LOT SENTENCING OF MICROBIAL CLUSTERING IN FOOD USING MIXED DISTRIBUTIONS

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ABSTRACT: *In the last two decades awareness regarding food contents has gained great significance, courtesy information explosion. This aspect of food content awareness gets more highlighted where infant meal is concerned. Microorganisms harm food items individually and also in the form of colonies or clusters. This article focuses on the application of a sampling technique called repetitive group sampling (RGS) plan, for checking the existence of pathogenic organisms in food, using three different types of distributions-Negative binomial, Poisson logarithmic and Zero-Inflated Poisson distributions. Mathematical models are developed and relevant tables are constructed with suitable appropriate optimal parameters of the sampling plan for specified various values of the acceptable quality level and limiting quality level. The plan parameters are designed based on the two-point approach. The results show that RGS plan gives more effective than the single sampling plan regarding minimum average sample number in detecting the microorganisms then the traditional methods. The advantages of the proposed plan are also discussed.*

Key words: Repetitive group sampling plan, Average sample number, Negative binomial, Poisson-logarithmic, Zero-inflated Poisson, Consumer's risk, Producer's risk, Operating characteristic curves.

1. INTRODUCTION:

The term 'quality' is essential in the life of every human being. From the beginning of the life of humans, they do care about the quality of the products, particularly food items. However, in our surroundings there exist many pathogenic organisms (an organism capable of causing disease in its host) which cannot be seen by naked eye. In 2005 Commission of Regulation (European Commission) applied some specific kind of methods for the pathogenic organisms. For checking the presence of pathogenic organisms in food items, an important sampling tool called the acceptance sampling plan is mostly used in manufacturing industries.

The acceptance sampling strategy is separated into two categories, that is, attributes and variables sampling plans. The ultimate aim of using an acceptance sampling plan is to save inspection time and cost as well as to improve the quality of the products in a short period [16]. Different kinds of sampling plans are available in the literature such as single sampling plan, double sampling plan, multiple sampling plans, sequential sampling plan and so on [17] . Every sampling plan has its own merits and demerits.

The current study focuses on the attribute sampling plans for inspection of food items by proposing a repetitive group sampling (RGS) plan for inspecting the presence of pathogenic organisms in food. The concept of RGS plan was developed by [15]. The RGS plan is known to be more efficient than the single sampling plan regarding minimum average sample number (ASN). The RGS plan has been investigated under various situations, including the testing of the percentile life of the products see for example [1].

The design of an acceptable sampling plan always involves two kinds of risks, namely the chance of discarding a high-quality lot, which is also known as the producer's risk (or probability of Type I error, α) and the probability of accepting a bad lot which is known as the consumer's risk (or probability of Type II error, β). The use of an operating characteristic (OC) curve for the mean level of contamination is carried out. The reader may refer to [12].

The acceptable quality level (AQL) is percent defective that a producer can afford during the manufacturing process and the rejection quality level (RQL) is percent defective that a consumer can afford. For an efficient sampling plan, the OC curve must go through these two points. The two points are designated as $(AQL, 1-\alpha)$ and(RQL, β)). A manufacturer requests that the chance of accepting a lot should be greater than $1-\alpha$ at the quality level of $AQL(or\ p_1)$. In most cases, a customer wants that the probability of the lot acceptance should be less than β at *RQL* (or p_2). Present study considers the values of p_1 as {0.001, 0.0025, 0.005, 0.01, 0.03, and 0.05} and the values of p_2 as {0.100, 0.150, 0.200, 0.250, 0.300, 0.350, and 0.650}.

Pathogenic microorganisms infect the foodstuff as clusters or set of entity cell and also spoil food in the form of colonies. The microbial cluster was lately studied through the application of sampling plan based on a mixture of distributions [12].The current study proposes a RGS plan under the assumption that the amounts of microorganisms present in the food product follow a various mix of distributions such as the negative binomial (NB), Poisson logarithmic (Plog), and zero-inflated Poisson (ZIP) distributions.

2. MATERIAL AND METHOD:

2.1 Proposed RGS plan

The proposed plan is stated as follows:

Step 1: Choose the values of Type I error α and Type II error β. Choose the value of AQL (p_1) and RQL (p_2).

Step 2: Draw a sample of size n from the submitted lot of food products.

Step 3: If the number of micro-organisms x are fewer than or equal to the acceptance number c_1, then declare the lot of food as good. If $x > c_2$, $(c_2 > c_1)$, then declare that the product is bad.

Step 4: If $c_1 < x \leq c_2$, go to Step1 and repeat the procedure until reaching a decision.

The performance of the RGS plan can be gauged by the OC curve, which depends on the sample size, sample weight *w* and the distribution under consideration. Three different probability distributions, namely NB, Plog and ZIP distributions are considered with the assumption that micro-organisms follow any of these three distributions.

2.2 Poisson lognormal distribution

Poisson lognormal distribution can be used for checking the presence of microorganisms in beef carcasses which was described by [7].The main cause of the bacterium and the main medium for its spread is rehydrated powdered infant formula (PIF) see [5]. The current study also uses the attribute sampling plan recognized by the European Commission 2073/2005 (European Commission, 2005) for detecting Cronobacterspp in PIF (nonappearance into $w = 10g$, different *n* sample used for element) even though the method discussed can be used for any other germ which shows certain level of clustering in foodstuff"[9]and [11].

2.3 The negative binomial distribution:

The microorganisms inside foodstuff influence quantity of bacteria in a lot, resulting from sampling and an account by bacteriological examinations. [8] (1981) and [3] used the NB distribution to check the presence of pathogenic organisms in liquid stuff. The NB distribution deals with the laboratory groups in an accurate way. NB distribution is a suitable distribution under mixture distributions. When the replicated samples are collected, the sample data follows the NB distribution. While bacterium is randomly distributed and the mean approaches the variance, the Poisson distribution may be used. In general, however, the distribution of bacterium can be described by the NB distribution [10].Our basic assumption is that a continuous Gamma distribution is useful toward generalizing the mean of a discrete Poisson distribution, a mixture of these two distributions is a discrete distribution which is known as a NB distribution. According to [9] a random variable, microbial concentration (cells/g) within the mass of food follows the gamma distribution and some observed counts (cell) follows the Poisson distribution with intensity λ. The same can be written as:

$$\text{Poisson}(\lambda\ \text{Gamma}(k,\tfrac{1}{k})) = \text{Poisson}(\text{Gamma}(k,\tfrac{\lambda}{k})) \quad (1)$$

Where *k* is an exponent of the NB distribution.

2.4 OC Function based on NB distribution

The probability mass function (pmf) of NB distribution is given as

$$P_X = \binom{k+x-1}{x}(1-p)^{1-x}p^k$$

where *x* is the total number of failures until the specified experiment time is ended and *k* is the number of successes.

The following expression is used for NB distribution

$$P_X = \frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(x)}\left[\frac{k}{k+\mu_{NB}}\right]^k\left[\frac{\mu_{NB}}{k+\mu_{NB}}\right]^x$$

where P_X is a chance that *x* organism occurs in a sample and Γ. is a complete gamma function.

The probable amount of bacteria λ_w trial of mass w and coefficient of variation (CV) of mass w be set by [12] are as

$$\lambda_w = \sum_{i=1}^{w}(k,p)\,\lambda_w = \sum_{i=1}^{w}(k,p) \quad (2)$$

$$CV_{NB} = \frac{\sqrt{nw\mu + wn\sigma_G^2}}{wn\mu} \quad (3)$$

Therefore, both the CVs of the NB changed through growing average plus the sample mass (w) and sample size (*n*). The RGS plan can be used by taking fixed values for AQL and RQL and there is a great effect of w and *n*, so values of w and *n* matter lot. From [12], we have

$$wnk = \frac{(wn\mu_{NB})^2}{wn\sigma_{NB}^2 + wn\mu_{NB}} \quad (4)$$

The lot acceptance probability with sample of mass wn from proposed plan is given as

$$P_a = \sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu}\right)^{wnk}\left(\frac{\mu}{k+\mu}\right)^{wnx} \quad (5)$$

The lot rejection probability is given as

$$P_r = P(x > c_2) = 1 - \sum_{x=0}^{c_2}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu}\right)^{wnk}\left(\frac{\mu}{k+\mu}\right)^{wnx} \quad (6)$$

Average sample number (ASN) is calculated as follows:

$$ASN = \frac{n}{\sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu}\right)^{wnk}\left(\frac{\mu}{k+\mu}\right)^{wnx} + 1 - \sum_{x=0}^{c_2}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu}\right)^{wnk}\left(\frac{\mu}{k+\mu}\right)^{wnx}} \quad (7)$$

The lot acceptance probability at AQL and LQL are given as follows

$$L(\mu_1) = \frac{\sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_1}\right)^{wnk}\left(\frac{\mu_1}{k+\mu_1}\right)^{wnx}}{\sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_1}\right)^{wnk}\left(\frac{\mu_1}{k+\mu_1}\right)^{wnx} + 1 - \sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_1}\right)^{wnk}\left(\frac{\mu_1}{k+\mu_1}\right)^{wnx}} \quad (8)$$

$$L(\mu_2) = \frac{\sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_2}\right)^{wnk}\left(\frac{\mu_2}{k+\mu_2}\right)^{wnx}}{\sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_2}\right)^{wnk}\left(\frac{\mu_2}{k+\mu_2}\right)^{wnx} + 1 - \sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_2}\right)^{wnk}\left(\frac{\mu_2}{k+\mu_2}\right)^{wnx}} \quad (9)$$

Then we find the design parameters of the assumed distributions like NB distribution as

Minimize

$$ASN(\mu_2) = \frac{n}{\sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_2}\right)^{wnk}\left(\frac{\mu_2}{k+\mu_2}\right)^{wnx} + 1 - \sum_{x=0}^{c_2}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_2}\right)^{wnk}\left(\frac{\mu_2}{k+\mu_2}\right)^{wnx}} \quad (10a)$$

Subject to

$$\frac{\sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_1}\right)^{wnk}\left(\frac{\mu_1}{k+\mu_1}\right)^{wnx}}{\sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_1}\right)^{wnk}\left(\frac{\mu_1}{k+\mu_1}\right)^{wnx} + 1 - \sum_{x=0}^{c_2}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_1}\right)^{wnk}\left(\frac{\mu_1}{k+\mu_1}\right)^{wnx}} \geq 1-\alpha \quad (10b)$$

$$\frac{\sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_2}\right)^{wnk}\left(\frac{\mu_2}{k+\mu_2}\right)^{wnx}}{\sum_{x=0}^{c_1}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_2}\right)^{wnk}\left(\frac{\mu_2}{k+\mu_2}\right)^{wnx}+1-\sum_{x=0}^{c_2}\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left(\frac{k}{k+\mu_2}\right)^{wnk}\left(\frac{\mu_2}{k+\mu_2}\right)^{wnx}} \le \beta \quad (10c)$$

2.5 The Poisson-logarithmic distribution (Plog):

In mixture distribution, it is assumed that food material in groups or colonies follows the Poisson process and the number of individual cells in each group follows the logarithmic distribution. From [2] and [14], we have following relation

$$NB = \text{Poisson}\,(\lambda_c)\text{^Lograithmic}(\theta) \quad (11)$$

where λ_c is the number of colonies and θ is the shape parameter. From [10], we have

$$wn\lambda_c = \text{wnk}\ln(q) \quad (12)$$

The number of bacteria within the colony calculated as follows

$$\mu_{\log} = \frac{p}{\ln(q)} \quad (13)$$

The lot acceptance probability for single sampling when c=0 is given as [12]

$$P_a = q^{-wnk} = \exp(-wn\lambda_c) \quad (15)$$

The plan parameters for Plog distribution will be determined using following inequities

Minimize $ASN(p_2)$ (16a)

Subject to

$$L(p_1) = \frac{\sum_{x=0}^{c_1}\frac{(wn\lambda_c)^x\exp(-wn\lambda_c)}{x!}}{\sum_{x=0}^{c_1}\frac{(wn\lambda_c)^x\exp(-wn\lambda_c)}{x!}+\left(1-\sum_{x=0}^{c_2}\frac{(wn\lambda_c)^x\exp(-wn\lambda_c)}{x!}\right)} \ge 1-\alpha \quad (16b)$$

$$L(p_2) = \frac{\sum_{x=0}^{c_1}\frac{(wn\lambda_c)^x\exp(-wn\lambda_c)}{x!}}{\sum_{x=0}^{c_1}\frac{(wn\lambda_c)^x\exp(-wn\lambda_c)}{x!}+\left(1-\sum_{x=0}^{c_2}\frac{(wn\lambda_c)^x\exp(-wn\lambda_c)}{x!}\right)} \le \beta \quad (16c)$$

2.6 The zero-inflated Poisson distribution (ZINB)

Outstanding technical growth, manufacture procedures is well calculated in such a way that the foodstuffs are in perfect form so that the number of zero defects will be found more in those cases (it means PIF free from microorganisms). However, random variations in the manufacturing processes may lead some foodstuffs to an imperfect state. The suitable probability distribution to describe such circumstances is a zero-inflated Poisson (ZIP) distribution like this distribution be use through [4,13,19].

The probability distribution for ZINB for counting x is given as follows

$$P(x \ge 1) = \pi\frac{\Gamma(x+k)}{\Gamma(x+1)\Gamma(k)}\left[\frac{k}{k+\mu_{NB}}\right]^k\left[\frac{\mu_{NB}}{k+\mu_{NB}}\right]^x$$

Where π denotes that positive counts that follow NB distribution. [18] Suggested that mean of ZINB distribution as

$$\mu_{NB} = \pi kp = \pi\mu_{NB}$$

The lot acceptance probability and rejection probability for single sampling is given as follows

$$P_a = \pi_w\sum_{x=0}^{c_1}\frac{wn\lambda_w\exp(-wn\lambda_w)}{x!}$$

$$P_r = 1-\pi_w\sum_{x=0}^{c_2}\frac{wn\lambda_w\exp(-wn\lambda_w)}{x!}$$

Where π_w is probability that the count follows an NB distribution in the sample of mass w. The ASN under ZIP model can be determined as

$$ASN = \frac{n}{\pi_w\sum_{x=0}^{c_1}\frac{wn\lambda_w\exp(-wn\lambda_w)}{x!}+\left(1-\pi_w\sum_{x=0}^{c_2}\frac{wn\lambda_w\exp(-wn\lambda_w)}{x!}\right)}$$

Table 1

n	p_1	p_2	K	c_1	c_2	ASN	$L(p_1)$	$L(p_2)$
30	0.010	0.25	0.5621083	2	6	33	0.9587	0.0179
30	0.0025	0.15	0.5903478	1	4	30	0.965	0.0341
29	0.0010	0.10	0.6777805	2	5	29	0.960	0.0207
27	0.030	0.30	0.9936503	2	3	27	0.9515	0.0087
26	0.010	0.25	0.5582001	4	10	26	0.9590	0.0184
26	0.005	0.20	0.5723764	2	9	26	0.958	0.0167
26	0.0010	0.10	0.4300877	5	10	26	0.9620	0.0249
25	0.001	0.10	0.6860674	1	7	25	0.9662	0.0380
22	0.0300	0.30	0.8063411	3	9	22	0.9527	0.0099
22	0.0010	0.10	0.7723437	6	8	22	0.9547	0.01207
21	0.0100	0.25	0.8118404	1	4	21	0.9524	0.0096
20	0.030	0.30	0.8350451	3	7	20	0.9591	0.0186
13	0.0500	0.35	0.5440578	5	9	13	0.9522	0.0094
13	0.0500	0.35	0.7641953	2	10	13	0.9552	0.01264
13	0.030	0.30	0.6391702	1	5	13	0.9685	0.0475
13	0.0010	0.10	0.7987210	8	10	13	0.9532	0.0103
13	0.001	0.10	0.8712549	1	3	13	0.9573	0.0157

The plan parameters will be determined by using following non-linear optimization solution

$$L(p_1) = \frac{\pi_w\sum_{x=0}^{c_1}\frac{wn\lambda_w\exp(-wn\lambda_w)}{x!}}{\pi_w\sum_{x=0}^{c_1}\frac{wn\lambda_w\exp(-wn\lambda_w)}{x!}+\left(1-\pi_w\sum_{x=0}^{c_2}\frac{wn\lambda_w\exp(-wn\lambda_w)}{x!}\right)} \ge 1-\alpha$$

$$L(p_2) = \frac{\pi_w\sum_{x=0}^{c_1}\frac{wn\lambda_w\exp(-wn\lambda_w)}{x!}}{\pi_w\sum_{x=0}^{c_1}\frac{wn\lambda_w\exp(-wn\lambda_w)}{x!}+\left(1-\pi_w\sum_{x=0}^{c_2}\frac{wn\lambda_w\exp(-wn\lambda_w)}{x!}\right)} \le \beta$$

3. Results and Discussion:

We present tables of plan parameters for Plog, NB, and ZIP distributions under the RGS plan. The OC curves for the three distributions are constructed using RGS plans with sample size *(n)* of 10 *g* each. The values used for p_1 are {0.001, 0.0025, 0.005, 0.01, 0.03, 0.05} and for p_2 {{0.100, 0.150, 0.200, 0.250, 0.300, 0.350} and values of *k* vary from (0.005 to 1.005).

Table 1 gives the optimal parameters of attribute RGS plan on behalf of some selected combinations of AQL and RQL and for α=5% and β=1%. From Table 1, we can observe that the values of *n* show a decreasing trend. We interpret the first row as when sample size *n*=30, sample of mass *w =10g* fixed for each, AQL is 1%, and RQL is 25%, c_1=2 and c_2=6 for these the chance of long-suffering a lot is almost 96% and chances that customer accept Powder Infant formula having microorganisms is 1.7% , and minimum value of ASN is equivalent to *n* and *k* is the dispersion parameter in the powder infant formula *k* actually is 1/*k*. Further, it is also illustrated that RGS plan is cost-effectively better than existing technique regarding minimum ASN. The chance of acceptance for existing and proposed table is given in Table

2.

The proposed plan do well as compared to existing plans for in the case of existing plan x=0 on the other hand x=0,1,2,…,n. Plog distribution and having λ_c / g (i.e., the number of clusters in the food matrix per gram) in RGS producer is 97% sure about that absence of microorganisms in powder infant formula as compared to existing plan in which producer is 89% sure about the absence of pathogens in PIF.

We can say that the values of n show decreasing trend. Table 3 gives the optimal parameters of the attribute RGS plan for some selected combinations of AQL and RQL and α=5% and β=1%. We interpret the first row as when lot size =29, a sample of mass w=10g fixed for each, AQL is 5%, and RQL is 20%, c_1=7 and c_2=8 for these the probability of accepting a lot is almost 96%, and the chances that consumer accepts Powder Infant formula having microorganisms is 9.7%. Further, it is also to be illustrated that the RGS plan is economically superior to the existing technique regarding minimum ASN. The probability of acceptance of the existing plan and proposed plan is given in Table 4

The proposed plan exists as compared to existing plan for in the case of existing plan x=0 on the other hand x=0,1,2,…n. NB distribution and having 1-g (i.e., the number of clusters in the food matrix per gram) in RGS plan is 95% sure about that absence of microorganisms in powder infant formula as compared to existing plans in which producer is 48% sure about the absence of pathogens in PIF.

Table 5 gives the optimal parameters of the attribute RGS plan for some selected combinations of AQL and RQL and α=5% and β=5%. From Table 5, it can be observed that the values of n are in decreasing trend. We interpret the first row as when lot size n=29, sample of mass w=10g fixed for each, AQL is 1%, and RQL is 25%, c_1=4 and c_2=10 for these the probability of accepting a lot is almost 99%, and the chances that consumer accept Powder Infant formula having microorganisms is 2% and minimum value of ASN is equivalent to sample size *(n)* and k is the dispersion parameter in the powder infant formula k actually is 1/k. Further, it is also to be illustrated that the RGS plan is economically superior to the existing technique regarding minimum ASN. The probability of acceptance for the existing and proposed plan is shown in Table 6.

From these results, we observe that the probability of acceptance through the RGS plan is 99% sure about that absence of microorganisms in powder infant formula as compared to existing plans in which producer is 75% sure about the absence of pathogens in PIF. So, the RGS plan gives more accurate results as compare to existing sampling plan.

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Table 2: Comparison of existing and proposed plan in Lot acceptance probability

p_1	Existing	Proposed
0.0010	0.89276035	0.9686217
0.0100	0.26251902	0.9683960
0.0010	0.69472593	0.9688960
0.0025	0.64641171	0.9613797
0.0300	0.75463548	0.9650484
0.0500	0.67285422	0.9655154
0.0010	0.01068195	0.9666399
0.0010	0.51234149	0.9595025
0.0010	0.66384039	0.9660919
0.0010	0.1026687	0.9579207
0.0025	0.3181665	0.9658699
0.0100	0.1864799	0.9606010
0.0010	0.3378230	0.9596717
0.0025	0.0143130	0.9678641
0.0025	0.3407450	0.9546109
0.0100	0.3979283	0.9569462
0.0500	0.6459424	0.9660013
0.0500	0.6126348	0.9687768

Table 3: The Plan parameters of Negative Binomial Distribution when and

n	p_1	p_2	k	c_1	c_2	ASN	$L(p_2)$	$L(p_2)$
29	0.005	0.2	0.6331949	7	8	29	0.963964	0.09899008
25	0.001	0.35	0.7354971	2	4	25	0.9582717	0.08341961
24	0.0025	0.1	0.8796365	1	2	24	0.9503125	0.06888116
23	0.001	0.1	0.5124265	1	3	23	0.9564353	0.07945745
19	0.005	0.2	0.4693831	5	6	19	0.9600163	0.08761263
19	0.0025	0.15	0.7886326	5	8	19	0.9553293	0.07726839
17	0.01	0.2	0.6608562	8	9	17	0.9624213	0.09419555
15	0.0025	0.1	0.803991	6	8	15	0.9544806	0.07568063
14	0.001	0.3	0.718685	1	5	14	0.9592047	0.08560624

Table 4: Comparison of existing and proposed plan

p_1	Existing Probability	Proposed Probability
0.001	0.4736752	0.9546838
0.0025	0.5224313	0.9532088
0.005	0.2756272	0.9573006
0.05	0.3247241	0.950351
0.005	0.8412498	0.9514521
0.001	0.1957946	0.9513057
0.03	0.55880391	0.9542066
0.03	0.88096993	0.9548901
0.03	0.14120938	0.9533996
0.0025	0.04901999	0.9559208
0.005	0.42031759	0.9584666
0.01	0.90611818	0.9536193

Table 5: The plan parameters of proposed plan of Zero Inflated Poisson Distribution when and

n	$p_1 p_1$	$p_2 p_2$	k	c_1	c_2	ASN	$L(p_1)$	$L(p_2)$
29	0.01	0.25	0.3810592	4	10	29	0.9999989	0.02360801
21	0.001	0.1	0.3236608	1	9	21	0.999999	0.09226512
20	0.05	0.35	0.6008233	8	9	20	0.9999982	0.07812677
20	0.01	0.25	0.10181318	8	10	20	0.9999998	0.09683693
14	0.005	0.2	0.6982307	5	7	14	0.9999993	0.01530015
13	0.01	0.25	0.51502573	2	5	13	0.999999	0.0643942
13	0.005	0.2	0.11757807	2	10	13	0.9999999	0.09246423
13	0.0025	0.15	0.7494183	5	6	13	0.9999985	0.03342517
13	0.001	0.1	0.23896444	5	9	13	0.9999995	0.007357
12	0.001	0.1	0.03395322	3	8	12	0.9999999	0.0496567

Table 6: Comparison of existing and proposed plan

P_1	Existing	Proposed
0.001	0.7589605	0.9999996
0.001	0.6145271	0.9999994
0.0025	0.4442186	0.9999995
0.03	0.5405115	0.9999981
0.001	0.9779262	0.9999999
0.001	0.6899572	0.9999994
0.005	0.2056955	0.9999994
0.05	0.9704242	0.999999
0.001	0.5135614	0.9999972

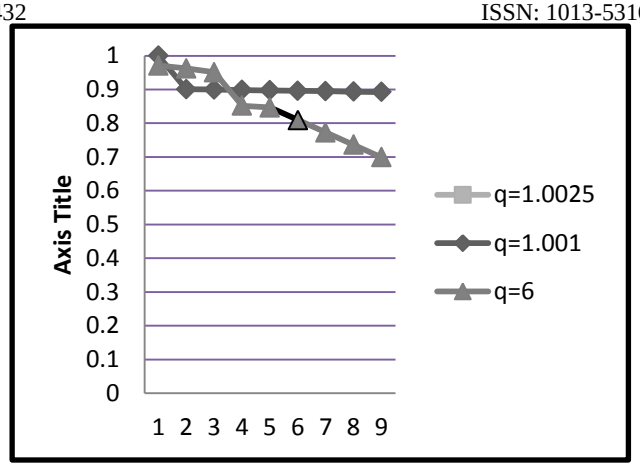

Figure 1a: Comparison of OC curves for the sampling plan $w = 10g$, for different n based on an NB distribution (mean microbial concentrations μ_{NB} or μ_{Plog}, respectively) with index of dispersion $q = \{1.001, 6\}$ (a) and $k = \{1/2, 1/5, 1/10\}$ (b).

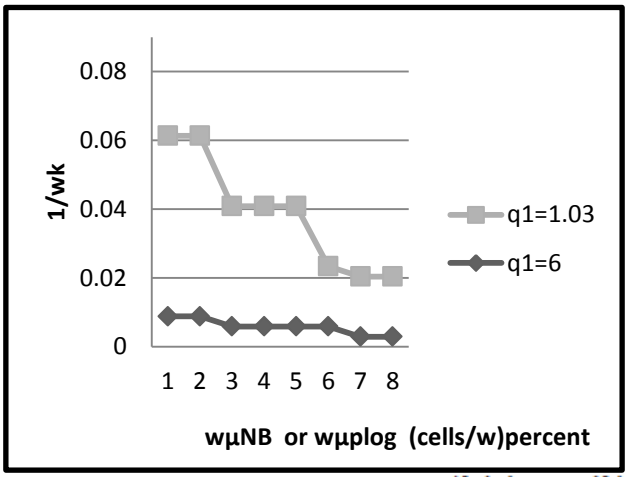

Fig. 2a. Effect on the indices of dispersion $1/k(a)$ and $q(b)$ in the sample of mass w by increasing the mean level of contamination ($w\mu_{NB}/w\mu_{Plog}$) in the sample having fixed values of $q = \{1.03\& 6\}(a)$ and $k = \{1/2, 1/5, 1/10\}(b)$ for NB distribution

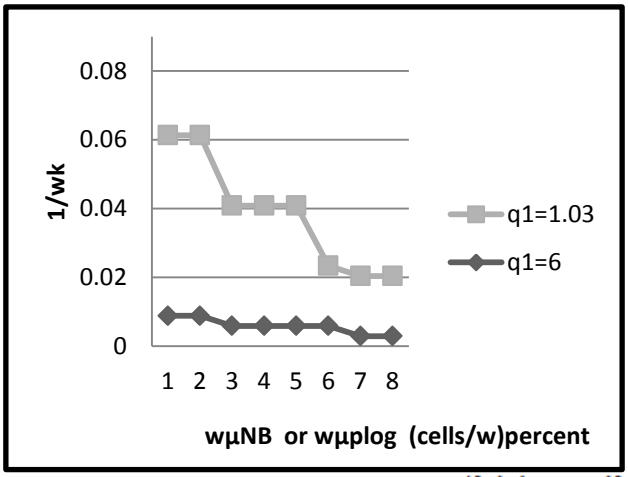

Fig. 2b. Effect on the indices of dispersion $1/k(a)$ and $q(b)$ in the sample of mass w by increasing the mean level of contamination ($w\mu_{NB}/w\mu_{Plog}$) in the sample having fixed values of $q = \{1.03\& 6\}(a)$ and $k = \{1/2, 1/5, 1/10\}(b)$ for Plog distribution.

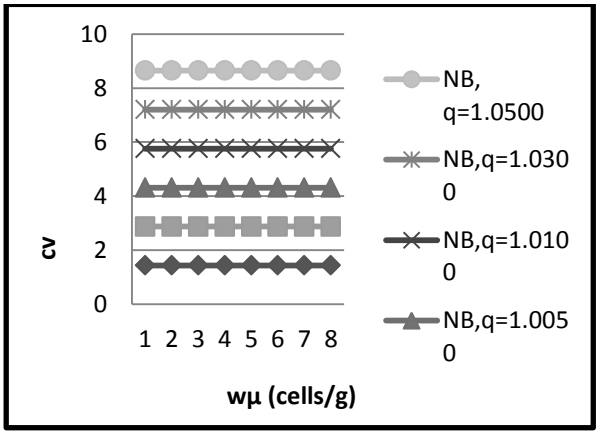

Fig.3.Coefficient of variation (CV) in relation to the mean level of contamination in the sample of mass w determined for a negative binomial (NB) or Poisson-logarithmic distributions assuming fixed values of $q = \{1.005, 1.0025, 1.001, 1.01, 1.03, 1.05\}$.

3.1 Comparison of study:

The outcome of this work is compared graphically through the OC curves based on following distributions NB, Plog and ZIP. While we desire in the direction of analysis the Efficiency of microbiological criterion for Cronobacterspp, the OC curves are created lying on the origin of RGS plan of samples (n) of 10g each w. The comparison is made for NB distribution which is as well as equivalent to the Plog distribution. The initial position of consequences exists in Fig. 1a and Fig.1b, which show a contrast of OC curves based on NB and Plog distribution with fixed values of indices of dispersion $q = \{1.001,6\}$ and $k = \{1/2,1/5,1/10\}$, respectively. The OC curve constructed on the Poisson distribution, both the customers, as well as producer quality levels, be affected. When q =1.001, means PIF have fewer chances of having microorganisms as compared to q=6. Assume a Plog plus having λ_c / g like entity for x alliance, OC curve based on Poisson allocation represented in Fig. 1a be able to understand the same as the amount of groups λ_c / g of some mass $\mu_{\log}$ on a certain chance of taking of group.

This signifies that, when taking into account the level of bacterial clustering, the sampling plan designed will be more conservative neither than those arising from a Poisson assumption to achieve the same level of safety. This is in agreement with [9] derived additional conservative sampling plans for Enterobacteriaceae counts in sheep carcasses when the highly cluster microbial information be represented by an NB (or Poisson-gamma) model. Furthermore, from Fig. 2a it is understood that the increasing the mean point of infectivity (μ_{NB}, μ_{Plog}) the index 1/k in the sample of mass w decreases while it increases in rising value of index q. This means that for the same degree of microorganisms is over-dispersion defined through q, the limits 1/k incorrectly proposes a decreasing outcome of grouping in support of increasing stages of infectivity with w, while 1/k correctly increases for growing values of q, therefore indicating an increasing effect of clustering.

Based on the misleading assumption that the NB distribution has fixed values of 1/*k* at any mean level of contamination and at any trial mass take on (Fig. 2b), just consumer quality level (CQL) would exaggerate even as on producer quality level (PQL). The given values, be similar mean levels of infection scaled on gram level $w\mu_{NB}/10g$ on which OC curves calculated on NB distribution congregate the OC curve based lying on Poisson allocation in Fig. 2b.

According to [16], anyone sees the CV of gamma allocation be set on every mean level of infectivity in addition to *w* assume at the same time as it increases for rising ethics of index 1/*k*. For the comparison assumed fixed *q* at any mean point of infectivity plus *w* chosen (Fig. 3), the CV of gamma allocation remains constant for growing mean levels of adulteration and sample weight. Additionally, CV_{NB} never approaches to the CV of the Poisson, as used for rising ethics of *q* it moves in the direction of congregating using the CV of the gamma. So, first set of the outcome, which evaluates OC curves based on NB distribution have predetermined ethics of 1/*k*.

Deriving an OC curve with a fixed index of dispersion *q* is equivalent to deriving it with a variable dispersion measure 1/*k* conditional on the mean concentration, as previously suggested by [7],[8] and[9] because *q* is a function of the mean and the dispersion 1/*k*. Thus, in the derivation of an OC curve, maintaining fixed *q* at every mean concentration implies varying 1/*k* at any mean attentiveness. So, in RGS plan reduces the variation and the chances of microorganisms in the number of food clusters reduce. The risks of both consumers and producer are reduced through the RGS plan.

4. CONCLUSIONS:

In this paper, we have proposed an attributes RGS plan based on three mixed distributions for the application of describing microbial clustering in food. It has been shown that the proposed sampling plan performs better than the existing sampling plan regarding minimum ASN and the higher probability of acceptance. It is seen that the producer and consumer risks are increased for the increased index of dispersion q. Through this study, we have evaluated the performance of the RGS plan implemented for Cronobacterspp. A comparison of OC curves has been made based on three different geometric distributions and index of dispersal usually, use for telling the consequence of clumping or clustering of microorganisms within foodstuff. Through this study, it has been proved that the RGS plan sampling gives better results for the presence of microorganisms in the PIF in the form of clusters means producer and consumers are satisfied from the acceptance of lot or foodstuff.

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