

## Refrigerator

### Background of the Invention

The invention relates to a refrigerator having separate  
5 coolers respectively for fresh-food and freezer compartments  
and having a vegetable container in the fresh-food compartment.

Household refrigerators of large volume capacity, which  
have doors for respective storage chambers, are commercialized  
to cope with various user demands. In such a commercial  
10 environment, refrigerant circuit is constructed such that the  
fresh-food compartment including the fresh-food and vegetable  
chambers is cooled by a fresh-food cooler, evaporation  
temperature of which is set as relatively high, while the freezer  
compartment including the freezer and icemaker chambers and  
15 a temperature-switchable chamber is cooled by a freezer cooler,  
evaporation temperature of which is set as relatively low.  
Separate fans respective for the fresh-food and the freezer  
coolers are arranged. As a result, energy efficiency of cooling  
cycle is improved. Moreover, humidity in the fresh-food  
20 compartment is kept as high as to keep freshness of foods for  
a long period. In view of easiness of use, it has become a  
main stream to arrange the fresh-food chamber at top, which  
is most frequently used and has largest volume capacity, and  
the vegetable chamber at beneath of the fresh-food chamber,  
25 while the freezer chamber is arranged on bottom of the

refrigerator. In a proposed arrangement of the refrigerators,  
an icemaker chamber and a multi-stage temperature-switchable  
chamber, which have relatively small volume, are arranged  
between the vegetable chamber and the freezer chamber as to  
5 further increase easiness of use. Please see JP-2004-037042A  
(Japan's patent publication application No.2004-037042) for  
example. In a refrigerator shown in the JP-2001-037042A, one  
outlet port of the three-way valve is connected to the fresh-food  
cooler and the other outlet port of the three-way valve is  
10 connected to the freezer cooler; and controlling is made such  
that switching is made between fresh-food cooling operation  
and freezer cooling operation.

The vegetable chamber placed at bottom or at an  
intermediate height as in above is cooled and kept at a  
15 temperature same with or higher than that of the fresh-food  
chamber, at 4°C for example, and is kept preferably at humidity  
of 80-90% as to be fit for preservation of vegetables. Two  
fans, which are for blowing and circulating of air that is cooled  
respectively by the fresh-food and freezer coolers, are operated  
20 respectively during the fresh-food cooling operation and the  
freezer cooling operation. The fan for the fresh-food  
compartment is rotated even during the freezer cooling operation  
as to melt frost attached on the fresh-food cooler and to send  
cooled air that has a lot of moisture, into the fresh-food  
25 compartment. In this way, humidities in the fresh-food chamber

and the vegetable chamber are kept as high.

Some refrigerators have been arranged such that the vegetable chamber is placed within a single continuous chamber including the fresh-food chamber. In most of such  
5 refrigerators, a vegetable container in a drawer arrangement is placed on a shelf on bottom part of the fresh-food compartment; as shown in JP-1993(H05)-157429A (Japan's patent application publication No. H05-157429).

As for the refrigerator proposed by the JP-2001-037042A,  
10 inside of the vegetable chamber is not viewable unless a drawer door is opened, which is exclusively for the vegetable chamber and is attached to a vegetable container. Thus, some vegetables may easily be left away for an excessively long time. As for the refrigerator proposed by the JP-1993(H05)-157429A,  
15 enhanced closeness of the vegetable container leads to high humidity and dew formation within the container; and thus, a moisture permeable film is arranged as to control the humidity. When to open up the vegetable container, there are required two steps of procedures---opening the flapper door, and pulling  
20 out the vegetable container.

In otherwise, there have been commercialized refrigerators having an arrangement that: front opening of the vegetable container in a drawer arrangement is closed and then opened up; by switching a state of a cover lid as to introduce  
25 or shut out cooled air into or from the vegetable container.

In this way, either of cooling and curbing of drying is prioritized by selection of the state of the cover lid. Even in this arrangement, humidity in the fresh-food compartment is as low as about 55%. And, it has been difficult to achieve  
5 curbing both of the drying and the dew formation within the vegetable container.

In view of the above, it is aimed to facilitate taking in and out of the vegetables to and from the vegetable container and in same time to keep high humidity in the vegetable chamber  
10 as to curb drying of the vegetables and achieve long-time keeping of their freshness.

#### Brief Summary of the Invention

A refrigerator of the invention comprises: a fresh-food cooler (22) for fresh-food compartment (3) and a freezer cooler  
15 (23) for freezer compartment (5); a controller configured to alternately switch between fresh-food cooling operation and freezer cooling operation, that are respectively for directing flow of refrigerant to the fresh-food cooler (22) and to the freezer cooler (23), and to keep rotating a fan (24) for  
20 circulating of cooled air in the fresh-food compartment (3) even during the freezer cooling operation; and a vegetable container (11) that is arranged on bottom part of the fresh-food compartment (3) and has a front opening (15), which is kept as opened.

25 By the above, due to increase in humidity within the

fresh-food compartment, humidity in the vegetable container arranged in the fresh-food compartment is kept as high. In same time, it is able to cool vegetables in the vegetable container at a proper temperature as to achieve long-time  
5 preservation of the vegetable.

#### Brief Description of the Several Views of the Drawing

Fig. 1 is a vertical sectional view of a refrigerator of an embodiment of the invention;

Fig. 2 is a front view of the refrigerator of Fig. 1,  
10 showing a state at which a pair of flapper doors on the fresh-food compartment is opened;

Fig. 3 is a schematic perspective view of a vegetable chamber within the fresh-food compartment appeared on Fig. 1;

Fig. 4 is a schematic illustration of a refrigerant circuit  
15 of the refrigerator of Fig. 1;

Figs. 5(a)-5(d) are variations of and from the vegetable container in respect of its opening with respect to all-around faces of box shape defined by the vegetable container; and

Fig. 6 is a graph showing varying extent of moisture  
20 retention in dependence of the variations of the vegetable container shown in Figs. 5(a)-5(d).

#### Detailed Description of the Invention

In following, an embodiment of the invention will be explained in dependence upon the drawings. Fig. 1 shows a  
25 vertical sectional view of a refrigerator; and Fig. 2 shows

front view of the refrigerator at a state a pair of flapper doors on the fresh-food compartment is opened. Refrigerator body 1 shown in Figs. 1-2 is constructed such that; heat a heat-insulator casing 2 is formed of outer casing, inner casing  
5 and heat-insulator foam filled between the outer and inner casing; and inside of the heat-insulator casing 2 is partitioned by a heat-insulating partitioner wall 4, into a fresh-food compartment 3 on top side and a freezer compartment 5 on bottom side.

10 Front opening of the fresh-food compartment 3 is to be closed by a pair of flapper doors 6 in a French-door arrangement. The fresh-food compartment 3 is partitioned to: a fresh-food chamber 8 on top part, which is arranged with a plurality of shelves 7; a vegetable chamber 10 having a vegetable container  
15 11 in a drawer construction; and a chill chamber 13 on bottom, which is maintained in a temperature range of about  $0^{\circ}\text{C}$  to  $-3^{\circ}\text{C}$ ; by a partitioner plate 9 that is formed of a transparent resin and serves also as a shelf at bottom of the fresh-food chamber 3 and by a partitioner plate 12 that serves as bottom wall of  
20 the vegetable chamber 10.

The vegetable container 11 is shaped as shown in the perspective view of Fig. 3, and is a vessel formed of; a low-rise front wall 11a of small vertical dimension, a rear wall 11b, right-hand and left-hand side walls 11c and a bottom wall 11d,  
25 so as to be opened on upper side and at upper part of front

side. A retainer rail frame is attached on outer face of each of the right-hand and left-hand side walls 11c as to run in front-rear direction over whole front-rear dimension of the vegetable container; and a rail 14 is attached on a side wall  
5 of the inner casing of the heat-insulator casing 2. In this way, the vegetable container 11 is supported from the inner casing, by way of the retainer rail frames and the rails 14, in a manner as to be freely slidable in front-rear direction and be easily pulled out.

10       When the vegetable container 11 is pushed in to preset position in the fresh-food compartment 3, upper side of the vegetable container 11 is closed by the partitioner plate 9 on top of the vegetable chamber 10. A front opening 15 is formed in this state, at between a top fringe of the low-rise front  
15 wall 11a and a front fringe of the partitioner plate 9, which is in a front-rear position receded from that of the top fringe, and at between rearwardly inclined fringes on front parts of the side walls 11c. A small-item container 16 is provided at left-hand-side portion of the vegetable container 11; and the  
20 small-item container 16 is supported as hung, at only its left-hand-side end in a manner of cantilever, on a rail formed on inner face of left-hand side wall 11c, so as to be freely slidable in front-rear direction.

      In the freezer compartment 5, arranged are an icemaker  
25 chamber 17, which is equipped with automated icemaker mechanism,

and an auxiliary freezer chamber 18. These chambers are relatively small in volume and arranged just below the heat-insulating partitioner wall 4 on side-by-side arrangement with each other, and are constructed as drawers as to be pulled  
5 out along with their doors on front side. At below these chambers, the freezer compartment 5 makes a freezer chamber 19 that is also constructed in a drawer arrangement in same manner as the two chambers 17 and 18 on upper position and has upper and lower containers 20a and 20b as parts of the drawer arrangement.

10 On rear of the fresh-food and freezer compartments 3 and 5, arranged respectively are a fresh-food and freezer coolers 22 and 23 for respective compartments as well as fans 24 and 25 for the respective coolers 22 and 23. Air cooled by the coolers 22 and 23 is led to the compartments 3 and 5 respectively  
15 by fans 24 and 25, through respective ducts. The fresh-food and freezer coolers 22 and 23 are arranged in a refrigerant circuit 21 illustrated on Fig. 4, in which on outlet port of a compressor 27 that is arranged on bottom of the refrigerator body, a condenser 28 and a three-way valve 29 for switching  
20 flow of the refrigerant are serially connected in this sequence. On an outlet port of the three-way valve 29, a fresh-food capillary 30 and the fresh-food cooler 22 are serially connected in this sequence; and on another outlet port of the three-way valve 29, a freezer capillary 31 and the freezer cooler 23 are  
25 serially connected in this sequence. Outlet of the freezer

cooler 23 is connected with an inlet port of the compressor 27, and outlet of the fresh-food cooler 22 is connected with outlet of the freezer capillary 31 and inlet of the freezer cooler 22.

5           The three-way valve 29 switches flow of the refrigerant in accordance with signals from a controller, as to direct flow of the refrigerant alternately to the fresh-food cooler 22 and to the freezer cooler 23. During a fresh-food cooling operation, flow of the refrigerant is directed by the three-way valve 29,  
10 to the fresh-food cooler 22 so that the refrigerant is evaporated mostly within the fresh-food cooler 22. Air cooled with heat exchange is sent out by the fan 24, into the fresh-food compartment 3 as to cool the fresh-food and vegetable chambers 8 and 10 to their proper temperatures. The chill chamber 13  
15 is cooled to a temperature lower than those in other parts of the fresh-food compartment 3, by introducing air that has been circulated in the fresh-food compartment 3 and in same time by directly introducing a portion of air that has just been cooled by the fresh-food cooler 22. During a freezer cooling  
20 operation, the refrigerant is directly led into the freezer cooler 23, as to be evaporated at a relatively low temperature. Air cooled to not higher than  $-20^{\circ}\text{C}$  is sent out by the fan 25 to the freezer and the icemaker chambers 19 and 17 and so on, as to keep the chambers at respective preset temperatures.

25           The controller compares a temperature in the fresh-food

compartment 3, mainly with that in freezer chamber 19, and actuates the compressor 27 and the fans 24 and 25. The controller actuates the three-way valve 29 for switching between the fresh-food cooling operation and freezer cooling operation when  
5 a temperature in a chamber becomes as low as a preset temperature. For example, the switching is made when a temperature detected by a sensor in the fresh-food chamber 8 becomes as low as  $0^{\circ}\text{C}$  and when a temperature detected by a sensor in the freezer chamber 19 becomes as low as  $-20^{\circ}\text{C}$ . In otherwise, the switching is  
10 made when duration of the cooling operation becomes as long as a preset time length. For example, the switching is made when duration of the fresh-food cooling operation has reached 15-20 minutes and when duration of the freezer cooling operation has reached 30-40 minutes.

15 At during the freezer cooling operation, surface of the fresh-food cooler 22 has frost and a temperature of about  $-3^{\circ}\text{C}$  even though refrigerant does not flow through the fresh-food cooler 22. By rotating the fan 24 in this state, cooled air in the fresh-food chamber flows along the fresh-food cooler  
20 22 and thus melts the frost. Resultantly, cooled air having lot of moisture flows through the fresh-food chamber 8 and then into the vegetable chamber 10. In this way, inside of the vegetable chamber 10 may be cooled as low as about  $2^{\circ}\text{C}$ , and keeps an average temperature of  $4^{\circ}\text{C}$ . Due to inflow of moistened  
25 air, humidities in the fresh-food and vegetable chambers 8 and

10 become as high as about 80%. In addition, when vegetables are stored, due to vapors from those, humidity becomes as high as 90-95%.

The humidity in the vegetable chamber 10 as well as  
5 dissipation of vapors from vegetables in the chamber 10 are varied with varying of opening ratio of the vegetable container 11; that is, a ratio of an area of the front opening 15 of the container 11 to overall surrounding area including the front and/or upward openings and all the walls of the container 11.  
10 The inventors have focused attention to this, and made an experiment of varying in manners of providing the opening to the vegetable container as in Figs. 5(a)-5(d), in the above refrigerator having the two separate coolers 22 and 23 respectively for the fresh-food and freezer compartments 3 and  
15 5 and having a vegetable chamber 10 within the fresh-food compartment 3. Fig. 5(a) shows a vegetable shelf 7, in which the opening ratio is 81%; Fig. 5(b) shows a vegetable container 11 that is provided with a ceiling wall as the partitioner plate 9 and has an opening for exposing whole of the front side of  
20 a box shape, and has the opening ratio of 15.9%; Fig. 5(c) shows a vegetable container 11 having a front opening 15 smaller than that of Fig. 5(b) and has the opening ratio of 12.6%; and Fig. 5(d) shows a vegetable container that is almost fully closed and has the opening ratio of 0.5%. By use of each of the vegetable  
25 containers of Figs. 5(a)-5(d), 5kg of vegetables were stored

in the vegetable chamber of the refrigerator in a state not wrapped up nor covered, for seven days; and an evaporation ratio as a ratio of weight decrease of the vegetables to its original weight was measured. Additionally, an extent of dew formation  
5 within the vegetable container 11 was measured. As a result of the experiment, the evaporation ratios was 6.7% for the container of Fig. 5(a), was 5.7% for that of Fig. 5(b), was 5.6% for that of Fig. 5(c) and was 0.6% for that of Fig. 5(d).

Fig. 6 is a graph showing a relationship between shaping  
10 of the vegetable container and the evaporation ratios obtained as above. The container of the Fig. 5(d) is the optimum in respect of appearance of the vegetables after the 7-day storage and no withering is observed; however, the container of the Fig. 5(d) is not adoptable because abundant dew formation in  
15 the vegetable container causes developing of bacteria and fungi in portions of dew drops as well as deterioration in appearances. The experiment revealed that the vegetables having been lost 10% or more their moisture are remarkably withered and not good to be eaten. The experiment also revealed that, when the  
20 evaporation ratio is about 6%, the vegetables are obviously good to be eaten in view of apparent freshness. Based on these results, it was concluded that the opening ratio of 35% or less is enough for long-time preservation of the vegetables because the evaporation ratio after one-week preservation was as low  
25 as 6% or less.

In other words, it is able to keep high humidity within the vegetable container 11 and suppress evaporation as to keep freshness of the vegetables for a long preservation period by that: switching is made between the fresh-food cooling and freezer cooling operations as to cool the fresh-food and freezer compartments, the fan 24 for circulating of cooled air in the fresh food compartment 3 is controlled to be rotated even during the freezer cooling operation; and the opening ratio of the vegetable container 11, which is an areal ratio of the front opening to total of all-around contour faces of an imaginary rectangular box defined by the vegetable container 11 and a partitioner plate 9, is set in a preset range. When the opening ratio is kept at 35% or less, the evaporation ratio of the vegetables is kept as low as 6% or less. When the opening ratio is kept at 10% or more, dew formation would not occur. Thus, proper range of the opening ratio is 10-35%, which enables good preservation freshness with no withering.

The vegetable container 11 of the embodiment, which has a widely-opened front opening 15, improves easiness to use the vegetable chamber; because, only after opening a pair of the flapper doors 6 for the fresh-food compartment 3, the vegetables are ready to be taken out and in, by reaching a hand through the front opening 15; and then the vegetable container 11 is pulled out if needed. Thus, the taken in and out of the vegetables are facilitated in a manner same as the taken in

and out of the foods on the shelves 7 in the fresh-food chamber  
8.

A lamp 32 is provided on a ceiling of the fresh-food  
compartment 3. Illumination from the lamp 32 and visibility  
5 is not enough for inside of the vegetable chamber 10 because,  
in the embodiment, the vegetables and chill chambers 10 and  
13 are arranged at beneath of the shelves 7 and partitioner  
wall 9 in the fresh-food compartment 3. Thus, as shown in Fig.  
3, an illumination lamp 33 formed of high-luminance LED or the  
10 like is arranged on rear-face wall of the vegetable chamber  
10 as to illuminate inside of the vegetable container 11. In  
an occasion of absence of the illumination lamp 33, enough  
attention on the vegetable chamber 10 would not be made because  
opening of the flapper doors 6 will show up whole parts in the  
15 fresh-food compartment 3; in view of the average height of the  
eye from the floor for typical and frequent women user of the  
refrigerator in Japan is about 144cm, which is higher not only  
than the vegetable chamber 11 but than most parts in the  
fresh-food compartment 3. By presence of the illumination lamp  
20 33, there are achieved enough attention on the vegetable chamber  
10 and sufficient visibility of the vegetables. Thus, managing  
of freshness of the vegetables may be made on basis of visual  
appearance as to curb erroneous leaving away of some of the  
vegetables for an excessively long time.

25 If the illumination lamp 33 is arranged at a height of

77-120cm from the floor, the vegetable chamber 10 is illuminated directly by the illumination lamp 33 and indirectly by a light transmitting through the partitioner plate 9. Thus, the attention is automatically focused on inside of the vegetable chamber 10 and visually obtainable information from the vegetables in the chamber will be increased as to facilitate the managing of freshness of the vegetables. Position of the illumination lamp 33 is not necessarily be on the rear-face wall of the fresh-food chamber and may be on right-hand and left-hand side walls or on front portion of the partitioner plate 9. The refrigerant circuit of the refrigerator is not necessarily be that shown in Fig. 4 as in the embodiment and may be one in which the fresh-food cooler 22 and the freezer cooler 23 are in a parallel arrangement, as needless to mention.

## Claims

1. A refrigerator (1) comprising: a fresh-food cooler (22) for fresh-food compartment (3) and a freezer cooler (23) for freezer compartment (5); a controller configured to  
5 alternately switch between fresh-food cooling operation and freezer cooling operation, that are respectively for directing flow of refrigerant to the fresh-food cooler (22) and to the freezer cooler (23), and to keep rotating a fan (24) for circulating of cooled air in the fresh-food compartment (3)  
10 even during the freezer cooling operation; and a vegetable container (11) that is arranged on bottom part of the fresh-food compartment (3) and has a front opening (15), which is kept as opened.

15 2. A refrigerator according to claim 1, wherein all-around contour faces of a box figure are assumed as defined by the vegetable container (11) and a partitioner plate (9); and then, an opening ratio that is an areal ratio of the front opening (15) to total of said all-around contour faces is in a range  
20 of 10-35%.

3. A refrigerator according to claim 1 or 2, wherein the front opening (15) is defined by an upper and bottom fringes and by right-hand and left-hand side fringes that are inclined so that  
25 the upper fringe is rearwardly positioned than the bottom fringe.