initial condition) a considerable impact on the extent of product losses have interacting with it during the storage process environment parameters. Among the main such parameters are: temperature, relative humidity, mobility and composition (pressure, radiation and lucidity may also have an impact on this indicator, but under usual storage conditions in refrigerated premises this impact is less influential).

Storage regimes for fruits and vegetables cargoes recommended for practical use govern wide ranges for variation of parameters in refrigeration sections – temperature T up to 4…8 ^{0}C, relative humidity RH – up to 10 % and circulation frequency N – up to 20 1/h, which extends the keepability range (chart 1) [4, 5]. For certain varieties these ranges get narrower, however they also do not provide an answer to rationale behind these intervals from the point of view of possible losses [6].

Instability of regime parameters objectively existing in refrigeration sections and product stocks, for instance due to cyclic character of refrigeration-ventilation equipment functioning, also has a considerable impact on losses.

Improvements of fruits and vegetables storage technology is linked with identification of environment parameters impact degree on losses extent, including in form of mass losses, which

Table 1. Recommended ranges for keepability of certain fruits and vegetables [4, 5]

Variety	T, ^{0}C	RH, %	N, 1/h	t
FRUITS				
Apples	–1…+4	85…95	20…40	1…8 months
Pears	–1…+4	85…95	20…40	1…7 months
Grapes	–1…0	85…95	10…20	1…6 months
Plums	–1…+1	85…95	20…40	2…8 weeks
Peaches	–1…+1	85…95	20…40	1…4 weeks
Sweet cherries	–1…+1	85…95	20…40	1…4 weeks
Strawberries	–1…+1	85…95	20…40	1…10 days
Currants	–1…+1	85…95	20…40	1…5 weeks
Oranges	+3…+10	82…90	10…30	2…5 months
Lemons	+2…+10	82…90	20…40	1…6 months
Bananas	+12…+16	82…90	20…40	5…20 days
VEGETABLES				
Potatoes	+2…+6	85…95	30…40	4…12 months
Carrots	–1…+1	90…95	10…20	3…8 months
Onions, garlic	–3…+1	70…80	30…40	3…10 months
White cabbage	–1…+1	90…95	30…40	4…8 months
Tomatoes				
verdant	+10…+15	85…90	20…40	3…8 weeks
ripen	0…+4	85…90	20…40	1…4 weeks
Pumpkins	0…+4	70…85	20…40	2…7 months
Cucumbers	+6…+10	85…95	-	1…2 weeks
Parsley	0	90…95	-	1…2 months
Lettuce	–1…+5	95	-	1…3 weeks

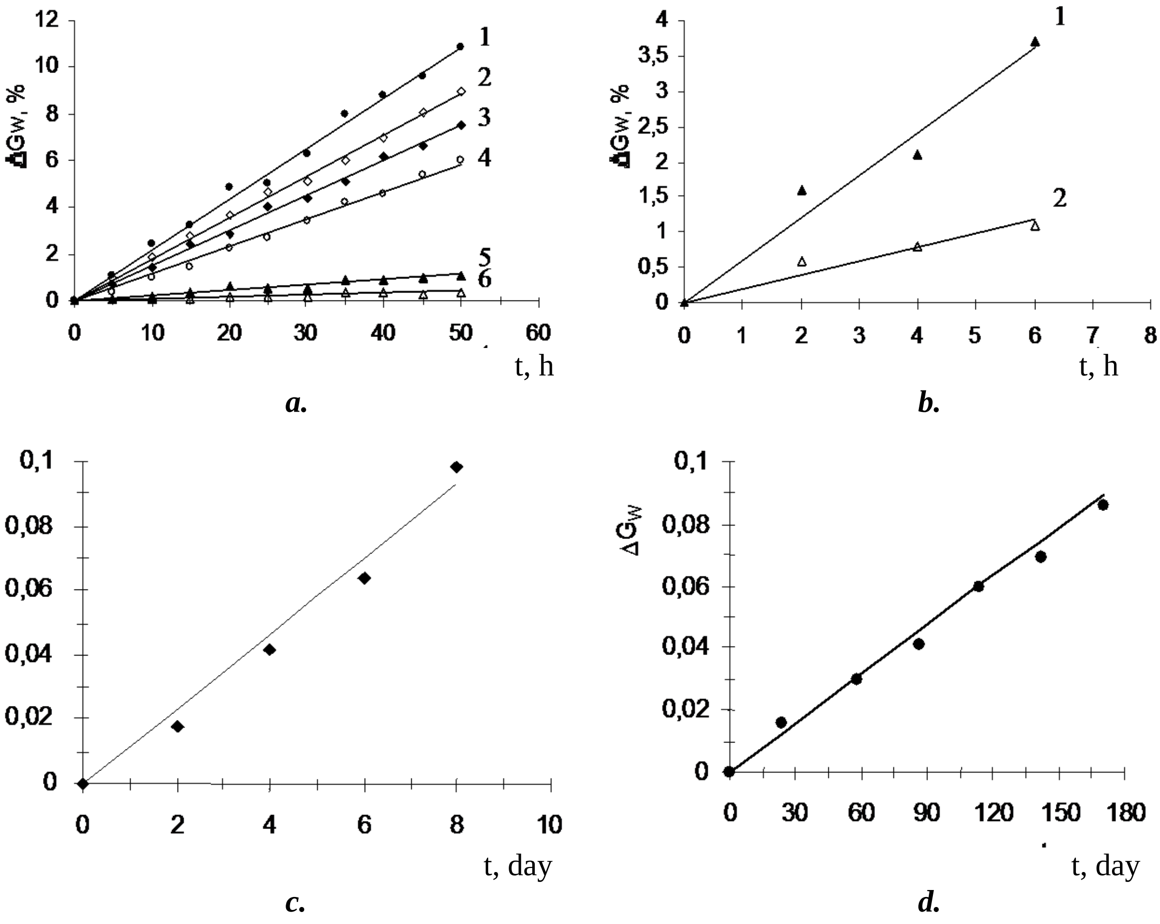
will enable a more reasoned regulation of storage regime.

I. ENVIRONMENT FACTORS IMPACT ANALYSIS

To study the impact of certain factors on mass losses there were involved well-known works on the examined problem, as well as the results of author's own research.

ucts properties and their internal metabolism processes (fig. 1, a).

In different periods of time dissimilar speed of mass losses is recorded [3]. Under short-term exposition this dependency has a linear representation (fig. 1, a). Under prolonged storage the mass losses are recorded according to an S-type curb, but with a minor погрешностью may be approximated by a linear function (fig.1, a, c, d), and such character is the same also in case of (emitted in form of warmth) in citrus fruits [11],



a. *b.* *c.* *d.*

Figure 1. Modifications of mass losses in fruits and vegetables under fixed environment parameters: ***a*** *– (T = 21 ^{0}C; RH = 65 %; N = 0 1/h) [7]: 1 – carrots; 2 – apricots; 3 – peaches; 4 – white cabbage; 5 – apples, Papirovka variety; 6 – apples, Summer Shaffran variety);* ***b*** *– peaches under two models of field storage [8]: 1 – outdoor model under T = 30,5 – 33,5 ^{0}C; 2 – under the trees shadow under T = 23,3 – 27,0 ^{0}C;* ***c*** *– apricots (T = 18-20 ^{0}C; RH = 80 – 85 %; N = 0 1/ч) [9];* ***d*** *– apples (T = 2 ^{0}C; RH = 85 – 90 %; N = 20 1/ч) [10]. Dots – experiments, lines – trends.*

Under fixed environment parameters figures, the mass losses are determined exclusively by prod- modifying the external conditions причем (fig.1, b) – R^2 = 0,9239…0,9628.

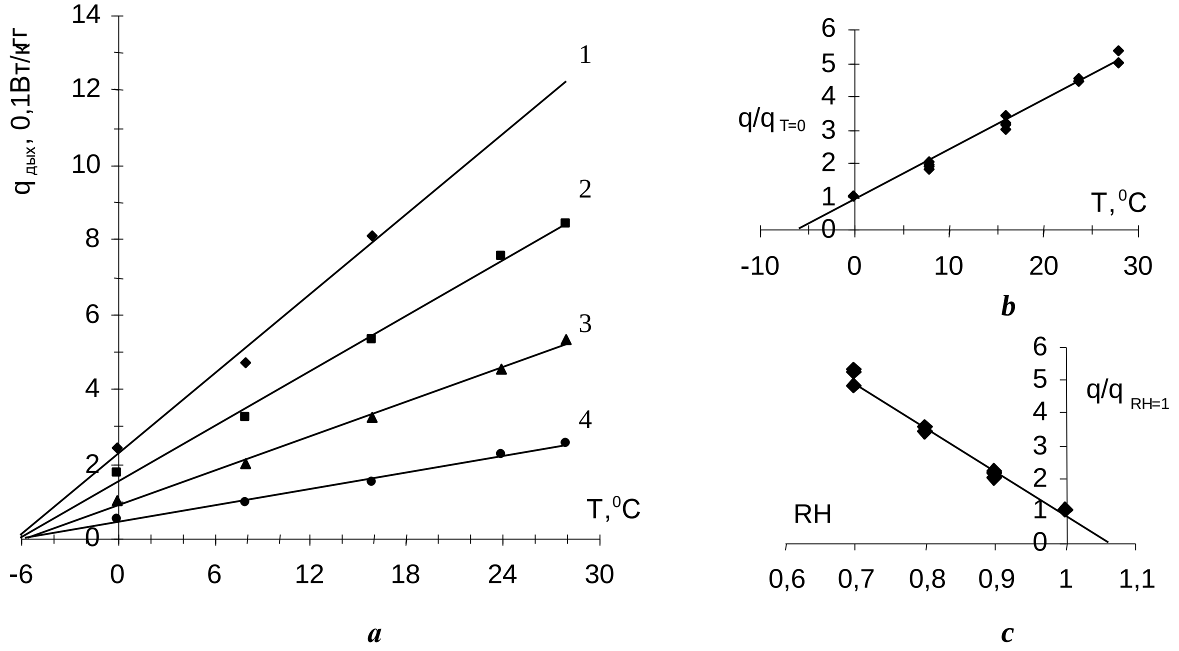
which is represented by the following equation [4]:

$$q = q_S + q_M = q_S(1 + \frac{q_M}{q_S}) = \\ = a(T - T_{M\min})[1 + b(1 - RH)] \quad (1)$$

Impact of temperature and relative air humidity is well reflected by a processing of experimental data on intensity of energy losses approximation correctness: $R^2 = 0{,}9816\ldots0{,}9961$ (fig. 3).

where ***a*** and ***b*** are permanent coefficients, depending on the product's properties.

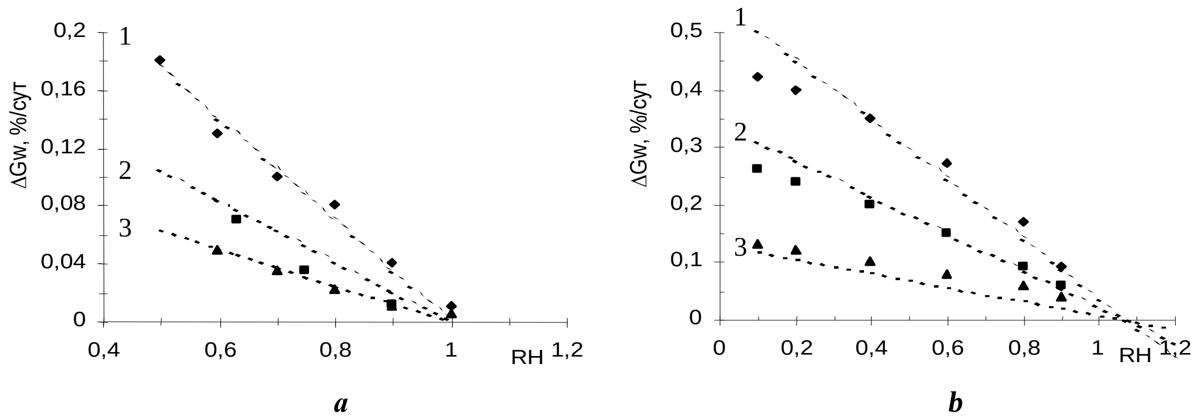
Between mass losses and temperature there is a direct proportional dependency, while between it and the relative humidity there is an inverse dependency represented by linear trend with



a *b* *c*

Figure 2. Approximation of experimental data on warmth emissions intensity in citrus fruits q of temperature T and relative air humidity RH (presented in shares of unit): ***a*** *– q = f(T) for RH = var: 1 - RH = 0,7; 2 – RH = 0,8; 3 – RH = 0,9; 4 – RH = 1;* ***b*** *–* $q/q_{T=0} = f(T)$ *for RH = var;* ***c*** *-* $q/q_{RH=1} = f(RH)$ *for T = var.*

Modifications of mass losses under the influence of environment mobility (circulation frequency N) (fig. 4), are represented through K_N parameter:

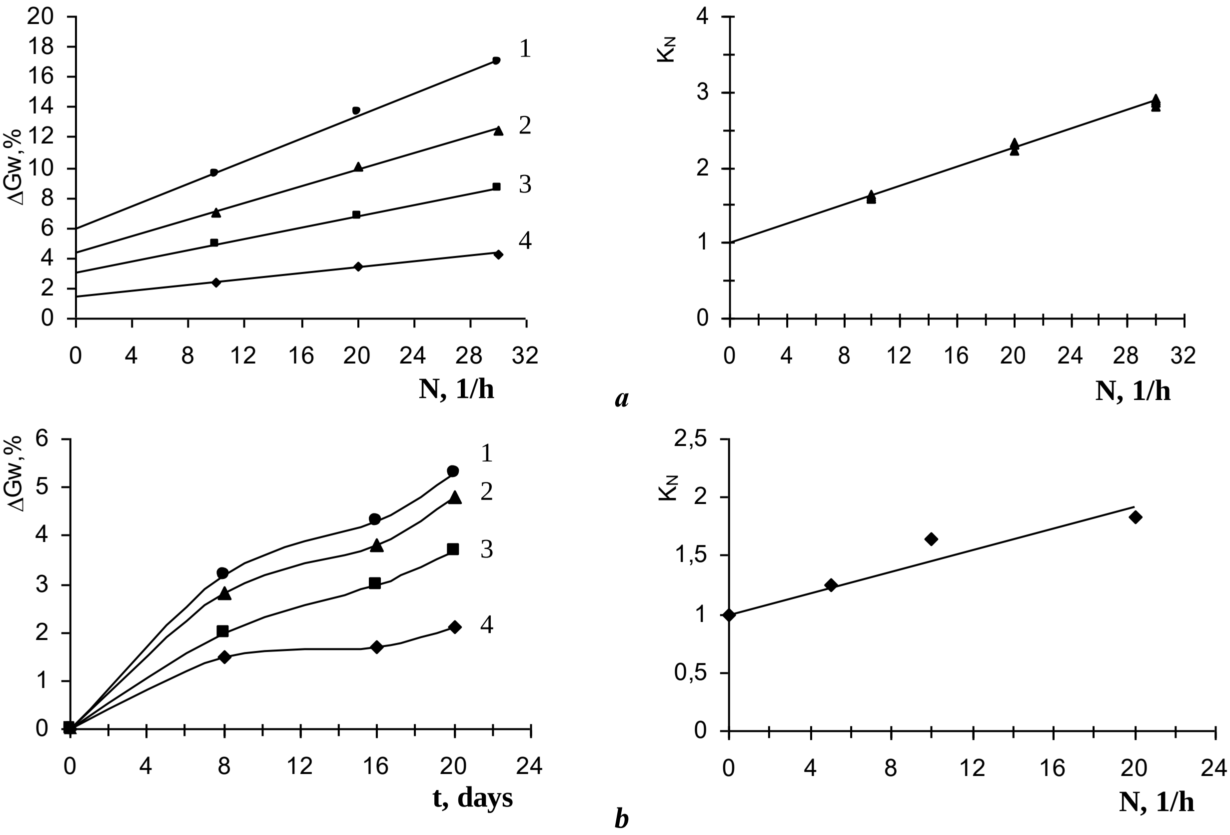


a *b*

Figure 3. Dependency of mass losses ΔGw from environment relative humidity RH: ***a*** *– apples under temperature: 1 – T = 19 ⁰C; 2 – T = 10 ⁰C; 3 – T = 4 ⁰C [12];* ***b*** *– potatoes under temperature: 1 – T = 20 ⁰C; 2 – T = 10 ⁰C; 3 – T = 0 ⁰C [13]. Dots – experiments, lines – trends.*

$$K_N = 1 + aN, \qquad (2)$$

where ***a*** – proportionality coefficient, while ≈ 0,05 ($R^2 = 0{,}9030\ldots0{,}9926$).



a

b

Fig. 4. Impact of environment mobility on mass losses ΔGw: ***a*** *– apples, depending on air circulation frequency N under relative humidity RH [14]: 1 – 0,8; 2 – 0,85; 3 – 0,9; 4 – 0,95;* ***b*** *– oranges under changing temperature of sea transportation T in function of N [15]: 1 – 20 1/h; 2 – 10 1/h; 3 – 5 1/h; 4 – 0 1/h. Dots – experiments, lines – trends.*

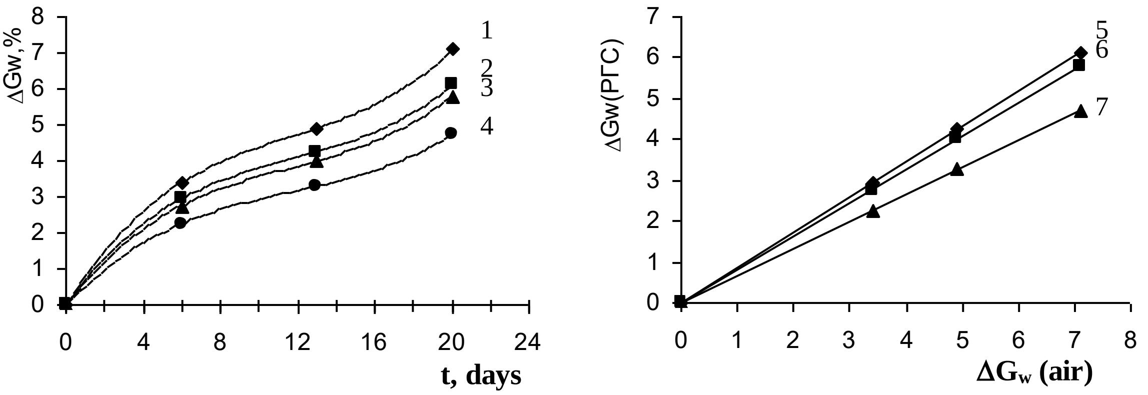


Fig. 5. Impact of environment composition on mass losses ΔGw in peaches during storage on the open air and in РГС of various composition [16]: *1 – air; 2 – РГС-1; 3 – РГС-2; 4 – РГС-3; 5 – dependency «air-РГС-1»; 6 – same, «air-РГС-2»; 7 – same, «air-РГС-3». Dots – experiments, lines – trends.*

Impact of environment composition on mass losses gets reflected through the methabolism break effect, which has been presented (fig.5) through indicator $К_{CO}$ (R^2 = 0,9611…0,9998), representing correlation of respiration warmth when stored in gas environment q_{MAP} and in open air q_{AIR}:

$$К_{CO} = q_{MAP}/\,q_{AIR}\,. \qquad (3)$$

II. CORRELATION FOR MASS LOSSES

The final equation of mass loss modification ΔGw in function of storage object characteristics and environment parameters, obtained in correspondence with the bio-energetic model of preservability (BEMP) concept [4, 17] and on the basis of dependencies analysis (1) – (3) for influencing factors, is presented in the following form:

$$\begin{gathered}\Delta G_W = F \cdot k_{Tr} \cdot t \cdot (T - T_M) \cdot \\ \left[n_S + k_{Tr}(1 - RH)\right] \cdot (1 + a \cdot N) \cdot K_{CO}\end{gathered}, \qquad (4)$$

where F is product bio-energetic indicator; n_S – concentration of dry substances; k_{Tr} – transpiration coefficient; t – time, days; T_M – cryoscopic temperature, ^{0}C; K_{CO} – environment composition parameter; a – coefficient.

III. CONCLUSION

As a result of study on rules of environment factors impact on mass losses in fruits and vegetables in post-harvest period we have received a calculable correlation, taking into account bio-energetic properties of vegetal products and the main regime parameters of refrigeration storage.

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