

Freezing of fruits and vegetables

An agribusiness alternative
for rural and semi-rural areas

by

Gustavo V. Barbosa-Cánovas

Washington State University

Pullman, Washington, United States of America

Bilge Altunakar

Washington State University

Pullman, Washington, United States of America

Danilo J. Mejía-Lorío

Food and Agriculture Organization of the United Nations

Rome, Italy

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

ISBN 92-5-105295-6

All rights reserved. Reproduction and dissemination of material in this information product for educational or other non-commercial purposes are authorized without any prior written permission from the copyright holders provided the source is fully acknowledged. Reproduction of material in this information product for resale or other commercial purposes is prohibited without written permission of the copyright holders. Applications for such permission should be addressed to the Chief, Publishing Management Service, Information Division, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy or by e-mail to copyright@fao.org

© 2005

• , - • , -

F g l a a l a a . S l a
g w w a w a a a . F l a
a a , w a a a g a a a . F l a
a a g a l a , a a g l a l g a l a a
a l a a a a a a a a a a a a a
a l a a a a a a a a a a a a a a a
w A a a a a a - g a a a g w a l a l a a
a a a a a a w a . F a g a l a a a a a a a

IV $F = a^2 + ab : a^2 - b^2 = a^2 + ab$

$\frac{a^2 + ab}{a^2 - b^2} = \frac{a^2 + ab}{a(a-b)} = \frac{a^2 + ab}{a^2 - ab}$

$\frac{a^2 + ab}{a^2 - ab} = \frac{a(a+b)}{a(a-b)} = \frac{a+b}{a-b}$

H-F-

IIR

I c

I F

L^I

L ca fr ra -

a r c d F d

r a r r f

c a

da

r fr a

r ra

r ar ac a

c fr

S c dar ac a

H I a a I a a g a
I a a a w a a
a a g a g a , a g a a ,

I I a a I .

L I g

F g a I a a a a a w
F I a a g w g a
a a a I w g a .
a a a a a a a a
a a a a a a a a
a a a a a a a a
() w a w a a a
g w g .

I a a a a a a a a
a a a a a a a a
w a a a w a a w .
A a a a a w a a
w g ; la a a l
l g a l a a a a a .

a w a g g a .
a a a a a a a a
A a a a g w a a w
A a a a a a a a
F g a a I a a a a l
a a a a .
A a a a g g I a I a a g .

S a c fr r

M l g w l
a l g a a a
w a w a a a
g a g a a a l a

<i>a</i>	33
<i>æ</i>	- e - a d /	34
<i>ɛ</i>	a e /	34
<i>ɑ</i>	a e /	36
 - a r F r a a d r c f c d fr f d r		
2.1 S	gla a a l	37
2.2 S	gla a a l gla	38
2.3 S	la a a l gla	41
	2.3.1 L a	41
	2.3.2 G a a a	41
 - a r Ra a r a a d r r d		
3.1 I g l a a a	43	
3.2 F g l a a	43	
3.3 P g l a a	44	
3.4 F a g l a	44	
 - a r R c a da f r f a r d c a		
4.1 S	a	45
4.1.1 P	a a	45
4.1.2 C	a a	46
4.2 H	g l a l a a a : gla a l a l	47
4.3 N	a a : gla	48

Ca 1

ee

F g l a l w l l l a w
 a w a a a , a l a a l a a
 l . g a a a a a a a a a
 a a a w g a a g w , a a a a a l ,
 a l a a a a a a l a l (D gal a l S, 2000).

1.1 e e ee s e se e

F g a a a a a ag a l g ag
 l . A a l g - a a a l g a , g
 g a g a l a a g a l l a w
 a a a l (F a , 1977). a a a l
 a a a a a a w g a w a a a a l ,
 g l a a g a a a l a a a a a a l ,
 l a a a l a w l a .

T d f r fr a d fr ra

F g a l g a l l l g - a a a l ,
 l g a g a -18 C w (F a , 1973). a a a
 l a a a g l w g l g w g
 a a a a a l a l g w g a a l w
 w a a a g a a a a a l (G g , 1993).

C g w w g a g l , l a g
 a a a a a l g a l g g ag
 (A , 1993). a l g , a l l a ,
 g l g g . A a a l
 a a a a a l g a , l g l l a a a g ,
 g w g a a w g g
 a l a g . H w w a a a l , g a a a a
 w (w) a a a a l l a (H a l K a , 1975).

— rr a f fr f d d r S a d r c r
I a a a a a a a a a a a a a
W a I a a a a a a a a a a a a
a E a a a a a a a a a a a a
a a a a a a a a a a a a a a
a S a a a a a a a a a a a a
\$ 75 \$ 27.3 \$.
a a (AFFI, 2003). I E , a a
11.1 13 \$ a 2000
(Q F F I a a , 2000). a 1 a a a a
2001.
a a a a a a a a a a a a

Ad a a f fr c d c r
D a a a a a a a a a a a a
g a . \$ a a a a a a a a a
7 \$. 01.

F *a* *b* *a* *d* *a* *b* *a* *a* *b* *a* *a* *a* *a* *a*

a *a* *a* *w* *a* *w* *w* *w* *a* *a* *w* *w* *w* *w* *a* *a* *a* *a* *a*

a a a a l a l a a a - a l a a a .
 a . B l , a l ag wa , a ag l a
 g a a l a a a a a a a a w g a l a a a
 a a l g a a a a a a .
 a l ag a a a w a a a .
 a g l a l a a a a a a .

ar ar f fr fr a d a
 l a l , a l g a a a a a a g a l a
 l g a g l a (A , 1993).
 l a l a a a a a a a a a 1869
 a l a l a a g l a a a l a a .
 a a g a a a a a a a a a a w
 a a g a a a a a a a a a a a 1929.

g a l g w a l
 a g a l g a 1940 . O a a a a
 g a l g a l , l g a g a a g a a
 a a a a a , a l a a a l g a
 l , g a a a a g a
 w l - l a g (l g a) A a , D a , F a l ,
 Fa , G a , Ia , N a l , N w a w l w a l , K a l . A .
 l g a a S a a S 2001 w a S 3.

C a a a a a l a g a a .
 a a a g a a a l g a a a a a a
 a 1905 (D a l , 1977). a a l a a g l S .
 a a a l a l a l a g l a a a
 All a , a a a a l a a a a a a
 a l w . A , g a a a a a a -
 g l a l a , a a a a a a a w
 , , , , I a a , a a a g a a a
 a a a a a a .

F r r d f r p c

W a l g a l a l a l a l , S a g
a a a a a a a a a a a a a
g . g w w a a a a a a a a a
a l g a a . G w a , a , a , a
l , a g a a l a l a l g a a a
g l a a a a a w a a a g
g (E a a l , 1977).

P a g w a l a g l a l a l a g a l a l a l
a a l a l a l a l a g - a a a a a a a ,
a a a a a a a a a a a a a a a a a a
g a a a a a a a a a a a a a a a a a
l . I a l l l l g a a a a a a a a a a
g a a a a a a a a a a a a a a a a a
l . A a , l g g a a a a a a a a a a a
a a a a a a a a a a a a a a a a a

|a a a a g| a | a a | a a | a a | a a |
| a a a a | a a | a a | a a | a a | a a |
a a a a | a a | a a | a a | a a | a a |
g w g a | g a | g a | g a | g a | g a |
a a a a | a a | a a | a a | a a | a a |
| a a w a | a w a | a w a | g w | (D a |
| w w | w w | g w | | (D a |
, 1977).

1.2 e e e e - s e ee - , e ss

F g a w | a | a | a | a | a | a a | a a | a a |
a a a a | a a | a a | a a | a a | a a | a a |
a a a a | a a | a a | a a | a a | a a | a a |
g w g w | g w | g w | g w | g w | g w | g w |
a a a a | a a | a a | a a | a a | a a | a a |
, a a w a g a

Wa a l l a a a a l l a a a l - a a l
a l g a l a .
l g l g a 1928 w l -
a a a g a l Ca B l A
g a l , l a a , a a a
W a g l - a a a a l a g l
W W a a a l g a g .
Wa a g l a a l a a g l a a g l - a a g l a l
g a . F , - g a a g l a a g l

w a a l a g a a a a (P a L a , 1993).
 g a l g a a a a a a l g g g g . a a a a l a a a g w
 g a a a a l g a a a g . F l a a a a ,
 a a a a a a a w a g l
 g a l (P a L a , 1993).

F
 Ag a , g a a a a a a a a a a a a a
 l l a a l w l a a a a a a a a a a a a a
 g l a a a a a a a a a a a a a a a a a
 l a l g g g S , a a a g a a a a a a a
 a , a a a a a a a a a a a a a a a a a
 a a a a a a a a a a a a a a a a a a a
 a a a a a a a a a a a a a a a a a a a
 (a a) a l a a l , a a a a a a l a a a a
 I a a I a g a (1986) l a a a a a g
 a a a a a l a g a a a (P a L a ,
 1993). a a :

- D a l a l , a a
 - I a a l a a a
 - a a g a g l
 - S a a a a a a
 - C a g a a a a
 - a a l a l a l

G a a g l l a a a a a a a a a a a a a a a a
 l a a , a l w a g l w a a a a a a a a a a a
 a g a l l a g . Pa ' a (E .1)
 l a a g , w l a a a a a a a a a a a a a a a a
 a a g a
 a a a w a a a a a a a a a a a a a a a a a a a
 a a a a a a g a a a a a a a a a a a a a a a a a a a

4. - ff c a d R f E a

Geometr	P	R	Dimen sion
Infinite slab	1/2	1/8	thickness e
Infinite cylinder	1/4	1/16	radius r
Sphere	1/6	1/24	radius r

$$t_F = \frac{\rho \lambda_e}{T_F - T_e} \left[\frac{e^2 R}{k} + \frac{e P}{h} \right] \quad (Pa\text{, } K)$$

1980).

(1)

$$\lambda_e = \frac{1}{4} \left(\frac{1}{R} + \frac{1}{h} \right) \left(\frac{1}{k} + \frac{1}{P} \right) \quad (Pa\text{, } K)$$

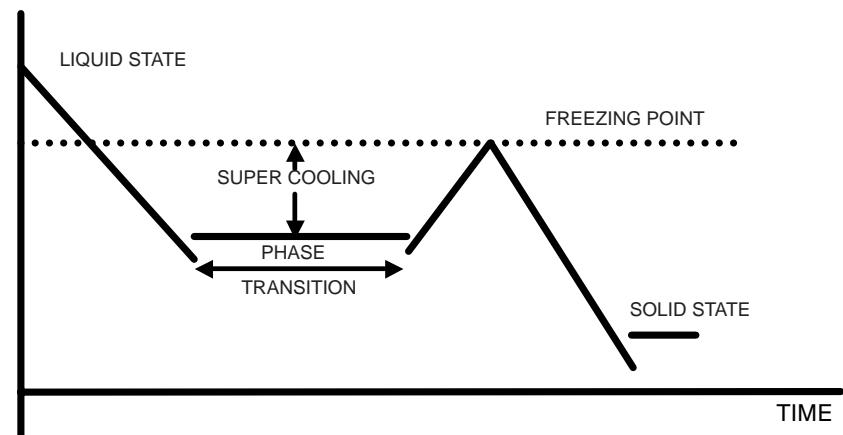
$$A = \frac{1}{4} \left(\frac{1}{R} + \frac{1}{h} \right) \left(\frac{1}{k} + \frac{1}{P} \right) \cdot H \quad (Pa\text{, } K)$$

(Bardas-Garcia et al., 2002).

S
Naga a w a a , a , a , a
(1955). Naga a ' a , a , a , a a a a a a a a a a a a a a a a a
(E . 2) a
a a , a
w a
a a
a a a a a g a
a a

Fig. 4. Freezing and melting curves

TEMPERATURE



Wang (1999). Fig. 4 Wang (1999) shows the phase transition curve of supercooled water.

Substituting X_{SNJ} into Eq. (2), we get

$$\Delta H = \left[1 - \frac{X_{SNJ}}{100}\right] \Delta H_f + 1.21 \left[\frac{X_{SNJ}}{100}\right] \Delta T$$

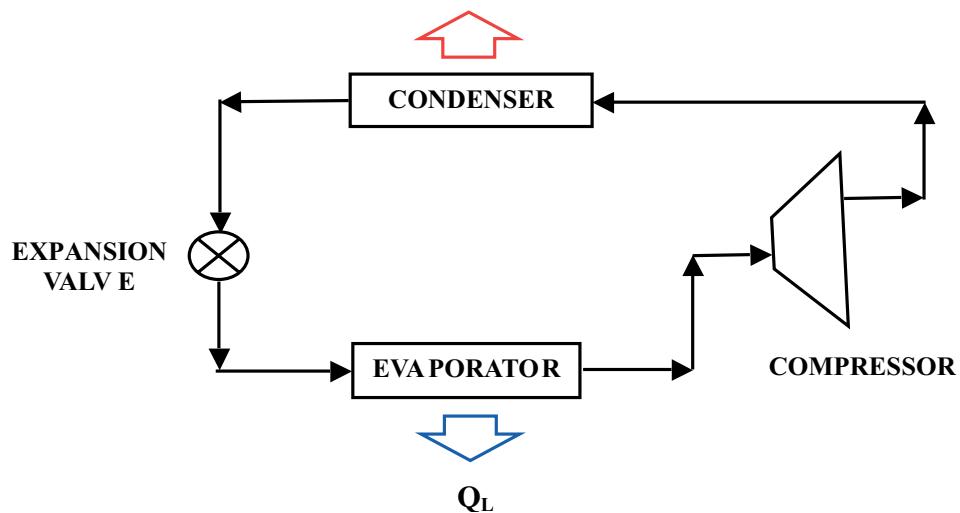
(Hwang et al., 1996).

Fritz (1949) also found that the phase transition curve of supercooled water is similar to that of pure water. The phase transition curve of supercooled water is shown in Fig. 4. The phase transition curve of supercooled water is similar to that of pure water.

$\Delta S_{NJ} = P \ln \left(\frac{P_2}{P_1} \right) + T \ln \left(\frac{T_2}{T_1} \right)$ (Dissipation term)
 $\Delta H = E_a - a_g + g_a - g_{a_g}$
 $\Delta U = E_a - a_g - w_a + a_g - a_a - a_g$

1.2.3 Refrigeration

Fig. 5. A schematic diagram of a refrigeration cycle showing the flow of refrigerant through the condenser, expansion valve, evaporator, and compressor. The cycle is powered by a motor (M) and includes a receiver (R) and a filter (F).



(LIN) \rightarrow (CO₂) \rightarrow (HCFC) \rightarrow (HFC)

1.2.4 Heat Pump

F... a d / ab : a a . - b , a , a , a , a a d , a a , a

a , | a a g a . A
| a a g a w Fg 5.

S a g a , | a a a .
w a a a a a a .
w g | w | a g g g a a |
g a | a . A a a a g | | | | ,
| w g | a a a w | a |
a | g a . Fa , | g a w g |
a a w | a a a | a a a | a a | a a | a a | a a | a a | a a | a a .

w a | l | l | g . . . g a | a a . . .

g a
 a a a g a a a a a . . . g a . . .

g a a | a , | a a a | a a a | a a

E a | a a a a a a g a ,
 a w | l | l | a a a a a a a a a

S a a | , | g a a a , a a a | a a a | a a

(a | J . , 1982). F | a a a a a , a a a

l , w a a a | a a a a a a a a

l a g a (P a | L a , 1993).

1.2.4 Feeling capacity

1.2.5 Feeling em

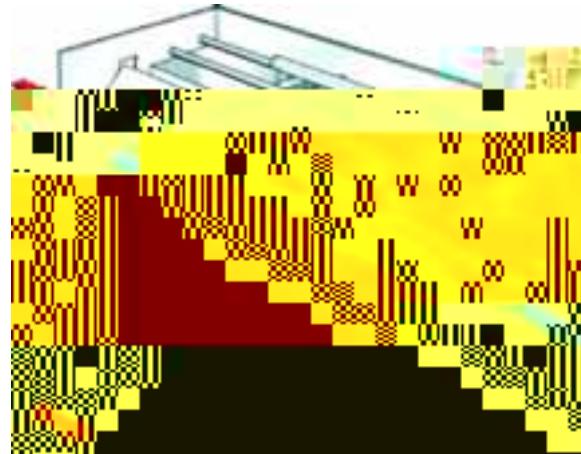
a a g a a a a g,a |
a a a a a a a a g a g
a a a a a a a a a a :
, a , a a | a . F a a a | a a a a
a a a a a | a | a | a | a | a | a | P | a | g
g a a | a | a | a | a | a | a | g a g g
a a a a a a a a a a F a a a
a a a a a a a a a a a a | a a a | a a
| , - a , a | a | a | a | a | a | a | a | a | a
| a a g a a a a a a g a | w g
| . M a a a a a a a a a | a
a a a a a a a a g a | a | . La ,

l a g a a g l a wa , a a a
g) a l a a . a a a a g l
l a l g g l . a a a a g .

-ba
a a l a l a l g a a l a
a a a a l a a l a l g a a a l a
g l l a 0 0 * ,

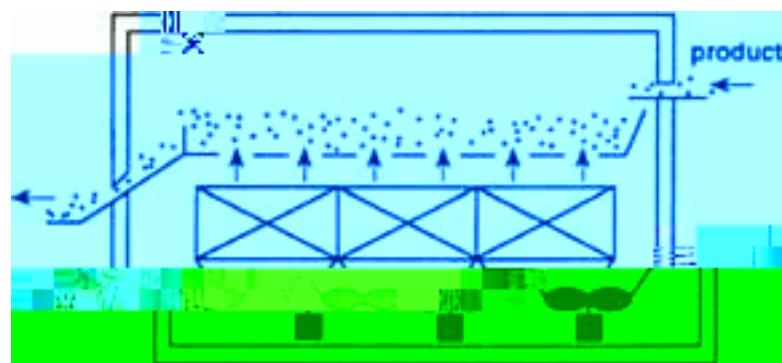
F a d / ab : a a , - b , a , a a d . . . , a a , a

Fig. 9 . -r c a f a f d d d f r r
 - r f Fr ca d a E L d



a a | a a a g | a a a g | a a a a a a a a a a
 a g | w a g | g | a a a a a a a a a a a a a
 a . C a a a a a a a a a a a a a a a a a a
 a a g | w a g | a a a a a a a a a a a a a
 a | w a a a a a a a a a a a a a a a a a
 a
 a
 a
 a
 a
 a
 a

Fg. 9 . S r r c f a f d d d f r r
 Sara ac r c f a f d d d f r r



T **f** r r
I a a a a a a a a a
I a a a a a a a a
I w a a w a a a a a
I a a a a a a a a a
I ,a g a a a a a a a
g a w a g a g a a a a
g a w a g a g a a a a
w a w Fg 7. (Ma..., 1993). A

B f r r
B w a g a a a a
w a a a a a a a a

a a w a g a a a a a
a w w a g a a a a a
I a a a a a a a a a

Fig. 11. Schematic diagram of a spray freezing system (Wang et al., 1999).

Fig. 11. Schematic diagram of a spray freezing system (Wang et al., 1999).

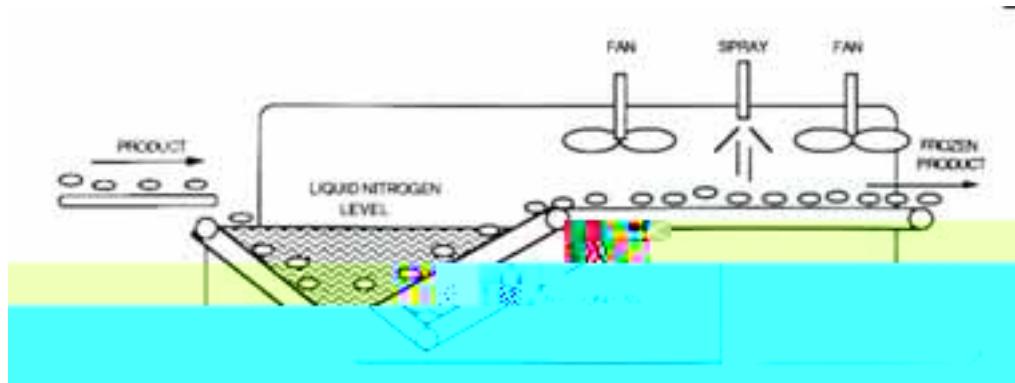


Fig. 12. Image of a freeze-dried product.

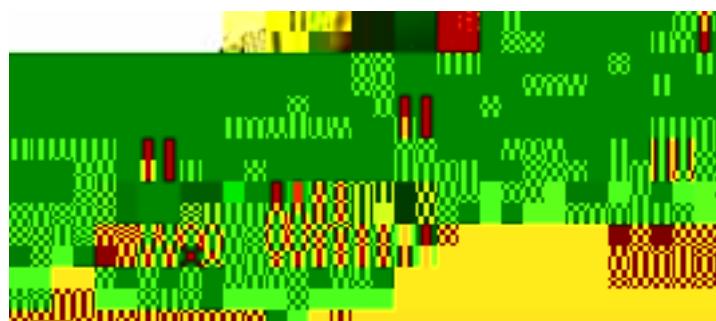
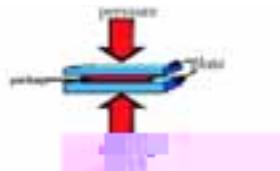


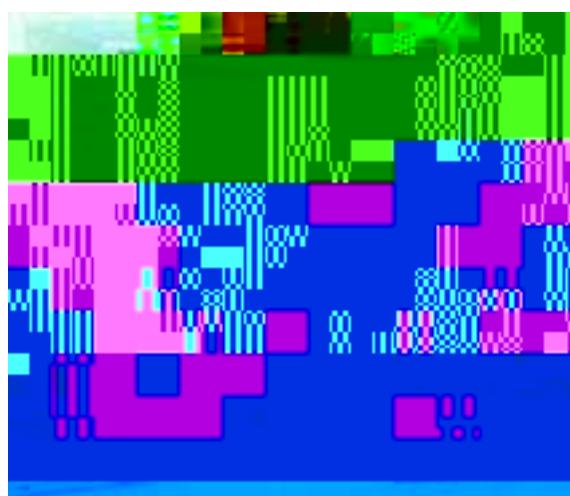
Fig. 12. Image of a freeze-dried product.

Fig. 13a. r r a ca a a fr r



g. a a a g. a a a IQF g. a a a
g. a , w , , , , , , , , , , , , , , , , , ,
,
g. A a ,
Fig. 9a 19.

Fig. 13. a fr r a a c r r a d a a r c d r
- r f SI Sa f Fr r Sr I



C a a g w a g a a a a . I g a a a a a a a
a w g , , , F , , , , , , , , , , , , , , , , , ,
a . A a a a g g Fig. 10. F , , , , , , , , , , , ,
,
a w a w a w g , , , , , , , , , , , , , , , , , , (Ma , 1993).

a a g l l l a a a a g l a a a . A l a ,
a a l a a a a a a a g l w a a a a a .

a fr r

a a a a a a a a a a a a a a a a a
g a a a g l a a a . P a a l g l a a a
a a w Fg 13.

g l g a - a l a a a a a a a a a a a a
a a a a - a l a a g l l . A a a a a a a a a w
Fg 13.

- ac fr r

l g w g - a l l - a l g
l a a a w Fg 14. l g a a a a g l w a l
l . a l a , a , g g , a a a l
(P a l L a , 1993).

C g g a a w l g w l g a a a a
a a a a w -60 C g l a w l g a a a
g a l l (H g a l K , 1996).

g l a g l a a a a a l l - g
a l a a a a a a a a l g
a w l g a l g a a a a a a l g
a a l a g a g a a a a a g (P
a l L a , 1993).

L d r fr r

L l g w a g a a -196 Ca a a a a a a a a
l g a
2 a , a l

L d car d d fr r
L a a a a a a a l g a w a a a a a a a a
L - w a a a a a a a a a a a a a a a a a
L a a a a a a a a a a a a a a a a a a
L g a a a a a a a a a a a a a a a a (G g , 1993).

1.2.7 Packaging

P a ag g a a a a a a a a a a a a a a
a l a ag w a a a a a a a a a a a a a a
l a , a , a , a l a a a a a a a a a a a
l g g a a a a a g a a a a a a a a a a
l g , a l g a l (a a , 1999). P a a a a
a ag a l a a a a a a a a a a a a a a
l : a , a a l a a a a a a a a a g a l a w
l a l a l a a a a a a a a a a a a a
a ag g a a a a a a a a a a a a a a a a
a a a a g g l a a a a a a a a a a (H a l C ,
1993).

B ag g a a a l a a a - a a a a a a a a ,
a g g a a a a a a l O g a a a a a a a
a a l a ag g a a a a a g a - - a a a a a
a l g l (A H AE, 1994; a , 1996). Ga a l g l a a a
a a a a a a S a a a a a a a a a a a a
a a a a a a a a a a a a a a a a a a
a a a a a a M a g w a g a a a a w a l a
l g a a g g a a a a a a a a a a a a a
l a a g g w a a a a a a a a a a a a a
a a a a a a a a a a a a a a a a a a a
a a a l a a a a a a a a a a a a a a (M S , 1999).

A ag g l a a a a g g a a a a g l a g l a l - g l
a a , a a a a a a a a g g g . Ga , a , a , a , a w a l
a l a l a a a g l a a g a l a l a a a a a a
l l l l . Ga a a a a a a a a a a a a a a
a a w a - a l . Pa a a l a a a a a a a a g l a (B l ,

Raw materials
(~~a~~ ~~a~~ ~~e~~ ~~f~~ ~~l~~ ~~t~~ ~~i~~ ~~a~~)

at rit assessme t

Pre arati
(lea i was i eeli i a i)

1982). N - gl l a
a
l a
gl a l a l gl (Ha a l C , 1993). a a a a a a a a a
W a l a l a a a a a a a a a a a a a a a a a a

S a a l a
a a a l
a
W 99 a

1.3.1 Feeding i

g, , a g , a l w g , a , a

C la ag a ag I ag .
 g. I a la g a I I a l w
 g. w w a a w a a I a a
 g. I g ag D a a a I a a a
 a g, a la a a a g a a a .

a a , a d / a d , a

F g a a a a a a a a a
 a a I a a a a a a a a a a a a
 a a . a a , a w a a g a a
 l a g. a g a I g g a a a
 w a a la w g. , a I a l a g
 g, g. g. F g a a I a
 a a a g, g, g, g, g, a I g
 S , 1984).

F a g I g I g g.
 P g l a l g w , a a a a a a (B a l
 l , 1968). g a a a a a a a a a a
 a a , l g w (, 1985), a a a (G a , 1990), a
 a g (G a l M a , 1992). a a g a a l a l a g
 l , a a a g . A a a g a a a
 a a w l a a a l a a g . B a a a ,
 a , a g a l w a a a g a a a a
 g S , 1996).

a a a a g a a a a a a a a g I a a g
 , l , a , a l a a a a , a a a a a a a a
 a a (G l , 1968). , a w a a a a a
 a l a a a a l g a g l a a a a
 a g a l a a a a a a a a (S , 1984).

a d ,
 Al g a a a a a a a g g
 a a a a a a a a l g g g
 a a a l a a a a , S g w l l l a l a
 w a , a a a a a a g g .

g a l
g w a l (M -D g a l,
1978).
S g a a g l 30-60
, a g a a a g a a l w g .
S a a a w g , a g a a , l ,
, a l g , a , a (G , l ,
1968).

a a /
F a l g a a l g a l a , a g

Fr i	Pre - r ion	e d P
Apples	Wash, peel, and slice into antidarkening solution -- 3 tablespoons lemon juice per quart of water	Pack in 30-40% syrup, adding 1/2 teaspoon crystalline ascorbic acid per quart of syrup. Pack dry or with up to 1/2 cup sugar per quart of apple slices.
Apricots	Wash, halve, and pit.	

P a a l l l gla a w g l , , ,
a l a . P a a l l l gl 1 w l l w 1
w a . a l l l a l l l 1 ; 1/2 gl a l l l
a l l l ; l w w a l l l w a .
P a a l a 4 6 a w a l l g
a l l l w a . a a l a l (Bal ,
2002).

S ar ac

I a gla gla a , gl a l l a a
a gl a l l l w a l l gl a l l a a
gl a l l l a a , w , , , a l
a , gl a l l l a a , w , , , a a
a w gl (B , 1996). S

d ac

w l a a a l a w a , l - a l , w
w a gl a a l , a l w l l . w a
l a l gl a a , gl l gl a a
w a a a a . G a , w l a l a w a l
w a w gl a w , a a a a , a l l a , gl
a , a l l a , gl , a , a l a a a a g l
a w gl (B , 1996).

Tra ac

w l a a gl a a l gl a a w a gl a
a l a l a l a w a , , , a l a a g l
a , a w gl g g w
a l a a g l

S ar r ac ac

A a w a a l a l gl a gl a
w a gl a a a l gl l w , w
a gl a a
F w gl w a l a l w w a
w gl (B , 1996).

1.3.2 Fee ing ege a le

F gl a l l l a l a l a a w a a a
gl a (G , 1996). F gl a a l a l a a gl a
a (Ma , 1993). a

g a l l a , a , a , P - a l g , g a a a , a ,
a l a , a , a , a , a , a , a .

a , a , d a , a d a ,
g a a l a , a , a , a , a , a , a , a , a ,
a , a , a , g w a , a , a , a , a , a , a , a , a ,
a , a , g a , a , a , a , a , a , a , a , a , g
a , , a g , a , a , a , a , a , a , a , a , a , a ,

a , a , a , a , a , a , a , a , a , a , a , a ,
a , a , l a , l a , l a , a , a , a , a , a , a , a ,
a a a a w (G , 1996): S

S a a a a a a a g
a
E a a a a l a , a l l a
a , l a
H g , l

A g a a a a a a a g a a a a ,
a a a l a a l g g w a a a a a g a ,
a , a , a , a , a , a , a , a , g w ,
a l a g a a a a l a , a a a , a , a ,
a , a , g , a , a , l a , a , a , l a , l a ,
a , a , l , w a , a , a , l , a , l , l ,
a , a , a , l , a , l , g , a , a , a , a , a , g
a , a , a , l , a , l , g , a , a , a , a , a , a , a , (H , a , 2004).

A a , a , g a a g a g a a g a a a a
a , l , , l , a , a , a , a , g a a a (A , 1993).

S w g a a g a a a l w a a a a , l , g
l , a , a , l , a , a , a , a , a , a , a , (L , 1989). M
g a a a , l , g , l , g a , g .

e e e	Pre - r ion	n ree e
-------	-------------	---------

Asparagus Wash and sort by size.

Snap off tough ends.

Cut stalks into 5-2q1Tf0.74 03.49D0.0027 (04 1 Tf 0.8949 0 40.0019 Tc (ut)-27m1(nt1 nT q 1Tf 6.4 0))10J787

F a a a a a d / ab : a a , - b , a , a , a , a a d , a a , a

g a a a a a a l a l a l g . P a l a
 a l g g a a a w l l a a a , , , , a l
 (L , 1989). l a w a a a l g l
 l l a a a g . C g g a a w a a
 a g , w l a a a - a , , , , l g
 a a g a a a a a g w a a l a
 l a g a (D , a , 1977).

B a e .

Ba g a a a a a Pa a g a (a a l g
 a) l a a l a l a l a g , a a g
 w a a a a w a a g a g w a l a A
 a a , w , a a a a a , a , , , , a l
 . I g a a a a l , , , , w
 a l g a a g a l a a g a g l
 a a l . Ba g a a w g g g a , a g
 a a a . I l a a a a a l a a a l
 (D , a l , 1977).

Ba g w a a 70 105 C a a a a w l
 a . Ba g a a a l w 75 a l 95 C 1 10
 , , , , , , , , , , , , , , , , , ,
 Ba l g a l l l l w a l a l (H w , 1983).
 l g a l a a l a a a (D , a , 1977).

l a l a
 l a , a a , a l a a g a . P l a a a a
 l g a a g , a l a a l a l a l
 a a (A , 1993).

g a a a a a l w a , a , a l w a . H w a
 a g w a g g a . Ba g
 l l a g a a g a g a 6 w l a a
 a a a a a l g l l l . F w a a g ,
 g a a a a a a l a a g w a w a
 l g g l a (A , a , 2003). S a a g a g a
 w a l , a w a - a w a - a a .



G a a a a a a l a a l g a a g a a
 , w a a a a a l a a l a a a l .
 l a l a l a l g a a l l a a a l g
 a a a a a a .

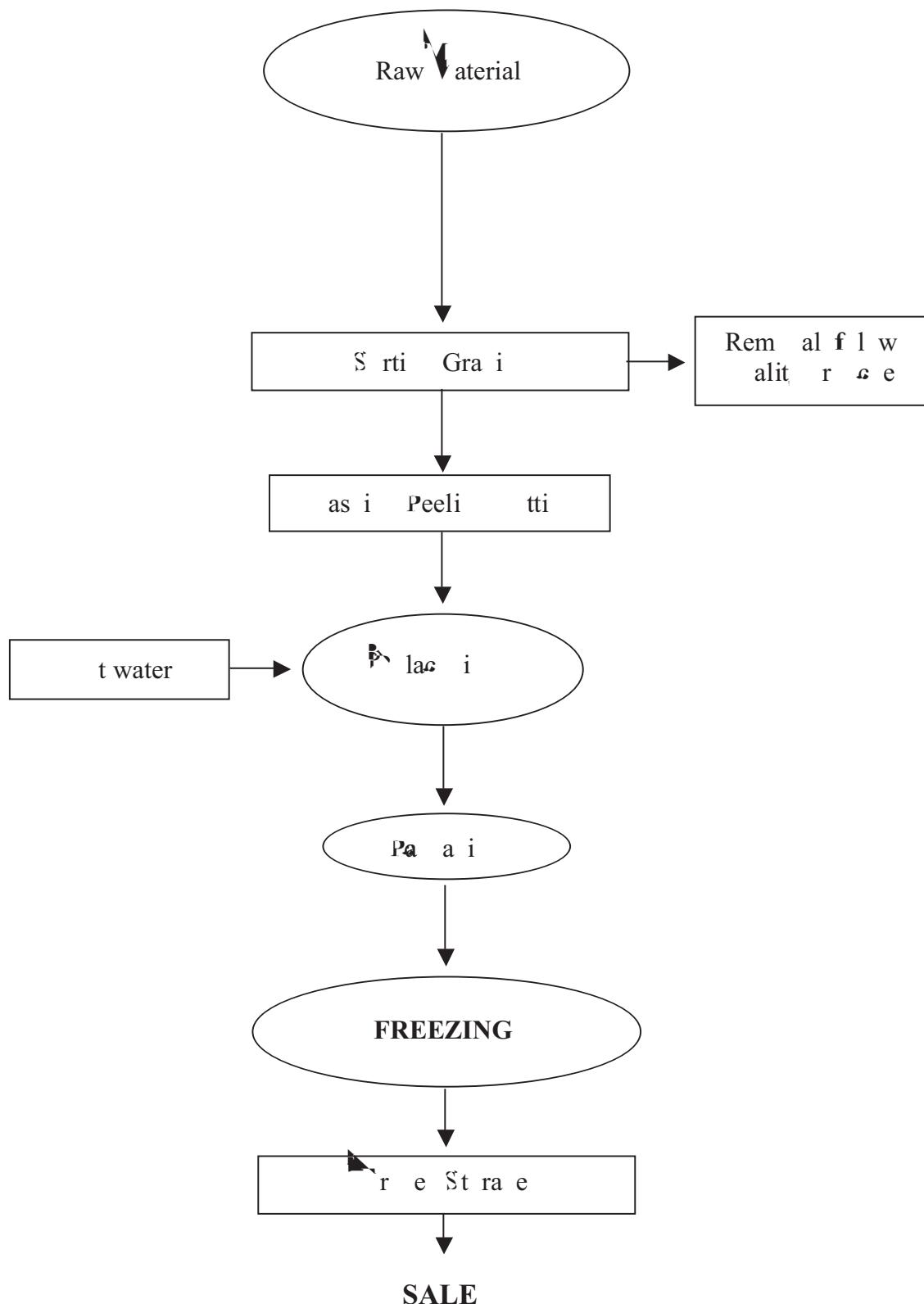


O a a a a a a l a a a a a a a a
 , w F g 16. a a a a a a a a a a a a
 a a , a l w . a w l a g a a a a a a a a
 a
 w a w w a l a a w a l a , l a a a
 , a g a a a w a . a a a a a a a a a a
 l a a a l a g g a a a a a a a a
 a a a l a a a a a a a a a a .

F g 16. Ra rr a d ac rr

P = $\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} g(x_1, x_2, x_3) dx_1 dx_2 dx_3$

Fig. 19. Flowchart of the process of apple juice production.



1 a g a a , 1, a a a 1 a wa
a a a a . 1 a a g g a 1 a g a a a a . 1 a
a a a a . 1 a a g g a 1 a .

Ca 3

v b a p t k

a g a a a a a a
 a g w a a a a a
 a a g a a a a a a
 a a a a a a a a
 a a a a a a a a

z.1 v b a p t k

a g a a a a a a
 w :

- F - a a a
 - a , a , g (40)
 - g a a a a
 G , g a a , a w , a

z. v b a p t k

A a a a a g , a a a a a
 a a a a a a a a a a a
 a a a a a a a a a a a
 a a a a a a a a a a a
 a a a a a a a a a a a
 a a a a a a a a a a a
 C a a a a a a a a a
 a g a g a a a a a a
 a a a a , a a a a a a
 w a a 414 w a a a
 g a . w F g 20.

Ca 4

— 10 7m 7m — 10 7m 10 7m —

a a a a a a a a a a
g a a a a a a a a a w a a a
ag a a a a a a a a a a a
a a a a g a a a a a a a
a a a a a a a a a a a a
a a a a a a a a a a a a
a a a a a a a a a a a a
a a a a a a a a a a a a
a a a a a a a a a a a a

.1 — 10 —

a a a a a a a a a a a a a a (a ,
1991). g a a a a a a a a g a w S a a
g a a a a a a a a a a
g a a a a a a a a a a
ag a a a a a a a a a a
a a a a a a a a a a a a
a a a a a a a a a a a
a a a a a a a a a a a
a a a a a a a a a a a
a a a a a a a a a a a
a a a a a a a a a a a
g g .

4.1.1 Physical aspects of effe ing

M a a a a a a a a a a
a , a a a a a a a a a a
a a a a a a a a a a (Pa a a M w , 1997).

T r
M a a g a a a a 90 w a a w g . w a a a
I a a a a g a w a g a a a a a a a
g a a a . I g w w w a
a a a a a a a a a a a a
C a a a a a a a a a a a a
a a a a a a a a a a a a

I a a w,a a a . I a a a a

D a g l a a a g l a a a a g l a ,
a g l a a a g l a a a a g l a ,
a g l a a a g l a a a a g l a ,
(Ma a l g , 1993).

cr ca a c f fr
M g a a a g a a a g ,
a a a g a a a g ,
W g a a a l g (A

1. Ma a a a l a a l, a l a w g l a a a g
a .

1. Ma a a a a a , a l l w g l a a a g a a , a l g a a g l a a .

F ab , d c .
a. Sa a a l g a , a a g a , a

Ma a a a .
1. Ma a a a a , a l l w g a , a l g a a g l a a .

2 K a l a a l , a a l , a a l , a a l , a a l
F a a l a a l , a a l , a a l , a a l , a a a (a ,
1996). a a a a a a a a a a l g a , a a a a a a l g
w l a l a a a a a , a a a l g a a a a a l g
(a a a l M , 1990).

— F M w a a a g a 8 12 .
w l w a a a a a l g a a

— g a M g a w a a a g a 12 18 a
-18 C w .

F a l g a a a a a a a C, a , a l a w
a l g a a a a a a a a l , a g a g (g w a -
a a a l g (B , 1981).

3 K a a l a a l , a a l , a a l , a a l , a a l
Ma g a a l a g a a a l g a a a g

a g a g a g w l a a l g a a a a l w l
a g , a a g a a a a a l .

S a ac a f r r d c
A g l a a a a a a a

F = $\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2}$ = $\frac{1}{128}$

r	Fac
S_{P}	$\frac{1}{2} S_{\text{P}}^{3/4} \cdot (85\%)$
S_{A}	$\frac{1}{2} S_{\text{A}}^{5}$
G_a	25
G_d	$a = 0$
$\% D_a$	a^*

C a . 5



A a . a . a a . a . g a a a a | a a a a a
a . a . 7a | 8 w a a g a a a a | a a a

F a d a d ab : a a , - b , a , a , a , a a d , a a , a

a 7. — ar f fr f r a fr a d a
e al.

e o

proxim effree in time

(10. —):

A.

3 . 5 .

1/2 . 2 .

B.

20 . 30 m.

B.

5 . 10 m.

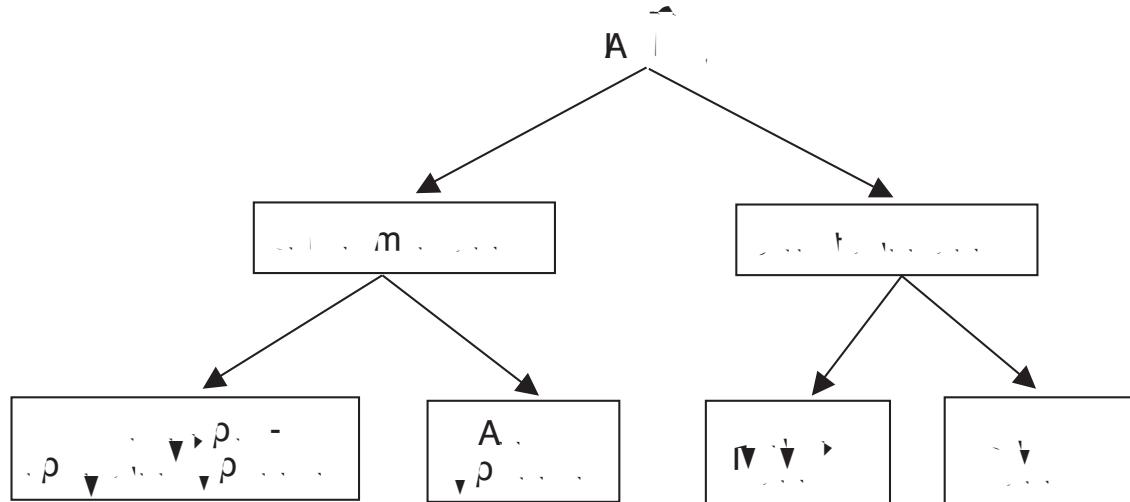
C.

1/2 . 1 m.

C.

5.1

a a a a g a g a l l w a a a : a a a
a a d e e a a a a a a a a a a a a a a a
a w w :



F a d ab : a a - b a a a a a a d a a a

a 9. E a f a c f r fr a

e o

e n i ni Co o Co

-	K	1	250.00	250.00
D		1	100.00	100.00
D	F	1	600.00	600.00
		1	300.00	300.00
		-	150.00	150.00

O AL \$ 1 400.00

r ra c - S
A c - S
I c - S

ar a c
a a a a ;
a a a a ;
a a a a (a , , , , , g a w a , ,);
a a a a ;
a a a g .

F **d c**

F **|** a a a a a a a a a a a | a w

| a . E **|** **|** : a .

- | a ;

- a a | a ;

- a | a .

a ab e : a

1. C a a a : C | g S \$ 300 () a a a a a a S \$ 600 a

g w w a a a a **| a a a a a a a a a a a a** S \$ 600 a

2. C g a g a a | a a a , w
g a g a a a a a a . Ba |
a a a a a a g a a a a a a | :

P | a : 1 000 g g a
(2 000 a a g);

F a a : 40 g | 20 ;

g a a : 500 a ;

A a g : \$ 0.10/ ;

w : 15 500 = 750 / ;
750 a S \$ 0.10/ = S \$ 75/ .

3. G. a w a a a | 100 g | .

R	m	e	i	n		ie	100	e	e	e
R	er	i		n		ni	Co	o	Co	
C	()			25		1.25		31.25		
G	B	()		25		2.50		65.50		
O	()			25		1.25		31.25		
C	()			25		2.00		50.00		
	()			500		0.01		5.00		
P	M			200		0.05		10.00		
O AL							\$ 193.00			

4. G. a w a a a | 1000 g | .

w a a a | : S \$ 193 10 = \$ 1 930.00
 La : \$ \$ 600.00
E g : \$ \$ 175.00
 T a ar a c - S ,

F. d e : a

1. G. a a | a :

$$\begin{aligned} A \ a | \ a &= a / 8 \\ M \ a | \ a &= A \ a | \ a / 12 \end{aligned}$$

$$\begin{aligned} a a &= S \$ 1400.00 \\ A a | a &= S \$ 1400 / 8 = S \$ 175 \\ M a | a &= S \$ 175 / 12 = S \$ 14.58 \end{aligned}$$

2. G a a a a a a a a :

$$\begin{array}{r} \text{D} \quad \text{a} \quad : \\ \underline{\text{A}} \quad \text{a} \\ \text{T} \quad \text{a} \quad \text{f} \quad \text{d} \quad \text{c} \end{array} - \begin{array}{r} \$ 14.58 \\ \$ 425.00 \\ \$ \quad , \end{array}$$

$$\begin{array}{r} \text{a} \quad \text{a} \quad \text{a} \quad : \\ \underline{\text{a}} \quad \text{a} \\ \text{T} \quad \text{a} \quad \text{r} \quad \text{d} \quad \text{c} \end{array} - \begin{array}{r} \$ 2605.00 \\ \$ 439.58 \\ \$ \quad , \end{array}$$

$$F = \frac{P}{(1 + r)^n} = \frac{a}{(1 + r)^1} + \frac{a}{(1 + r)^2} + \dots + \frac{a}{(1 + r)^n}$$

~~Gross profit margin~~ $\approx \frac{\text{Gross Profit}}{\text{Sales}}$

$$\text{Gross Profit Margin} = \frac{\$3,044.58}{\$2,000} = 1.52$$

$$\text{Gross Profit Margin} = \$3.20 / \$2,000 = 1.6\%$$

~~Fixed costs~~ $= \frac{\text{Total fixed costs}}{\text{Sales}}$

~~Contribution margin ratio~~ $= \frac{\text{Contribution margin}}{\text{Sales}}$

$$\text{Margin of safety} = F / (1 - \text{Gross Profit Margin})$$

$$\text{Margin of safety} = \$2,000 / 1.6\% = 125,000$$

$$\text{Margin of safety} = \frac{\text{Contribution margin}}{\text{Contribution margin per unit}} = \frac{\$3.20}{\$1.30} = 2.46$$

$$\text{Margin of safety} = \frac{\$439.58}{\$1.30} = 338.83$$

~~Margin of safety~~ $= \frac{\text{Margin of safety}}{\text{Sales}} = \frac{125,000}{\$2,000} = 62.5\%$

AFFI 2003. A a F F I ,
 (/a a - / a) : NPD, G , I ., F I
 I , F F I Ag , I I, N a S a a A a , , I ,
 a I S A a .

Arc r a d a d A 1995. wa I I
 a
 J a F I S a I g . 30, . 711.

Arc a 2003. F g g a G I E-320. M S a ,
 g Ag a H E E S

Ar 1993. F g g a a I . I : M , C.P. I , F I
 g Ca a a I Ha , L I , K.

ASHRAE Ha d 1994. g a a a a I A a , A a
 Ha g , g a g , a I A - I g E g , A a a , GA,
 S A.

Bar a-a a a a d I ar A 2002. O a F I E g .
 C C P , B a a , FL, S A.

B a ard a d Fra F 1987. I a a a a I
 a I a . F I S a I a , A a I P , L I , K,
 . 51-65.

B a d r A E 1981. F a a a a a a . N a a a a F I I ,
N a g g S . 19, . 24.

B a d f r d E R 1968. a a a a a a a a ,
F a g P a a F I , . 3, 4 I , A I , C , S A.

B a d F r B a d f r d E R 1977. F a g . I :
D , N. , D.K. , F a a F I F a g . A
P a g I . , S A. . 135-215.

Br a d A 1982. Pa M a . 4 I , B w , L I , K.

- a ad a F d I c A c L a 2004. P a I a I P
C a , F a I a I D g g a , C. C., . 870
(w w . g . a / g / g / g .).

- a a d ar A 1992. Pg a a a a a a a a a a a a
a I w a J a A F I C . 40, . 2141.

- a a d 1996. g a , F g E Q a , M D , N .

- a a d ar A a d F r - 1990. F g a a a a , I
a a a a a a a a g . J a F I S . 55,
4, . 1070.

- a a d 1985. I a a a a g a I w g I a
a I a a a a a . J a F I S . 50.

- a a d a d - a a d A - 1987. P I g a I w g
- I a a a a a a a a a a a a a a a a a a
I a a a J a g a . 10, . 156-164.

- a a d a d - a a d A - 1987 . P I g a I w g
- I a a a a a a a a a a a a a a a a a a
J a g a . 10, . 234-240.

a d A E a d S 2000. Ha a I a a a a a a a a
a a w . J a F I E g g . 47, . 157-174.

r **r** **a d** **r** **r** 1977. P F ↓ F ,
F ↓ F , 4 ↓, A I P C . I . C , S A.

r **r** **a d Tr** **r** 1977. F ↓ a a F ↓ F , A I
P C . I . C .

r c - R **L** 1959. a H a d B
1959. a a a a a , F ↓ , 13:258.

SI Sa f Fr r Sr I (~~www.~~ a).

E c a R a d r c R 1977. F ↓ F , P
F ↓ F , 4 ↓, A I P C . I .
C , S A.

F 2000. F ↓ a a a ↓ a a C C P ,
B a a , FL

F **a** 1977. L a a a a ↓ a ↓ F ↓ ,
12:32-38.

F **a** **R** 1973. ~~www.~~ a P a a a a ↓ a ↓ a a
F a , O ., ~~www.~~ , D., M ., E. H., E , P , ~~www.~~, C .3.

Fra **F** 1985. B a ↓ a a a ~~www.~~ a , G ↓
P , G ↓ , K . 21.

Fr ca da **L T** (~~www.~~ ↓ /FMC).

r R 1993. F ↓ a ↓ a ↓ a ↓ a ↓ F ↓
a ↓ a ↓ 4, 134.

c d 1968. P g a ↓ ~~www.~~ a a a g ,
a a a a a a , ~~www.~~ a a B g
F ↓ , A a F ↓ S , 4, P g a P , L ↓ .

rad **H** 1988. a g a a a a a a g a a a a a a

a a a . D A I B48:9.

Harr R S a d r a r E 1975. N E a a P g, 2 l, .
A P g C , S A.

Harr a d -r c r 1993. R a g g F F l, F F l
g (M CP l.) C a a a l H , L l , K.

Harr T 1968. C a g g a l g a a g
F F l P g Pa , H S g , A a a , 23 l a A .

Harr S 1983. P a F a l g a F l P l ,
M a a P , L l , K.

Harr a a S r a a E rr a d 2004.
H l g a P a a l P g M D , I .

Harr - a d 1996. F l a a a - a g . F l
50:59.

, 14:549.

a 1993. F F ↗ g . C a a a ↗ H a , L ↗ , K.

a T a d T 1993. P ↗ S a E a C , F
F ↗ g (M CP ↗.) C a S a a ↗ H a , L ↗ , K.

c a S a - r E 1999. C a g . P g F ↗
S a (M . P / / / 01/01600506).

a ad A 1978. E g , ag a ↗ a a ↗
a a ↗ , a a a ↗ g a . F ↗ Q a a ↗
N , A ↗ P ↗ L ↗ . L ↗ , K.

a a a Ta S a d H a S 1955. E g
a - a , P . 9 I C g , B , Fa .

r a d L da 1993. F g g , F F ↗ g
(M CP ↗.), C a a a ↗ H a , L ↗ , K.

a T a d a R F 1977. M g a a ↗ I a a
F F ↗ . I : Q a F F ↗ , E , M. C., H g , E ↗ .
C a a a ↗ H a , N w

a R 1980. E E ↗ F a I ↗ a ↗ a A a , B a a :

c Fr F d I r a a 2000. G a F F ↗ A a a , 33, N .2.

R a S 1999. H a ↗ F ↗ P a , M D , N , S A.

R a a H S a d T A 1984. A w ↗ g ↗ g
J a F ↗ P E g g . 7, . 169-203.

R d L 1949. C a E g g g . 21, . 340.

R r L 1985. C a g a ↗ a ↗ a ↗ a
w g g a ↗ a g . F ↗ C , . 17, . 25.

im n ro i e i n e en i inform ion onfree in e noo o re er e
fin ee e in m eo er ion . Pr i ex m e emon / in e
ion of ee noo re i en o ro i e eer n er n in d e
ro e e free in i em o i e / e me o dfoo re er ion er mi in
re en ion d i d e ro / rin on erio d or e Com re oo er
on en ion me o e in e or edfi n ee e free in i em o
if or me o in erm d i ro e n oer o Curren efro en
foo mre i one e re e or in efro in r n rie onrie
omin e er einfro enfoo ommo i ie / eeo in onrie n o e eo
eiro nfro enfoo in rie n ro iond e / efree in e noo e on
eer n er n in d e e ni n r i ro e e i e eni ome e
ro in on mer em n forfro enfoo in e eo in onrie

