

### Question-1

a)

The height of red-black tree  $\leq 2\log_2(n+1)$  This means maximum height of red black tree is  $2\log_2(n+1)$

b)

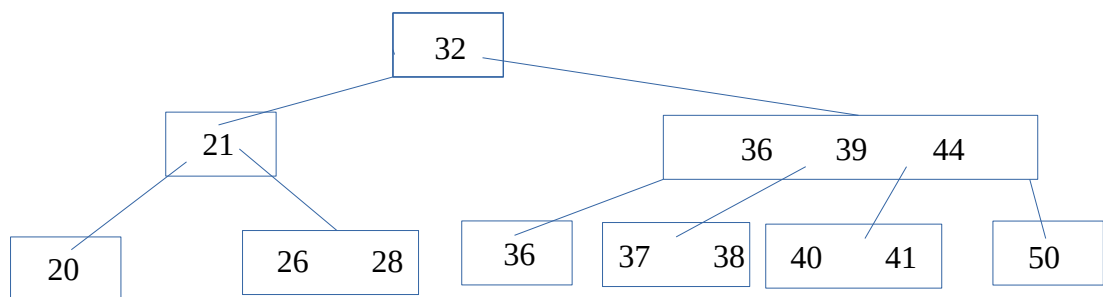
AVL Tree has more space complexity since It stores balance factor for each node. It takes  $O(N)$  extra space.

c)

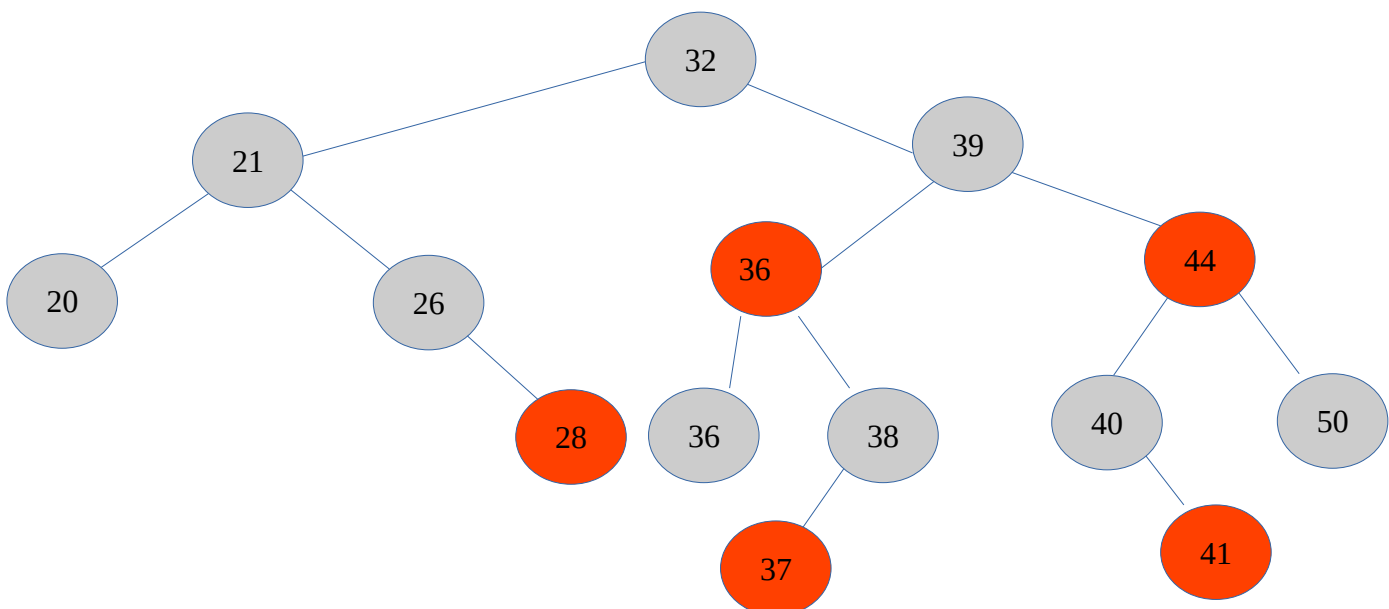
The criteria is whether there is unvisited vertices or not. If there are unvisited vertices, the algorithm is going on until there is no unvisited vertices.

### Question-2

a)



b)



c)

Step	V	vertexSet	V1	V2	V3	V4	V5
1	--	V5	3	inf	inf	inf	0
2	V1	V5, V1	3	4	inf	4	0
3	V2	V5, V1,V2	3	4	7	4	0
4	V4	V5, V1,V2,V4	3	4	6	4	0
5	V3	V5, V1,V2,V4,V3	3	4	6	4	0

When go to V3 from V5, We can go with 6 weight. The Path is  $V5 \rightarrow V1 \rightarrow V4 \rightarrow V3$

d)

From Arad to Bucherest using Breadth First Search:

Arad, Zerid, Timisora, Sibiu,Aradea,Lugoj,Rimnicu Vilcea,Fagaras,Mehadia,Petesti,Craiova, Bucharest.

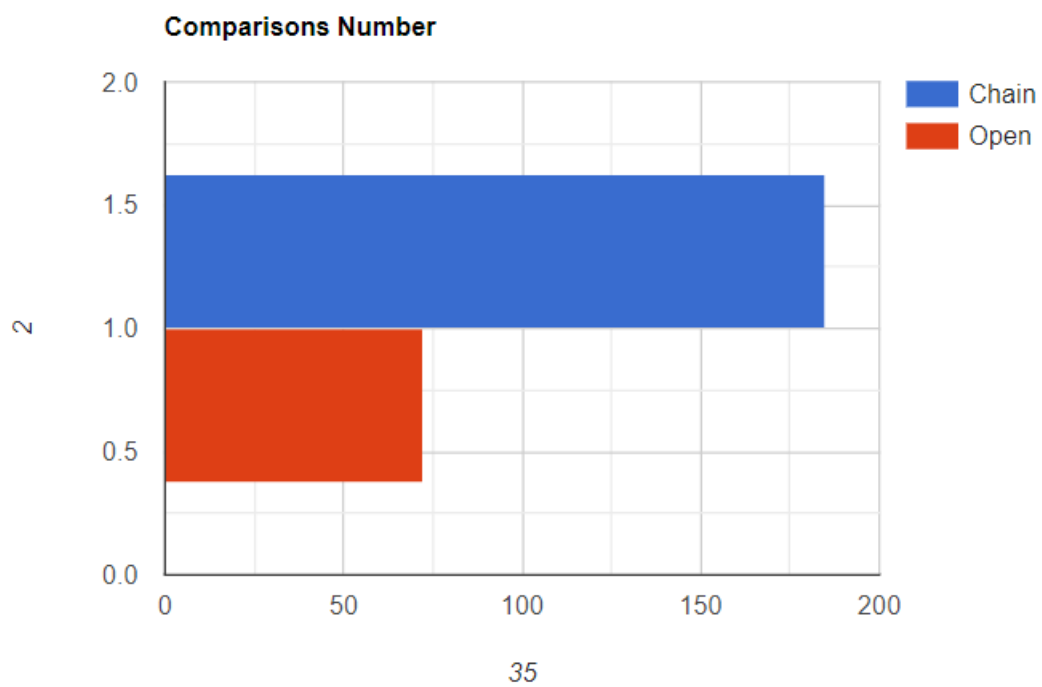
Lenght of Road =  $140 + 99 + 211 = 450$  ( Arad  $\rightarrow$  Sibui  $\rightarrow$  Faragas  $\rightarrow$  Bucharest )

### Question 3

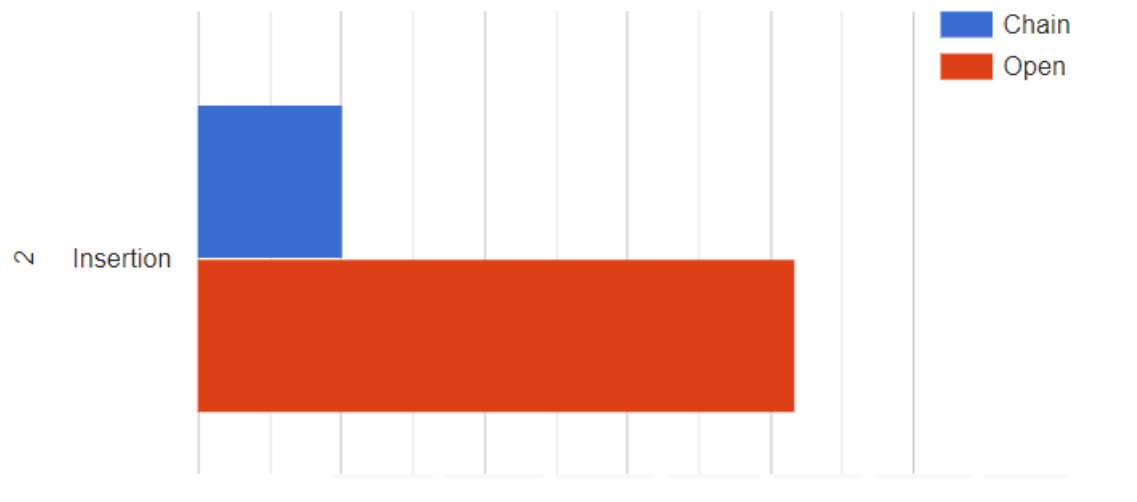
When creating Hash function, firstly the input and key value is carried. Both input and key value is string; thus ASCII representation can be used for calculation of key value. When calculation key value as integer, string is tranformed into integer with their ASCII representation leter by leter.

To create open addressing hash table, 151 is chosen as size of array because it is a prime number. The second reason to choose 151 is in the items.txt there are 150 items and the size of array must be greater than it.When calculating location of input into array, this formula is using :  $h(x) = x + i^2$  where  $i=1,2,3..$  In this way the risk of collision and number of collusion is decreasing.

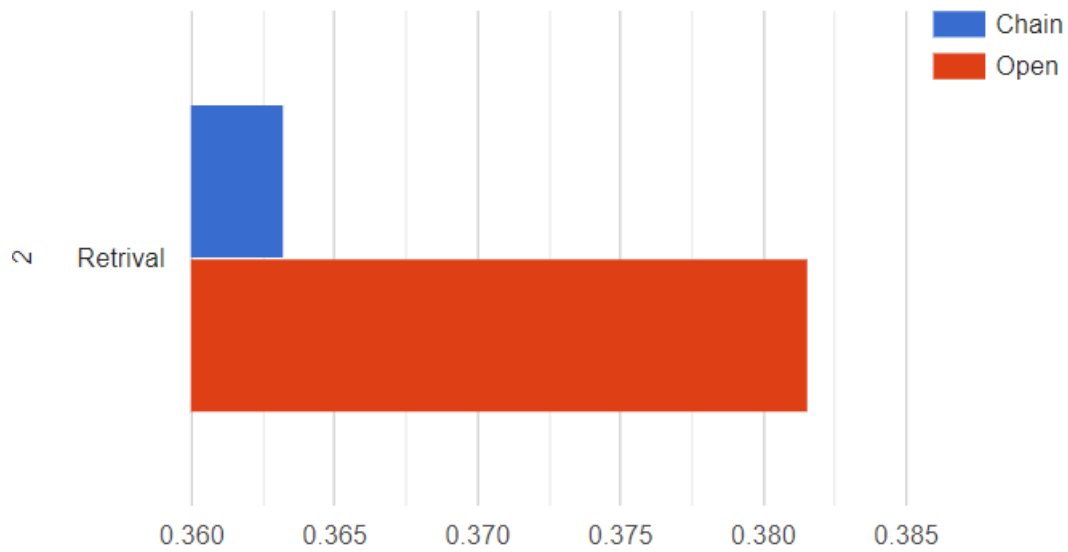
To create Chain Hash Table, less than 151 is approprite for size of array since every element of array is also linked list. Therefore every element can storege more than one item. But for storing a lot of element I choose again 151.



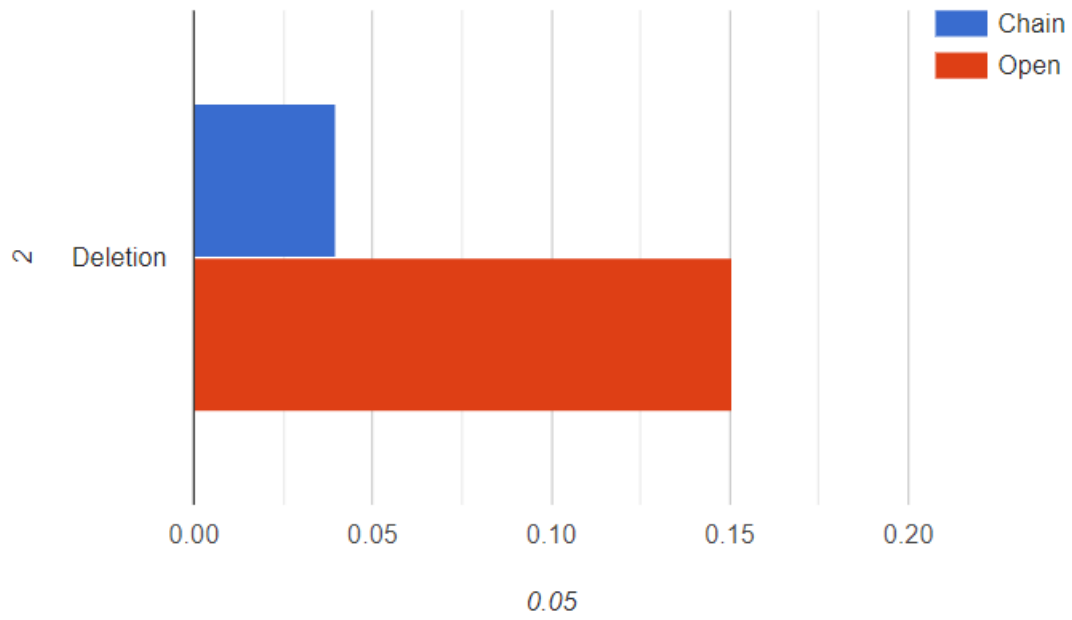
Required Time For Operation of Hash Table



Required Time For Operation of Hash Table



Required Time For Operation of Hash Table



This part is not seen in the dijkstra.

Most Part is seen in The Dijkstra but The first some part may be not seen and my some friend could't see thir part because of that I put some part.

```
OpenHashTable
0 : tomatoes cherry = 3146,
1 : chile dry california = 3188,
2 : plums red = 4041,
3 : lettuce = 4061,
4 : lemons yellow = 4053,
5 : banana = 4011,
6 : beans black = 3176,
7 : beans haba fresh = 4528,
8 : turnips = 4813,
9 : chile yellow = 4680,
10 : jicama = 4626,
11 : carrots = 4562,
12 : nectarines = 4036,
13 : parsley = 4899,
14 : epazote = 4909,
15 : onions green = 4068,
16 : squash acorn = 4750,
17 : squash spaghetti = 4776,
18 : squash yellow = 4784,
19 : orange navel = 4012,
20 : piloncillo = 4873,
21 : chile de arbol fresco = 4822,
22 : chile habanero = 3125,
23 : duritos = 4874,
24 : grapefruit = 4282,
25 : beans green = 4066,
26 : garlic = 4608,
27 : green turnip = 4619,
28 : bok choy = 4545,
29 : tomatillo = 4801,
30 : bean sprouts = 4536,
31 : lettuce romaine = 4640,
32 : onions white = 4663,
33 : alfalfa sprouts = 4514,
34 : beets bunch = 4539,
35 : guajes = 4821,
36 : lettuce red leaf = 4075,
37 : squash butternut = 4759,
38 : onions brown = 4093,
39 : watercress = 4815,
40 : celery = 4583,
41 : papaya = 4395,
42 : tangerine honey = 4453,
43 : tomatoes reg = 4063,
44 : strawberry basket = 4028,
45 : plums black = 4039,
46 : beans garbanzo = 3174,
47 : cabbage green = 4069,
48 : potato white = 4083,
49 : tuna = 4471,
50 : beans pinto = 3172,
51 : nuts peanuts = 4931,
52 : beets loose = 4540,
53 : cabbage Napa = 4556,
54 : limes mex key = 4305,
55 : tejocote = 4472,
56 : pineapple = 4430,
57 : radish red bunch = 4089,
58 : beans black eye = 3196,
59 : chile jalapeto = 4693,
60 : nuts pistachios = 4939,
61 : apple gala = 4133,
62 : asparagus = 4525,
63 : ginger root = 4612,
64 : chile anaheim = 4696,
```

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59 : chile jalapeto = 4693,
60 : nuts pistachios = 4939,
61 : apple gala = 4133,
62 : asparagus = 4525,
63 : ginger root = 4612,
64 : chile anaheim = 4696,
65 : grapes red seedless = 4023,
66 : limes sweet = 4306,
67 : nuts pecans = 4936,
68 : green kale = 4627,
69 : tangerine mineola = 4055,
70 : basil = 4885,
71 : peaches yellow = 4038,
72 : squash kabocha = 4769,
73 : nuts walnuts = 4943,
74 : tangerine clementine = 4450,
75 : onions boiling = 4658,
76 : squash chayote = 4827,
77 : corn yellow = 4078,
78 : camote de cerro = 4820,
79 : leeks = 4629,
80 : melon honeydew = 4034,
81 : black berries = 4239,
82 : yucca = 4819,
83 : chile pasilla = 4701,
84 : mamey = 4310,
85 : chile dry arbol = 3185,
86 : apple fuji = 4131,
87 : bell pepper red = 4088,
89 : limes = 4048,
90 : avocado large hass = 4225,
91 : broccoli = 4060,
92 : pear anjou = 4416,
93 : mango = 4051,
94 : avocado small = 4227,
95 : chile dry japanese = 3181,
96 : eggplant = 4081,
97 : chile hungaro = 4692,
98 : lettuce green leaf = 4076,
99 : brussel sprouts = 4550,
100 : cucumber = 4062,
101 : tomatoes roma = 3145,
102 : nuts brazil = 4926,
103 : chile serrano = 4709,
104 : banana macho = 4235,
105 : corn white = 4077,
106 : green collard = 4614,
107 : beans peruano = 3170,
108 : beans haba dry = 3175,
109 : beans lentils = 3173,
110 : chile dry guajillo = 3186,
111 : squash mexican = 4786,
112 : guasanas = 3189,
113 : beans red = 3177,
114 : apricots = 4218,
115 : guayabas = 4299,
116 : persimmon = 4427,
117 : malanga = 4644,
118 : pear bartlett = 4409,
119 : onions red = 4082,
120 : potato red = 4073,
121 : cilantro = 4889,
122 : jamaica = 4870,
123 : pomegranate = 4445,
124 : cauliflower = 4079,
125 : pear bosc = 4026,
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108 : beans haba dry = 3175,
109 : beans lentils = 3173,
110 : chile dry guajillo = 3186,
111 : squash mexican = 4786,
112 : guasanas = 3189,
113 : beans red = 3177,
114 : apricots = 4218,
115 : guayabas = 4299,
116 : persimmon = 4427,
117 : malanga = 4644,
118 : pear bartlett = 4409,
119 : onions red = 4082,
120 : potato red = 4073,
121 : cilantro = 4889,
122 : jamaica = 4870,
123 : pomegranate = 4445,
124 : cauliflower = 4079,
125 : pear bosc = 4026,
126 : watermelon reg = 4031,
127 : yams medium = 4818,
129 : melon cantaloupe = 4050,
130 : cucumber persian = 4593,
131 : spinach = 4090,
132 : coconut white = 4260,
133 : mushroom pack = 4646,
134 : cabbage red = 4554,
135 : nectarines white = 4188,
136 : watermelon seedless = 4032,
137 : apple granny smith = 4017,
138 : banana burro = 4229,
139 : grapes globe = 4273,
140 : potato russet loose = 4072,
141 : yams jumbo = 4817,
142 : mint = 4896,
143 : banana leaf = 4234,
144 : cherries red = 4045,
145 : mushroom bulk = 4645,
146 : grapes green = 4022,
147 : oregano = 4897,
148 : chile dry pasilla = 3184,
149 : banana baby = 4232,
150 : bell pepper green = 4065,
*****
Favorite 3 fruits:
Name: banana macho Available: 4235
Name: chile habanero Available: 3125
Name: cucumber persian Available: 4593
*****
```

ChainHashTable

```
1: squash spaghetti = 4776 , chile dry california = 3188 ,
2: squash yellow = 4784 , plums red = 4041 ,
3: lettuce = 4061 ,
5: epazote = 4909 , beans black = 3176 , banana = 4011 ,
7: beans haba fresh = 4528 ,
9: jicama = 4626 , chile yellow = 4680 ,
11: watermelon seedless = 4032 , nectarines = 4036 , carrots = 4562 ,
13: parsley = 4899 ,
15: onions green = 4068 ,
16: squash acorn = 4750 ,
18: tomatoes reg = 4063 ,
20: piconcillo = 4873 ,
21: chile de arbol fresco = 4822 ,
22: garlic = 4608 , chile habanero = 3125 ,
23: duritos = 4874 ,
24: grapefruit = 4282 ,
25: beans green = 4066 ,
26: tangerine honey = 4453 ,
27: lettuce romaine = 4640 , green turnip = 4619 ,
28: bok choy = 4545 ,
30: bean sprouts = 4536 ,
31: onions white = 4663 ,
32: radish red bunch = 4089 , potato white = 4083 , papaya = 4395 ,
33: alfalfa sprouts = 4514 ,
34: watercress = 4815 , turnips = 4813 , beets bunch = 4539 ,
35: lettuce red leaf = 4075 , guajes = 4821 ,
37: squash butternut = 4759 ,
38: onions brown = 4093 ,
40: celery = 4583 ,
45: plums black = 4039 ,
46: cabbage green = 4069 , beans garbanzo = 3174 ,
47: squash kabocha = 4769 ,
50: nuts peanuts = 4931 , beans pinto = 3172 ,
51: tomatoes cherry = 3146 ,
52: pineapple = 4430 , cabbage Napa = 4556 , beets loose = 4540 ,
53: limes mex key = 4305 ,
58: yams medium = 4818 , chile jalapeno = 4693 , beans black eye = 3196 ,
59: nuts pistachios = 4939 ,
61: asparagus = 4525 , apple gala = 4133 ,
63: ginger root = 4612 ,
64: nuts walnuts = 4943 , chile anaheim = 4696 ,
65: limes sweet = 4306 , grapes red seedless = 4023 ,
67: nuts pecans = 4936 ,
68: green kale = 4627 ,
69: tangerine mineola = 4055 ,
70: peaches yellow = 4038 , basil = 4885 ,
75: tomatillo = 4801 , squash mexican = 4786 , onions boiling = 4658 ,
77: watermelon reg = 4031 , nuts brazil = 4926 , mango = 4051 , corn yellow = 4078 ,
78: camote de cerro = 4820 ,
79: melon honeydew = 4034 , leeks = 4629 ,
80: yucca = 4819 , persimmon = 4427 ,
81: black berries = 4239 ,
83: squash chayote = 4827 , chile pasilla = 4701 ,
84: mamey = 4310 ,
85: limes = 4048 , chile dry arbol = 3185 ,
86: tangerine clementine = 4450 , apple fuji = 4131 ,
87: bell pepper red = 4088 ,
90: guayabas = 4299 , green collard = 4614 , brussel sprouts = 4550 , broccoli = 4060 , avocado large hass = 4225 ,
91: pear anjou = 4416 ,
94: chile dry japanese = 3181 , avocado small = 4227 ,
95: eggplant = 4081 ,
96: guasanas = 3189 ,
97: chile hungaro = 4692 ,
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78: camote de cerro = 4820 ,
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117: malanga = 4644 ,
124: pear bosc = 4026 , cauliflower = 4079 ,
129: mushroom pack = 4646 , melon cantaloupe = 4050 ,
130: cucumber persian = 4593 ,
131: tomatoes roma = 3145 ,
132: coconut white = 4260 ,
134: cabbage red = 4554 ,
135: nectarines white = 4188 ,
137: apple granny smith = 4017 ,
138: tuna = 4471 , spinach = 4090 , mint = 4896 , grapes globe = 4273 , banana burro = 4229 ,
139: potato russet loose = 4072 ,
143: oregano = 4897 , cherries red = 4045 , banana leaf = 4234 ,
144: mushroom bulk = 4645 ,
145: orange navel = 4012 ,
146: lemons yellow = 4053 , grapes green = 4022 ,
148: chile dry pasilla = 3184 ,
149: banana baby = 4232 ,
150: bell pepper green = 4065 ,
*****_
Name: banana macho      Available Quantity: 4235
Name: chile habanero    Available Quantity: 3125
Name: cucumber persian  Available Quantity: 4593
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26: tangerine honey = 4453 ,  
27: lettuce romaine = 4640 , green turnip = 4619 ,  
28: bok choy = 4545 ,  
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69: tangerine mineola = 4055 ,  
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75: tomatillo = 4801 , squash mexican = 4786 , onions boiling = 4658 ,  
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79: melon honeydew = 4034 , leeks = 4629 ,  
80: yucca = 4819 , persimmon = 4427 ,  
81: black berries = 4239 ,  
83: squash chayote = 4827 , chile pasilla = 4701 ,  
84: mamey = 4310 ,  
85: limes = 4048 , chile dry arbol = 3185 ,  
86: tangerine clementine = 4450 , apple fuji = 4131 ,  
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94: chile dry japanese = 3181 , avocado small = 4227 ,  
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96: guasanas = 3189 ,  
97: chile hungaro = 4692 ,  
98: lettuce green leaf = 4076 ,  
99: cucumber = 4062 ,  
103: onions red = 4082 , chile serrano = 4709 ,  
104: potato red = 4073 , banana macho = 4235 ,  
105: cilantro = 4889 , corn white = 4077 ,  
106: tejocote = 4472 , jamaica = 4870 ,  
107: beans peruano = 3170 ,  
108: beans lentils = 3173 , beans haba dry = 3175 ,  
109: yams jumbo = 4817 ,  
110: chile dry guajillo = 3186 ,  
113: beans red = 3177 ,  
114: strawberry basket = 4028 , pomegranate = 4445 , pear bartlett = 4409 , apricots = 4218 ,  
117: malanga = 4644 ,  
124: pear bosc = 4026 , cauliflower = 4079 ,  
129: mushroom pack = 4646 , melon cantaloupe = 4050 ,  
130: cucumber persian = 4593 ,  
131: tomatoes roma = 3145 ,  
132: coconut white = 4260 ,

63: ginger root = 4612 ,  
64: nuts walnuts = 4943 , chile anaheim = 4696 ,  
65: limes sweet = 4306 , grapes red seedless = 4023 ,  
67: nuts pecans = 4936 ,  
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130: cucumber persian = 4593 ,  
131: tomatoes roma = 3145 ,  
132: coconut white = 4260 ,  
134: cabbage red = 4554 ,  
135: nectarines white = 4188 ,  
137: apple granny smith = 4017 ,  
138: tuna = 4471 , spinach = 4090 , mint = 4896 , grapes globe = 4273 , banana burro = 4229 ,  
139: potato russet loose = 4072 ,  
143: oregano = 4897 , cherries red = 4045 , banana leaf = 4234 ,  
144: mushroom bulk = 4645 ,  
145: orange navel = 4012 ,  
146: lemons yellow = 4053 , grapes green = 4022 ,  
148: chile dry pasilla = 3184 ,  
149: banana baby = 4232 ,  
150: bell pepper green = 4065 ,