A STRATEGY FOR MINIMIZING PROPORTION OF OVER- AND UNDER-WEIGHTS IN MINIMUM-WEIGHT-PACKAGED CHICKEN BREAST FILLETS

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Background.

Food marketing changes in the USA have led to a shift from unit pricing to minimum weight pricing (MWP) in some wholesale and retail situations. Under the former, products are priced at a fixed rate per unit weight. Under the latter, products of varying sizes but meeting weight minima are priced at fixed rates. Under MWP, it is sometimes necessary to fill containers beyond the stated weights in order to ensure meeting the minimum. Product above the stated weight is commonly designated as "give away." An example of this situation is chicken breast fillets sold in 1816 g packages. One approach to minimizing give away would be to reduce variation by categorizing the fillets by weight and packaging by numbers from each category. This study evaluated one approach to minimizing give away by categorizing the fillets by weight prior to packaging and then packaging by numbers from each category.

Objective.

The objective of this study was to determine the number of weight categories needed to reduce give away to less than 3 percent and underweight packages to less than 1 percent using Monte Carlo simulation models.

Methods.

Twice on each of three days, either eight or nine nominal 1816 g (4 lb.) MWP bags of individually quick frozen breast fillets were randomly selected from a production line in a commercial plant. In all, 42 bags were selected. Total weight of each bag and weights of individual pieces were observed. Means and standard deviations of bag and piece weights were calculated using SAS® Proc UNIVARIATE (SAS Institute, Inc., 1988). The distribution of bag weights with no partitioning of piece weights was simulated by randomly adding pieces from a computer-generated normal distribution with the same mean and sd as found in the commercial plant until weights of the simulated bags exceeded the minimum bag weight observed in the plant (1865 g). The simulations were continued through 10,000 realizations of bag weights greater than 1865 g. Piece count in each simulated bag was monitored with the aid of a simple counter programmed into the iterative process. SAS® RANNOR function (SAS Institute, Inc., 1985) was used to produce the N(1,0) distribution. Simulated random piece weights were calculated as,

$$\text{piece weight} = \text{mean} + (\text{sd} * (X))$$

where X is a randomly selected observation from the N(0,1) distribution.

Using the distribution of piece weights, pieces were partitioned into 2, 3, ..., 6 quantiles using SAS® Proc RANK (SAS Institute, Inc., 1988). Mean and standard deviation for each quantile were calculated. Bag weights were simulated using 1, 2, or 3 fillets randomly selected from each quantile group. All possible combinations were modeled and the three combinations which exceeded the nominal weight by the least were recorded. Mean and variances of the simulated bag weights from each combination were calculated as the weighted means of the means and variances of the quantile groups from which the fillets came. The distributions of bag weights were simulated for each combination using Monte Carlo simulations with 2,500 iterations. Fillet weights in each weight category were assumed to be distributed as truncated normal distributions with means and standard deviations estimated from the quantile means and standard deviations. Crystal Ball® modeling software (Decisioneering, Inc, 1998, Denver, CO, USA) was used for the Monte Carlo simulations. Mean give away of each model was calculated as the difference between mean modeled bag weights and the nominal weight of 1816 g. Proportion in each model not meeting nominal weight was estimated directly from the Crystal Ball® simulations by setting the lower boundary of the simulations to 1816g.

Results and Discussion.

Mean bag weights of the randomly packaged fillets observed in the processing plant was 2057.7 g and sd was 141.1. Piece counts varied between 6 and 9 and averaged 7.62. The mean, sd, and piece counts of the bag weight simulation of unpartitioned pieces were 2007.4 g, 87.9, and 7.43, respectively. Since the nominal package weight was 1816 g, mean give aways were 191 g and 241.1 g or 10.5% and 13.3% for the simulated and actual bags, respectively. This loss represents a direct loss of profit since other production costs are little affected by the amount of give away.

Table 1 shows the three combinations of fillets from each weight class which exceeded the nominal weight by the least for the 2 to 6 class models. As the number of weight classes increased from 2 to 6, mean bag weight, and thus mean give away, tended downward. Moreover, increasing the number of classes improved uniformity of bag weights as shown by average sd declining from 176.4 for the two class model to about 24.5 for the 6 class model. Mean give away was similar among the three least wasteful combinations within each model. Percentage of under weight packages varied and was little affected by the models.

For models which had four or more weight classes, the models which exceeded the nominal weight by the least did not utilize the largest or smallest fillets (Table 2). All weight classes except the largest and smallest were bounded. Consequently, the sd of those classes were reduced compared to the unbounded largest and smallest classes (data not shown). Thus, combinations which included the unbounded classes tended to exceed the nominal weight by more than those which did not include those classes.

Conclusions

While MWP offers purveyors an efficient vehicle for marketing large volumes of food products, give-away will be greater than when product is marketed under strictly unit weight pricing. It is especially important that this give-away be controlled in the case of high value products such as chicken breast fillets, because ingredient costs are a larger part of overall costs than in the case of lower value products such as potatoes or fresh fruits. These models demonstrate that one approach to controlling give-away is to pre-size the product and then package by piece numbers from each weight category. Under this system, a small proportion of the containers will be under weight, but that proportion can be predicted and controlled by proper selection of weight categories.

In developing practical applications of these models, consideration should be given to the following recommendations:

(1) Instead of demanding that only the optimum combinations of weight classes be used .multiple low give-away combinations should be accepted, since to do otherwise might lead to excessive demand for some classes and under demand for others.

(2) Consideration should be given to reducing package size variation by developing alternate uses for the largest and smallest weight classes so that they are not used in MWP packages.

Pertinent References.

SAS Institute Inc. 1988. *SAS Procedures Guide, Release 6.03 Edition*. Cary, NC: SAS Institute Inc.

SAS Institute Inc. *1985. SAS Language Guide for Personal Computers, Version 6 Edition.* Cary, NC: SAS Institute Inc.

Cochran, William G. and Cox, Gertrude M. *Experimental Design, 2nd Ed.* 1957. John Wiley & Sons, New York, NY.

Table 1. Optimum fillet weight combinations from each class

Classes	Mix No.	Bag Weight (g)	Std. Dev.	Give Away (%)	Under Weight (%)
2	1	2050.6	169.2	12.9	8.9
	2	2182.8	184.4	20.2	2.3
	3	2273.3	175.7	25.2	<1.0
3	1	2053.6	107.3	13.1	<1.0
	2	2115.7	114.4	16.5	<1.0
	3	2188.3	135.9	20.5	<1.0
4	1	1977.9	43.6	8.9	<1.0
	2	1942.6	84.9	7.0	8.4
	3	1981.7	90.0	9.1	3.8
5	1	1889.3	21.7	4.0	<1.0
	2	1889.3	29.1	4.0	<1.0
	3	1914.4	25.4	5.4	<1.0
6	1	1862.4	25.5	2.6	3.9
	2	1863.8	23.5	2.6	<1.0
	3	1861.9	25.4	2.5	3.3

Table 2. Number of fillets from each weight class required to meet stated weight specifications

		Number of Fillets from Each Class					
Classes	Mix No	1	2	3	4	5	6
2	1	5	3				
	2	4	4				
	3	3	5				
3	1	1	3	3			
	2	3	3	2			
	3	3	2	3			
4	1	0	3	3	1		
	2	3	2	2	0		
	3	3	3	1	1		
5	1	0		3	2	0	
	2	0	2	1	3	0	
	3	0	3	3	3	0	
6	1	0	1	0	3	1	0
	2	0	3	1	1	2	0
	3	0	3	2	2	1	0