

DESCRIPTION**TITLE OF THE INVENTION**

REFRIGERATOR

TECHNICAL FIELD

[0001]

The present invention relates to a refrigerator such as a household refrigerator, and more particularly, to a refrigerator including a light emitting device that irradiates the contents in a vegetable compartment with light.

BACKGROUND ART

[0002]

Conventionally, there has been developed a refrigerator in which a Light Emitting Diode (LED) is arranged on a back surface of a vegetable compartment and irradiates vegetables stored in the vegetable compartment with light (for example, Patent Document 1). By irradiating the vegetables with light, it is possible to obtain effects of, for example, activating chlorophyll of green leafy vegetables to produce vitamin C, and promoting an increase in the amount of polyphenol therein.

PRIOR ART REFERENCE**PATENT REFERENCE**

[0003]

Patent Document 1: Japanese Patent Publication No. 4433958 (see paragraph 0027 and FIG. 2).

SUMMARY OF THE INVENTION**PROBLEM TO BE SOLVED BY THE INVENTION**

[0004]

Here, since the back surface of the vegetable compartment is generally a vertical surface, a direction of an optical axis of emission light from the LED is horizontal. Thus, if the LED is arranged on an upper part of the back surface of the vegetable

compartment, there is a possibility that sufficient light is not applied to vegetables other than tall vegetables such as spinach or Chinese cabbages (uncut) stored upright in the vegetable compartment.

[0005]

Further, if the LED is arranged on a lower part of the back surface of the vegetable compartment, there is a possibility that light is applied to a part of a vegetable such as a root or a stem that does not need to be irradiated with light, or a vegetable such as a potato that is better not to be irradiated with light.

[0006]

The present invention is made to solve the foregoing problems, and an object of the present invention is to provide a refrigerator capable of efficiently irradiating vegetables stored in a vegetable compartment with light.

MEANS OF SOLVING THE PROBLEM

[0007]

A refrigerator according to the present invention includes a vegetable compartment, a vegetable storage case provided in the vegetable compartment, and a light emitting device provided in the vegetable compartment. The light emitting device has a light emitting part having an optical axis tilted downward with respect to a horizontal plane, and emits light from the light emitting part toward an inside of the vegetable storage case.

EFFECTS OF THE INVENTION

[0008]

According to the refrigerator of the present invention, the light is emitted from the light emitting part having the tilted optical axis toward the inside of the vegetable storage case, and thus it is possible to irradiate even low-height vegetables with sufficient light.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1 is a side sectional view of a refrigerator according to a first embodiment of the present invention.

FIG. 2 is a front view of the refrigerator according to the first embodiment of the present invention.

FIG. 3 is a sectional view showing a structure of a vegetable compartment of the refrigerator and its surroundings according to the first embodiment of the present invention.

FIG. 4 is a perspective view of a vegetable storage case according to the first embodiment of the present invention.

FIG. 5 is a sectional view showing a structure of a light emitting device according to the first embodiment of the present invention;

FIG. 6 is a diagram showing an arrangement of LEDs in the light emitting device according to the first embodiment of the present invention.

FIG. 7 is a sectional view showing another structural example of the light emitting device according to the first embodiment of the present invention.

FIG. 8 is a sectional view showing a further structural example of the light emitting device according to the first embodiment of the present invention.

FIG. 9 is a diagram showing a driving circuit of the light emitting device according to the first embodiment of the present invention.

FIG. 10 is a flowchart showing an operation of the light emitting device according to the first embodiment of the present invention.

FIG. 11 is a timing chart showing the operation of the light emitting device according to the first embodiment of the present invention.

FIG. 12 is a sectional view showing a structure of a

vegetable compartment of a refrigerator and its surroundings according to a second embodiment of the present invention.

FIG. 13 is a block diagram showing a control system of the refrigerator according to the second embodiment of the present invention.

FIGS. 14 (A) and (B) are schematic diagrams for describing examples of an operation of a light emitting device according to the second embodiment of the present invention.

MODE FOR CARRYING OUT THE INVENTION

[0010]

FIRST EMBODIMENT

A first embodiment of the present invention will be described with reference to FIGS. 1 to 11. FIG. 1 and FIG. 2 are a side sectional view and a front view of a refrigerator according to the first embodiment, respectively. In this regard, FIG. 1 corresponds to a sectional view at a line I-I in FIG. 2 viewed in a direction of arrows. A refrigerator 1 is, for example, a household refrigerator. As shown in FIG. 1, the refrigerator 1 includes a plurality of storage compartments, namely, a refrigerator compartment 11, a switching compartment 12, an ice-making compartment 13 (FIG. 2), a freezer compartment 14, and a vegetable compartment 15.

[0011]

In this example, the refrigerator compartment 11 is arranged at an uppermost stage, the switching compartment 12 and the ice-making compartment 13 are arranged side by side in a left-right direction below the refrigerator compartment 11, the freezer compartment 14 is arranged below the switching compartment 12 and the ice-making compartment 13, and the vegetable compartment 15 is arranged at a lowermost stage. However, the refrigerator 1 is not limited to this arrangement.

[0012]

The refrigerator compartment 11 includes double swinging

type rotary doors 11a (or single swinging type rotary door) on its front surface. An inside of the refrigerator compartment 11 is partitioned into a plurality of spaces by food shelves 11b. Below the lowermost food shelf 11b, a chilling compartment is provided, and a chilling case 11c that can be pulled out frontward is arranged in the chilling compartment.

[0013]

The switching compartment 12 is a storage compartment whose temperature is switchable between two temperature ranges, i.e., a temperature range for freezing (for example, -18°C) and a temperature range for soft freezing (for example, -7°C). The switching compartment 12 includes a drawer door 12a on its front surface and also includes a food storage case 12b therein. The ice-making compartment 13 is arranged side by side with and at the same height as the switching compartment 12. The ice-making compartment 13 includes a drawer door 13a on its front surface and also includes an ice storage case (not shown) therein.

[0014]

The freezer compartment 14 includes a drawer door 14a on its front surface and also includes a food storage case 14b therein. The vegetable compartment 15 includes a drawer door 15a at its front surface and also includes a vegetable storage case 4 therein. The storage compartments in the refrigerator 1 are not limited to these examples.

[0015]

The refrigerator 1 has a refrigeration cycle device for cooling each of the storage compartments. The refrigeration cycle device includes a compressor 17 provided at a lower part on a back surface side (rear) of the refrigerator 1, a condenser (not shown) for condensing a refrigerant discharged from the compressor 17, and a throttle device (not shown) for expanding the refrigerant flowing out of the condenser. The refrigeration cycle device also includes a cooler 18 for cooling air by heat exchange with the refrigerant expanded by the throttle device,

a fan (blowing fan) 19 for sending the cooled air to each of the storage compartments, and an air blowing passage 22 as a passage for the air. A defroster 23 is arranged below the fan 19.

[0016]

The air cooled by the cooler 18 is sent by the fan 19 to each of the storage compartments (the refrigerator compartment 11, the switching compartment 12, the ice-making compartment 13, the freezer compartment 14, and the vegetable compartment 15), and cools an inside of each of the storage compartments. Air warmed by cooling the contents in each of the storage compartments returns to a periphery of the cooler 18 from suction ports provided in the respective storage compartments through return ducts. Then, the air cooled by the cooler 18 is sent again to each of the storage compartments.

[0017]

An operation panel 21 as an operation input part is arranged at a front surface of the refrigerator 1. The operation panel 21 is a part at which a user inputs settings of a temperature and the like for each of the storage compartments. The operation panel 21 is arranged on the rotary door 11a of the refrigerator compartment 11 in this example, but may be located at any position where the user can easily operate the operation panel 21.

[0018]

The refrigerator 1 is provided with a controller 20 (a control board) for controlling the entire refrigerator 1. The controller 20 controls operations of the compressor 17, the fan 19, and a damper (not shown) connected to each of the storage compartments based on an output signal from a temperature detection sensor (for example, a thermistor) provided in each of the storage compartments and information set at the operation panel 21. The controller 20 also communicates with external devices. For example, the controller 20 receives an instruction to change the set temperature, an instruction to check an inside

condition of the refrigerator and the like from a smartphone, and transmits responses to these instructions.

[0019]

The temperature inside each of the storage compartments is detected by the not shown temperature detection sensor (for example, the thermistor). The controller 20 adjusts an opening of the not shown damper, a capacity of the compressor 17, an air blow amount of the fan 19 and the like in order that the temperatures detected by the temperature detection sensors become preset temperatures.

[0020]

The refrigerator 1 is covered with a housing 16 having a heat insulating member such as a urethane foam or a vacuum heat insulating material. Further, a partition having a heat insulating member such as a urethane form or a vacuum heat insulating material is provided between the storage compartments in the refrigerator 1.

[0021]

The refrigerator 1 of the first embodiment includes a light emitting device 5 provided in the vegetable compartment 15. The light emitting device 5 irradiates vegetables stored in the vegetable storage case 4 with light. Hereinafter, structures of the vegetable compartment 15 and the light emitting device 5 will be described.

[0022]

FIG. 3 is a diagram showing the structure of the vegetable compartment 15 and its surroundings. The vegetable compartment 15 is provided with the vegetable storage case 4 for storing vegetables and a large size (for example, 2-liter) PET bottle 201. The vegetable storage case 4 is integrated with the above described drawer door 15a and configured to be movable in a front-back direction (in a direction indicated by an arrow B in FIG. 1). A door opening/closing sensor 25 for detecting opening/closing of the drawer door 15a is provided at a front

upper part of the vegetable compartment 15.

[0023]

The door opening/closing sensor 25 outputs an ON signal when the door opening/closing sensor 25 detects that the drawer door 15a is in an opened state, and outputs an OFF signal when the door opening/closing sensor 25 detects that the drawer door 15a is in a closed state. The ON signal and the OFF signal of the door opening/closing sensor 25 are collectively referred to as a door opening/closing signal. The controller 20 measures a time period during which the drawer door 15a is opened (a door opening time period), and uses the measured time period as various control parameters, or generates a buzzer sound to alert the user when the door opening time period exceeds a set time. In this regard, a similar door opening/closing sensor is also provided in each of the storage compartments other than the vegetable compartment 15.

[0024]

The vegetable storage case 4 has a structure divided into two, i.e., upper and lower separate sections. More specifically, the vegetable storage case 4 has a lower case 41 and an upper case 42. A part of a back surface of the lower case 41, i.e., a part of the lower case 41 positioned in front of the light emitting device 5 is opened to irradiate the inside of the lower case 41 with the light from the light emitting device 5 when the door is closed. In this regard, each of the lower case 41 and the upper case 42 may be partially or entirely formed of a transparent plastic or the like so as to allow the light from the light emitting device 5 to pass therethrough.

[0025]

The lower case 41 (a large vegetable case) stores relatively large vegetables, for example, leafy vegetables (green vegetables) 202 such as spinach, Japanese mustard spinach, a cabbage and a Chinese cabbage, and heavy root vegetables 203 such as a potato and a Japanese white radish. The upper case 42

(a small vegetable case) stores relatively small vegetables, for example, a partially-used vegetable, and a cucumber, a tomato, or the like.

[0026]

FIG. 4 is a schematic diagram showing an example of a shape of the vegetable storage case 4. The lower case 41 has a front surface portion 41a, a back surface portion 41b, a left side surface portion 41c, a right side surface portion 41d, and a bottom surface portion 41e, and an upper side of the lower case 41 is opened. The upper case 42 has a front surface portion 42a, a back surface portion 42b, a left side surface portion 42c, a right side surface portion 42d, and a bottom surface portion 42e, and an upper side of the upper case 42 is opened.

[0027]

The upper case 42 is held on the left and right side surface portions 41c and 41d of the lower case 41. Front parts (parts close to the front surface portion 41a) of the side surface portions 41c and 41d of the lower case 41 are formed to have a higher height than other regions thereof, and restrict a position of a front end of the upper case 42. Thus, a region not covered with the upper case 42 is formed in a front part inside the lower case 41. In this region, for example, the large size PET bottle 201 (see FIG. 3) is stored.

[0028]

With reference to FIG. 3 again, the vegetable compartment 15 includes a bottom portion 31 facing the bottom surface of the vegetable storage case 4, a ceiling portion 32 facing a top surface of the vegetable storage case 4, a back surface wall 33 facing a back surface of the vegetable storage case 4, and side walls 34 and 35 (FIG. 2) facing both of right and left side surfaces of the vegetable storage case 4.

[0029]

The light emitting device 5 is arranged on the back surface wall 33 of the vegetable compartment 15 so as to face the back

surface of the vegetable storage case 4. The light emitting device 5 is arranged above a center of the vegetable storage case 4 in a vertical direction. In this example, the light emitting device 5 is arranged at a position where the light emitting device 5 faces the back surface portion 41b of the lower case 41 in the vegetable storage case 4. That is, the light emitting device 5 is arranged at a position lower than the upper case 42. Further, the light emitting device 5 is arranged at, for example, a center part of the refrigerator 1 in the right-left direction as indicated by reference character A1 in FIG. 2.

[0030]

The back surface wall 33 of the vegetable compartment 15 is configured by the above-described heat insulating member and has high strength. Thus, by arranging the light emitting device 5 on the back surface wall 33, vibrations applied to LEDs (described later) of the light emitting device 5 can be suppressed, and thus reliability of the light emitting device 5 can be enhanced. In addition, driving components such as the fan 19 and the damper are also arranged on the back surface side of the refrigerator 1. Thus, there is also an advantage that wiring to the light emitting device 5 can be simplified.

[0031]

In this regard, the arrangement of the light emitting device 5 is not limited to the example described above. For example, the light emitting device 5 may be arranged at an upper corner on the back surface side of the vegetable compartment 15 as indicated by reference character A2 in FIG. 3, or may be arranged at an upper right corner or an upper left corner on the back surface side of the vegetable compartment 15 as indicated by reference character A3 in FIG. 2. There are few vegetables having angular shapes such as a rectangular parallelepiped shape, and thus there is usually no vegetable (few light blocking objects) present in an upper space on the back surface side of the vegetable storage case 4. Thus, even if the light emitting

device 5 is arranged at such a position, the light can be applied over a relatively wide range in the vegetable storage case 4.

[0032]

Further, as indicated by reference character A4 in FIG. 2, the light emitting device 5 may be arranged on the side wall 34 or side wall 35 of the vegetable compartment 15. In this case, there is an advantage that a lighting state of the LEDs in the light emitting device 5 can be easily checked by the user.

[0033]

Further, as indicated by reference character A5 in FIG. 2, the light emitting device 5 may be arranged at the ceiling portion 32 of the vegetable compartment 15. The ceiling portion 32 serves as a partition between the vegetable compartment 15 and the freezer compartment 14, and is detachable from the housing 16 of the refrigerator 1. Thus, when the light emitting device 5 is attached to the ceiling portion 32, there is an advantage that the light emitting device 5 can be easily attached thereto or detached therefrom when failure occurs.

[0034]

The light emitting device 5 is arranged above the center of the vegetable storage case 4 in the vertical direction and arranged so that an emission optical axis Ax is tilted downward with respect to a horizontal plane H. By arranging the light emitting device in this way, the vegetables stored in the lower case 41 of the vegetable storage case 4 can be efficiently irradiated with light. Hereinafter, the specific structure of the light emitting device 5 will be described.

[0035]

FIGS. 5 and 6 are a sectional view and a front view showing a structural example of the light emitting device 5, respectively. The light emitting device 5 includes a plurality of semiconductor light emitting elements having different wavelengths. Specifically, the light emitting device 5 includes LEDs 51a and 51b serving as a first light emitting part and emitting red light

(light having a wavelength in a range of 600 to 780 nm), LEDs 52a and 52b serving as a second light emitting part and emitting green light (light having a wavelength in a range of 500 to 550 nm), and LEDs 53a and 53b serving as a third light emitting part and emitting blue light (light having a wavelength in a range of 430 to 500 nm).

[0036]

As shown in FIG. 6, the red LEDs 51a and 51b are arranged side by side in the left-right direction to form an LED group 51. Below the red LEDs 51a and 51b, the blue LEDs 53a and 53b are arranged side by side in the left-right direction to form an LED group 53. Below the blue LEDs 53a and 53b, the green LEDs 52a and 52b are arranged side by side in the left-right direction to form an LED group 52. Although two LEDs are arranged for each color in this example, one or three or more LEDs may be arranged for each color.

[0037]

With reference to FIG. 5 again, the light emitting device 5 includes a mounting board 55 to which the LEDs 51a, 51b, 52a, 52b, 53a and 53b (hereinafter referred to as the LEDs 51a to 53b) are fixed by solder, and a cover member 54 covering an emission side of the LEDs 51a to 53b. The cover member 54 is configured by a member that allows the light emitted from the LEDs 51a to 53b to pass therethrough.

[0038]

The cover member 54 includes an emission surface portion 54a arranged on the emission side of the LEDs 51a to 53b, a peripheral wall portion 54b surrounding the LEDs 51a to 53b and the mounting board 55, and a base portion 54c formed at an end of the peripheral wall portion 54b. The base portion 54c of the cover member 54 is fixed to the back surface wall 33.

[0039]

The mounting board 55 with the LEDs 51a to 53b fixed thereto is fixed to the emission surface portion 54a of the cover

member 54 by screws 56 in such a manner that an irradiation angle does not vary due to vibrations of the refrigerator 1. Further, in order to prevent short-circuit of a circuit on the mounting board 55, a back surface side of the cover member 54 is covered with a seal 57.

[0040]

The light emitting device 5 is incorporated in an upper part of the back surface wall 33 of the vegetable compartment 15 (in a part above the center of the vegetable storage case 4 in the vertical direction) at an angle such that the emission optical axis Ax as an optical axis of each of the LEDs 51a to 53b directs downward by an angle θ with respect to the horizontal plane H. The angle θ is in a range of 5° to 85° , desirably 10° to 45° , as described later.

[0041]

In the structural example shown in FIG. 5, a tilted attachment surface 33a is formed at the back surface wall 33, and the light emitting device 5 is attached to the attachment surface 33a, in order that the emission optical axis Ax of the LEDs 51a to 53b is tilted with respect to the horizontal plane H.

[0042]

In this regard, the light emitting device is not limited to the structure shown in FIG. 5, and it is sufficient that the emission optical axis Ax of the LEDs 51a to 53b is tilted with respect to the horizontal plane H. For example, as shown in FIG. 7, the LEDs 51a to 53b may be formed of bullet-shaped LEDs having long leads (legs) 58, and each of the leads 58 may be tilted by the angle θ with respect to the horizontal plane H.

[0043]

Further, as shown in FIG. 8, a mounting board 55a with the LEDs 51a and 51b fixed thereto, a mounting board 55b with the LEDs 52a and 52b fixed thereto, and a mounting board 55c with the LEDs 53a and 53b fixed thereto may be configured by separate

members and respectively attached to tilted surfaces of a support substrate 59.

[0044]

With the structures shown in FIGS. 7 and 8, the light emitting device 5 does not need to be tilted as a whole. Thus, there is a merit that it is unnecessary to thin the back surface wall 33 of the vegetable compartment 15 (reduce heat insulating property), or to reduce a space for housing the vegetable storage case 4.

[0045]

FIG. 9 is a diagram showing a circuit structure of the light emitting device 5. As shown in FIG. 9, the LEDs 51a to 53b are connected in parallel to a voltage source of DC (direct current) voltage of 2 V to 15 V. Further, microcomputers 101, 102 and 103 are connected to the LED groups 51, 52 and 53, respectively. That is, the LEDs 51a and 51b emit light by application of a current of 10 to 50 mA under control of the microcomputer 101. The LEDs 52a and 52b emit light by application of a current of 10 to 50 mA under control of the microcomputer 102. The LEDs 53a and 53b emit light by application of a current of 10 to 50 mA under control of the microcomputer 103.

[0046]

For each color of the LEDs (i.e., for each of red, blue, and green), the controller 20 previously stores a combination of an amount of light and an irradiation time that are effective for activating the function of vegetables. The controller 20 drives the microcomputers 101, 102 and 103 based on the stored combination of the amount of light and the irradiation time.

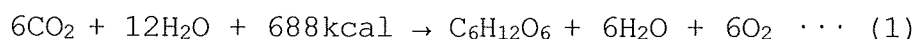
[0047]

In this regard, the current flowing through each LED is as small as 10 to 50 mA, and thus the LEDs have high safety. Further, the LEDs 51a to 53b are controlled on a group-by-group basis (for each of the LED groups 51, 52 and 53), and therefore the

number of ports of the microcomputers can be reduced and the controller 20 can be simplified.

[0048]

Next, effects of light irradiation by the light emitting device 5 will be described. First, a photosynthetic reaction will be described. The photosynthetic reaction is expressed by the following chemical formula (1).



[0049]

In the formula (1), CO_2 is carbon dioxide, H_2O is water, and O_2 is oxygen. 688 kcal is light energy, and $\text{C}_6\text{H}_{12}\text{O}_6$ is glucose. This reaction is divided into a light reaction using light energy and a dark reaction using no light energy.

[0050]

The light reaction is a reaction that converts light energy into chemical energy. At this stage, carbon dioxide is not used, and a pigment such as chlorophyll decomposes water into hydrogen and oxygen using light energy, and chemical energy is stored by action of an enzyme protein. On the other hand, the dark reaction synthesizes glucose by using hydrogen generated in the light reaction and carbon dioxide in the air. A vegetable with increased glucose has an increased storability and also produces vitamin C.

[0051]

In the first embodiment, red light, green light, and blue light are used, and these have their own effects individually. Red light has a wavelength at which high absorptivity by chlorophyll in vegetables is obtained, and the red light is absorbed in surfaces of leaves and is used for photosynthesis. Green light exhibits low absorptivity by chlorophyll, and therefore the green light penetrates into an inside of the leaves, is repeatedly reflected by and absorbed in the leaves, and is used for photosynthesis. Blue light serves as a signal for notifying vegetables of the irradiation with light, and thus is

used to open pores of the leaves to take in carbon dioxide. By these effects, the photosynthetic reaction represented by the formula (1) is efficiently promoted.

[0052]

Among vegetables stored in the lower case 41, a vegetable that is better to be irradiated with light is, for example, a leafy vegetable such as spinach, Japanese mustard spinach, and a cabbage. On the other hand, a vegetable that is better not to be irradiated with light is, for example, a potato. Both the leafy vegetable and the potato may be placed on a bottom surface portion 41e of the lower case 41, and the potato has a lower height than the leafy vegetable.

[0053]

For this reason, by setting an angle θ of the emission optical axis Ax of the light emitting device 5 to 5° to 85° (more desirably 10° to 45°), the vegetable (leafy vegetable) that is better to be irradiated with light can be irradiated with light, whereas the vegetable (potato) that is better not to be irradiated with light can be prevented from being irradiated with light.

[0054]

In this regard, although an area for storing the large size PET bottle 201 and the like is provided at the front part of the lower case 41, the contents stored in this area are not influenced by the irradiation with light and thus do not affect the setting of the angle θ .

[0055]

The light emitting device 5 is desirably arranged above a center of a height from the bottom surface portion 41e of the lower case 41 to the bottom surface portion 42e of the upper case 42. By arranging the light emitting device 5 in this way, an elongated leafy vegetable such as spinach can be irradiated with light even when the leafy vegetable is placed leaning against the back surface portion 41b of the lower case 41, or

even when the leafy vegetable is placed lying on a center of the bottom surface portion 41e of the lower case 41.

[0056]

In this example, the upper case 42 as the small vegetable case is provided above the lower case 41 as the large vegetable case. However, these cases may be provided upside down, that is, the large vegetable case may be provided above the small vegetable case. This prevents small vegetables stored in the small vegetable case from rolling into the large vegetable case and being spoilt without being noticed. Further, the large vegetable case functions as a lid of the small vegetable case, and thus used vegetables can be prevented from being dried. In this way, quality of the vegetables stored in the vegetable compartment 15 can be enhanced as a whole.

[0057]

Next, control of light irradiation by the light emitting device 5 in the refrigerator 1 having the above described structure will be described. First, the concept of activation of the function of vegetables will be described. Most of organisms normally live with a circadian rhythm, i.e., with day and night, and plants are no exceptions. Since vegetables are alive even when they are stored, it is desirable to provide an environment in which a light-irradiated time period and a non-light-irradiated time period alternate, i.e., in which there are day and night, in the same manner as before harvesting.

[0058]

For this reason, the light emitting device 5 repeatedly turning on and turning off the LEDs at a constant rhythm. Each of a turning-on time and a turning-off time of the LEDs is 5 hours or more, and desirably 5 to 15 hours. This is because, if the turning on and the turning off are repeated in an extremely short cycle, it gets dark before activation of a biosynthetic function by light occurs, which results in the same situation as when the contents are not irradiated with light.

[0059]

Irradiation of plants with blue light is a sign for informing the plants of start of irradiation with light. Thus, the plants (in this example, vegetables) open their pores and take in carbon dioxide needed for biosynthesis from the air. Simultaneously with the irradiation with the blue light, the vegetables are irradiated with red light and green light that activate chlorophyll of the vegetables, generate glucose by the biosynthetic function, and promote synthesis of vitamin C and the like associated with the generation of glucose.

[0060]

It is more efficient when the amount of the blue light is weaker than the red light and the green light. Thus, the amount of the blue light is desirably $1/4$ or less, and more desirably $1/5$ or less of each of the amount of the red light and the amount of the green light. After the pores of the vegetables are opened, it is desirable to turn off the blue light. After the light irradiation is continued for a certain period of time in this way, the LEDs of the light emitting device 5 are turned off.

[0061]

In view of the above-described points, an operation of the light emitting device 5 (light irradiation control) will be described. FIG. 10 is a flowchart showing a flow of the operation of the light emitting device 5. After a power source of the refrigerator 1 is turned on, the controller 20 starts light irradiation control based on a circadian rhythm of a vegetable according to a user's operation at the operation panel 21 (step S1). First, it is determined whether or not a current time is within a time period (a daytime period) during which light irradiation is to be performed (step S2).

[0062]

The determination as to whether it is the daytime period or a nighttime period is made by using a 24-hour timer provided in the controller 20. For example, a period from 6:00 to 18:00

is set as the daytime period, and the other period is set as the nighttime period in advance. Timings of the daytime period and the nighttime period may be seasonally changed. For example, the daytime period may be set to be the longest in a season around the summer solstice and the daytime period may be set to be the shortest in a season around the winter solstice. Further, although the daytime period and the nighttime period constitute 24 hours in this example, this length may be changed as appropriate.

[0063]

If it is determined in step S2 that the current time is within the daytime period, the controller 20 starts light irradiation in a daytime mode. That is, the irradiation of red light by the LEDs 51a and 51b, the irradiation of green light by the LEDs 52a and 52b, and the irradiation of blue light by the LEDs 53a and 53b are started simultaneously (step S3). As described above, the red light and the green light are light appropriate for activating the function of the vegetables, whereas the blue light is light serving as a trigger to open the pores of the vegetables. Then, the controller 20 starts measuring the time in the daytime mode, for example, by using the timer (step S4).

[0064]

The irradiation of the blue light by the LEDs 53a and 53b is continued for a time required to open the pores of the vegetables, for example, 10 minutes or more, and the LEDs 53a and 53b are turned off when the required time elapses (step S5). Thereafter, an elapsed time after the start of the daytime mode is acquired (step S6). When the elapsed time reaches an upper limit time in the daytime mode previously set (step S7), the operation proceeds to a nighttime mode, so that the LEDs 51a, 51b, 52a and 52b are turned off (step S8). In this way, all the LEDs 51a to 53b are turned off, and thereby the nighttime mode is started.

[0065]

Simultaneously with the start of the nighttime mode, the controller 20 starts measuring the time in the nighttime mode using, for example, the timer (step S9). Thereafter, an elapsed time after the start of the nighttime mode is acquired (step S10). When the elapsed time reaches an upper limit time in the nighttime mode previously set (step S11), the operation returns to the above described step S3, so that the light irradiation in the daytime mode is started.

[0066]

FIG. 11 is a timing chart showing the operation of the light emitting device 5. As shown in FIG. 11, simultaneously with the start of the daytime period, the irradiation of the red light by the LEDs 51a and 51b, the irradiation of the green light by the LEDs 52a and 52b, and the irradiation of the blue light by the LEDs 53a and 53b are started at the same time.

[0067]

When a time required to open the pores of the vegetables elapses, only the irradiation of the blue light by the LEDs 53a and 53b is stopped. Consequently, the vegetables in the vegetable storage case 4 are irradiated only with the red light and the green light, which are used for photosynthesis. Then, simultaneously with the end of the daytime period, the irradiation of the red light by the LEDs 51a and 51b and the irradiation of the green light by the LEDs 52a and 52b are stopped. This results in an environment in which the vegetables in the vegetable storage case 4 are not irradiated with light.

[0068]

In this regard, the determination as to whether it is within the daytime period or the nighttime period is made by using the 24-hour timer in this example, but a method using no timer is also possible. For example, the time during which a frequency of opening and closing the drawer door 15a is the smallest may be determined as a midnight, i.e., 0 o'clock, based

on an output from the door opening/closing sensor 25 of the vegetable compartment 15.

[0069]

According to the operation of the light emitting device 5 described herein, even when the drawer door 15a is opened and closed in the daytime period (for example, the time period from 6:00 to 18:00) and external light enters the vegetable compartment 15, the vegetables are subjected to less stress because these vegetables have already been irradiated with light by the light emitting device 5.

[0070]

Further, during the nighttime period (for example, the time period from 18:00 to 6:00 next morning), the vegetables in the vegetable storage case 4 are not irradiated with light by the light emitting device 5. Since the drawer door 15a is less frequently opened and closed during night, the vegetables are subjected to less stress.

[0071]

Although the light emitting device 5 includes the LEDs 51a to 53b that emit red light, green light, and blue light in this example, the light is not limited to these wavelength bands, but it is sufficient that the light causes activation of the function of vegetables. According to purpose, it is also possible to add, for example, a light emitting element (LED or the like) that irradiates ultraviolet rays for increasing an amount of polyphenol.

[0072]

Further, it is also possible to add white light to the blue light by combining the blue LEDs 53a and 53b with a yellow phosphor. Thus, the vegetables can be irradiated with the white light together with the blue light, and visibility can be enhanced.

[0073]

As described above, according to the first embodiment of

the present invention, the light emitting device 5 arranged in the vegetable compartment 15 includes the LEDs 51a to 53b each having the emission optical axis Ax tilted downward with respect to the horizontal plane H, and emits light from the LEDs 51a to 53b toward the inside of the vegetable storage case 4. Thus, even low-height vegetables can be irradiated with sufficient light.

[0074]

Further, the light emitting device 5 is arranged above the center of the vegetable storage case 4 in the vertical direction and faces the back surface portion 41b of the vegetable storage case 4. Thus, an elongated leafy vegetable can be irradiated with light even when the leafy vegetable is placed leaning against the back surface portion 41b of the vegetable storage case 4, or even when the leafy vegetable is placed lying on the center of the bottom surface portion 41e of the vegetable storage case 4.

[0075]

Further, the vegetable storage case 4 includes the lower case 41 and the upper case 42 and is configured so that the light emitted from the light emitting device 5 is directed toward the lower case 41, and therefore leafy vegetables mainly stored in the lower case 41 can be efficiently irradiated with light.

[0076]

Further, since the angle between the emission optical axis Ax and the horizontal plane H is within a range of 5 degrees to 85 degrees (more desirably, 10 degrees to 45 degrees), the leafy vegetable that is better to be irradiated with light can be irradiated with light, and the potato that is better not to be irradiated with light can be prevented from being irradiated with light.

[0077]

Further, the light emitting device 5 includes the LED group 51 that emits red light, the LED group 52 that emits green light,

and the LED group 53 that emits blue light. After the LED groups 51 to 53 simultaneously emit light, the LED group 53 is first turned off. In this way, after the pores of the vegetables are opened by the irradiation with the blue light, the vegetables can be irradiated only with the light necessary for photosynthesis (the red light and the green light), and thus energy consumption can be reduced.

[0078]

SECOND EMBODIMENT

Next, a second embodiment of the present invention will be described. FIG. 12 is a diagram showing a structure of the vegetable compartment 15 and its surroundings in the second embodiment. In the second embodiment, the light emitting device 5 is swingable about a swing shaft 62 in the horizontal direction (more specifically, the left-right direction), so that the tilt of the emission optical axis Ax of the light emitting device 5 with respect to the horizontal plane H is changeable.

[0079]

Specifically, the light emitting device 5 is supported by a swing frame 61 that is swingable about the swing shaft 62. The swing frame 61 is swung by a motor 6 as a driving device. The motor 6 is, for example, a stepping motor. The motor 6 and the swing frame 61 constitute a movement mechanism for moving the light emitting device 5 (i.e., swinging the light emitting device 5 about the swing shaft 62).

[0080]

The structure of the light emitting device 5 is as described in the first embodiment. For example, when the light emitting device 5 has the structure shown in FIG. 5, a swingable structure can be obtained by attaching the cover member 54 (FIG. 5) of the light emitting device 5 to the swing frame 61.

[0081]

Further, in the second embodiment, a camera 7 as an imaging device is arranged on the back surface side of the vegetable

compartment 15. The camera 7 is arranged to take an image of the inside of the vegetable storage case 4 (here, the inside of the lower case 41).

[0082]

FIG. 13 is a block diagram showing a control system of a refrigerator according to the second embodiment. An operational input from the operation panel 21, a door opening/closing signal from the door opening/closing sensor 25, and image data from the camera 7 are input to the controller 20 of the refrigerator 1. The controller 20 controls the compressor 17, the cooler 18, the fan 19, the motor 6, and the light emitting device 5 (LEDs 51a to 53b) based on these inputs.

[0083]

In the second embodiment, the controller 20 processes the image data taken by the camera 7, and detects a position of the leafy vegetable by extracting, for example, a green image. Then, the controller 20 drives the motor 6 according to the detected position of the leafy vegetable to change the tilt of the emission optical axis Ax of the light emitting device 5 so that the leafy vegetable can be irradiated with light most efficiently.

[0084]

FIG. 14 is a schematic diagram showing an example of change in the tilt of the emission optical axis Ax of the light emitting device 5 in the second embodiment. As shown in FIG. 13(A), when the leafy vegetable 200 is located at a high position in the vegetable storage case 4, a tilt angle $\theta 1$ of the emission optical axis Ax of the light emitting device 5 with respect to the horizontal plane H is made smaller, so that the light is applied to a relatively high position in the vegetable storage case 4.

[0085]

In contrast, as shown in FIG. 13(B), when the leafy vegetable 200 is located at a low position in the vegetable storage case 4, a tilt angle $\theta 2$ of the emission optical axis Ax in the light emitting device 5 with respect to the horizontal

plane H is made larger, so that the light is applied to a relatively low position in the vegetable storage case 4. With this structure, the leafy vegetable 200 stored in the vegetable storage case 4 can be efficiently irradiated with the light.

[0086]

Although the position of the vegetable in the vegetable storage case 4 is detected based on the image taken by the camera 7 in this example, the position of the vegetable in the vegetable storage case 4 may be detected using other methods. For example, the user may input the position of the vegetable using the operation panel 21 (FIG. 1) or another input terminal. In this case, the internal space of the vegetable storage case 4 may be divided into a plurality of areas, and the user may select one from the areas. In such a case, the internal space of the vegetable storage case 4 may be divided into, for example, three (front, middle, and rear) spaces in the front-rear direction, two (right and left) spaces in the left-right direction, and two (upper and lower) spaces in the vertical direction.

[0087]

Further, although the tilt of the entire light emitting device 5 is changed in this example, it is also possible to change only a tilt of a specific LED group among the LED groups 51 to 53 described in the first embodiment. Alternatively, it is also possible to arrange light emitting devices 5 at a plurality of positions, and change the tilt of each light emitting device 5 depending on necessity of light irradiation (for example, the position of the leafy vegetable).

[0088]

As described above, in the second embodiment of the present invention, the tilt angle of the emission optical axis Ax of the light emitting device 5 with respect to the horizontal plane H is changed according to the position (height) of the vegetable in the vegetable storage case 4, and therefore the vegetable in the vegetable storage case 4 can be efficiently irradiated with

light according to a storage condition of the vegetable therein.
[0089]

Further, by determining the position of the vegetable in the vegetable storage case 4 based on the image taken by the camera 7, convenience for the user can be further enhanced.
[0090]

In the first and second embodiments described above, the light emitting device 5 has the LED groups 51, 52 and 53, each LED group including two LEDs, and controls light emission for each group (for each of the LED group 51, 52 and 53). However, it is also possible to provide one LED for each wavelength band, and control light emission for each LED (for each light emitting element). Further, the light emitting element is not limited to an LED, and other light emitting elements may be used.
[0091]

Further, in the above described first and second embodiments, the vegetable storage case 4 is divided into the lower case 41 and the upper case 42. However, the vegetable storage case 4 is not necessarily divided.
[0092]

Further, in the above described first and second embodiments, the entire vegetable storage case 4 (the lower case 41 and the upper case 42) may be made transparent. Alternatively, only a part of the vegetable storage case 4 through which the light from the light emitting device 5 passes may be made transparent. Alternatively, a part of the vegetable storage case 4 through which the light from the light emitting device 5 passes may be an opening.
[0093]

Although the desirable embodiments of the present invention have been specifically described, the present invention is not limited to the above described embodiments, and various modifications or changes may be made to the above described embodiments without departing from the scope of the

present invention.

DESCRIPTION OF REFERENCE CHARACTERS

[0094]

1 refrigerator; 4 vegetable storage case; 5 light emitting device; 6 motor (driving part); 7 camera (imaging device); 11 refrigerator compartment; 12 switching compartment; 13 ice-making compartment; 14 freezer compartment; 15 vegetable compartment; 16 housing; 17 compressor; 18 cooler; 19 fan; 20 controller; 21 operation panel (operation input part); 25 door opening/closing sensor; 41 lower case (lower case); 42 upper case (upper case); 51 LED group (first light emitting part); 51a, 51b LED (light emitting element); 52 LED group (second light emitting part); 52a, 52b LED (light emitting element); 53 LED group (third light emitting part); 53a, 53b LED (light emitting element); 54 cover member; 55 mounting board; 56 screw; 57 seal; 58 lead; 59 support substrate; 61 swing frame; 62 swinging shaft; 101, 102 and 103 microcomputer.

WHAT IS CLAIMED IS:

1. A refrigerator comprising:
a vegetable compartment;
a vegetable storage case provided in the vegetable compartment; and
a light emitting device provided in the vegetable compartment,
wherein the light emitting device has a light emitting part having an optical axis tilted downward with respect to a horizontal plane, and emits light from the light emitting part toward an inside of the vegetable storage case.
2. The refrigerator according to claim 1, wherein the light emitting device is arranged above a center of the vegetable storage case in a vertical direction.
3. The refrigerator according to claim 1 or 2, wherein the light emitting device is arranged to face a back surface of the vegetable storage case.
4. The refrigerator according to any one of claims 1 to 3, wherein the vegetable storage case has an upper case and a lower case, and
wherein the light emitting device is arranged so that the light emitted from the light emitting part is directed toward an inside of the lower case.
5. The refrigerator according to any one of claims 1 to 4, wherein an angle formed by the optical axis and the horizontal plane is in a range of 5 degrees to 85 degrees.
6. The refrigerator according to claim 5, wherein the angle formed by the optical axis and the horizontal plane is in a range

of 10 degrees to 45 degrees.

7. The refrigerator according to any one of claims 1 to 6, wherein the light emitting device has a plurality of light emitting parts to emit light having different wavelengths, and causes a light emitting part selected from the plurality of light emitting parts to emit light.

8. The refrigerator according to claim 7, wherein the plurality of light emitting parts is a plurality of light emitting elements or a plurality of groups of light emitting elements.

9. The refrigerator according to any one of claims 1 to 6, wherein the light emitting device has a first light emitting part to emit red light, a second light emitting part to emit green light, and a third light emitting part to emit blue light, and

wherein, after the first light emitting part, the second light emitting part, and the third light emitting part simultaneously emit light, the third light emitting part is first turned off.

10. The refrigerator according to any one of claims 1 to 9, wherein the light emitting device emits light during a daytime period, and the light emitting device is turned off during a nighttime period.

11. The refrigerator according to any one of claims 1 to 10, further comprising:

a movement mechanism to move the light emitting device so as to change a tilt of the optical axis with respect to the horizontal plane; and

a controller to control the movement mechanism according

to a position of a vegetable in the vegetable storage case.

12. The refrigerator according to claim 11, further comprising an imaging device to take an image of an inside of the vegetable storage case,

wherein the controller detects the position of the vegetable in the vegetable storage case based on the image taken by the imaging device.